PROCEEDINGS

OF THE

TWENTY-SECOND ANNUAL CONVENTION

OF THE

American Railway Engineering Association

HELD AT THE

CONGRESS HOTEL, CHICAGO, ILLINOIS

March 15, 16 and 17, 1921

VOLUME 22

PUBLISHED BY

AMERICAN RAILWAY ENGINEERING ASSOCIATION
CHICAGO

1921

(A)

TABLE OF CONTENTS

CONSTITUTION

GENERAL INFORMATION

BUSINESS SESSION

COMMITTEE REPORTS

MONOGRAPHS

Part 2

DISCUSSIONS

CONSTITUTION

CONSTITUTION.

REVISED AT THE FIFTH, EIGHTH AND TWELFTH 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 Requirement.

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 Direction, 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 applicants 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 complied 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 reinstatement 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.

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 Secretary,
A Treasurer,
Nine Directors,

*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.

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.
Secretary, one year.
Treasurer, one year.
Directors, three years.

Officers Elected Annually.

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

A President,
One Vice-President,
A Secretary,
A Treasurer,
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	1	1
Secretary	1	1
Treasurer	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 convention 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 this 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 Secretary.

2. 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.

Duties of Treasurer.

3. 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.

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 of three members.

b. Publication Committee of three members.

c. Library Committee of three members.

d. Outline of Work of Standing Committees of five members.

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 begin upon the third Tuesday in March of each year, and shall be held at such place in the City of Chicago as the Board of Direction may select.

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 the 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. Signs, Fences and Crossings.
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.
XX. Uniform General Contract Forms.
XXI. Economics of Railway Operation.
XXII. Economics of Railway Labor.
XXIII. Shops and Locomotive Terminals.

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.
Clearance Diagram.

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.

Sequence. (D) CONSIDERATION OF COMMITTEE REPORTS.

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.

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 15, 1921

MORNING SESSION

The Twenty-second Annual Convention of the American Railway Engineering Association was called to order by the President, Mr. H. R. Safford, Assistant to the President, Chicago, Burlington & Quincy Railroad, at 9:15 a. m.

The President:—The Twenty-second Annual Convention of the Association will please come to order.

The first matter of business is the reading of the Minutes of the last Convention; but inasmuch as the Minutes have been printed and distributed to the members, unless there is some objection to them, and the opportunity will be given for making objection, they will stand approved. Such opportunity is now given. There being no objection to the Minutes as printed, they will stand approved.

The Chair desires to extend the usual invitation to members of faculties of colleges and universities and to railway officials to the privileges of the floor in discussion, and you are all cordially invited to take part therein.

The next order of business is the address of the President.

ADDRESS OF PRESIDENT H. R. SAFFORD

This annual meeting marks the close of the twenty-second year of the life of the American Railway Engineering Association—practically a generation as human life is measured.

And, in some ways, it would seem that we have just passed through a period which will mark a very definite generation in the history of railroads.

This thought is suggested when we recall that at the end of the Association's twenty-first year we find the railroad industry, of which we are a part, at the threshold of a new era.

Many things point to this belief, marked primarily by a new Transportation Act expressing a desire on the part of the public for private control with protective regulation, with expressed support of efficient and honest management and an earnest desire to restore confidence in the enterprise and credit to the structure.

The termination of Federal control and the restoration of the properties to their owners coincident with the passage of the new Transportation Act seem to mark the close of a period when there was a noticeable and increasing tendency toward excessive and burdensome regulation, an increasing failure upon the part of the public to fully understand and appreciate the rail transportation structure and especially a failure to realize the interdependence and joint responsibility resting upon both the railroad and the user to create, support and maintain what the public most desires, namely, good transportation.

These tendencies were the natural result of influences not of a constructive character and preaching discontent, unfairness, and discrimination, appealing to the individual or the territorial group of the public and shipper who naturally felt interested from a viewpoint of limited scope and dominated by selfishness rather than a desire to assume any responsibility for maintaining an efficient public service in general.

In two years the test of centralized direction has taught the public what could not and would not have been learned through any other agency.

A great change and I believe for the better has taken place—new powers and responsibilities are assumed by lawfully created public bodies—a different attitude is observed on the part of the shipper and the traveller and new conditions also surround the details of operation affecting theories of development and expansion of existing properties and the promotion of new projects, which are vastly different from twenty-one years ago.

This Association in devoting its entire attention to Railway Construction, Operation and Maintenance will find its efforts and results measured by the same standards applied to the various phases of railway service and we must feel the same sense of responsibility in trying to perfect the studies of the service which are entrusted to us that is felt by the executive and financial heads if we are to do our part in making the business successful and of permanent existence as a private enterprise.

I believe I sense correctly when I say that our responsibilities are greater than ever before because the public in expressing preference for private operation places the responsibility in the owners' hands, but will, through its established lawful representatives, scrutinize our performance and expect consistent practice along efficient and economic lines—but wanting at the same time all the initiative and resourcefulness within our power.

Probably no industry felt as severely the impact and the continued stresses of war. It seemed sometimes as if the structure would not survive the eccentric and unexpected strains for which it was not designed, but it has done so and from the test will be developed new formulae giving truer results in future study and the structure should be much more scientifically designed than ever before.

We are now passing through the severe and trying period of readjustment from the war strain and greater therefore is the need for intensive study of economic problems and renewed efforts to direct controlling influences to a stabilization of the situation so that the industry may thrive and prosper as intended by the new legislation.

A review of our own activities as an Association for the past year seems quite in order and I turn first to the matter of membership.

It has always been the policy to place a high premium upon quality of membership with the very definite goal of securing the highest degree of efficiency and the most finished product in the Manual. On the other hand the restrictions have not been pronounced insofar as departmental representation is concerned and encouragement has always been given to applications from officers in the Transportation as well as from the Construction and Maintenance Department; this because the Association has endeavored to coördinate Transportation, Construction and Maintenance of Way in matters which jointly interested these several branches. I believe that this idea has done much to keep interest in the Association and accounts for the par excellence of its work.

The encouragement which has always been given by Railway Executives has made it attractive for members to join and work. We have probably inclined in the past too much toward the policy of allowing the individual to seek us and have made too little effort to interest the outsiders and while it is possible always to go too far in adding members for numbers only, we, on the other hand, must not sit idly by and fail to keep apace with the natural growth in general railway organization and should not hesitate to fully and aggressively show to all interested in the business the benefit to be derived from membership.

There are a great many officers who are not, but should be, members and if the practical advantages are indicated to them they might become members. We have always disliked the idea of a spectacular and exciting campaign for membership, but last year a dignified but earnest effort was made to interest new members, with the result that from January 27th, 1920, to March 1st, 1921, there were 514 additions to the membership.

I would take this opportunity to make an appeal to the membership to augment our numbers by that personal solicitation in trying to show the benefits which will accrue both to the individual as well as to the employee. We individually have an obligation to draw to ourselves continually new men and thus perpetuate and strengthen our Association.

The general character of the work should appeal to the young and ambitious man. Its varied character is such that it may be said that it is a continuation of the same educational plan that characterizes University life. It should be felt that we are continuing where the University stops, for our work is almost entirely educational in its character —educational as to the technical field, but this is not all.

It has an educational value from the personal contact in the intensive committee service—from the exchange of ideas, the spirit of compromise and the fraternity spirit which has done much to emulate the sense of equity and I believe these effects have done much to make railroad business easier in negotiation and adjustment because they make for a universal language of business intercourse.

There were also deaths of some members which are recorded with deep regret, men who gave a great deal of earnest effort to the work and whose counsel is missed.

O. W. Albee
Sir James B. Ball
W. A. Cattell
P. S. Hildreth
A. S. Markley
John G. Shillinger
T. H. Hickey
William Travers
T. H. Sears
J. W. Wilkinson
Paul L. Wolfel
R. C. Sattley
E. S. Draper
W. H. Moore
A. T. Tomlinson
L. J. Putnam
G. W. Vaughan
E. V. Smith

Financial

The reports of the Secretary and Treasurer show a very satisfactory situation for the year and reflect great credit upon these officers as well as the Board Committee in charge of Finance. In the face of continual increase in costs of printing especially and perhaps to a less extent in other things we have been able to carry on without any increase in dues nor drawing upon our reserves. It is hoped this may continue, although until prices become more nearly normal, it may not be expected that our assets will increase as rapidly as in past years.

It has been the policy not to try to build up a large investment, but to invest the surplus in such a manner as to be in position to meet any emergency which may require temporary assistance in meeting annual expenses from interest-bearing securities.

The time may come when some use may be made of these funds in their application to research work and this possibility should be kept in mind, as I believe that should be the ultimate desire.

It is proper here to allude to the several kinds of assistance from outside agencies in promoting research work. The splendid results which have come from these special lines of study speak for themselves and this assistance is appreciated.

I refer particularly to the work of the Committee on Stresses in Track and the Committee on Rail.

I would especially commend to the members the published result of the last two years from these committees. It is not a waste of time to read them and give these committees all the support possible by way of suggestion.

Committee Service—Personnel

The increasing membership offers new problems in arranging the personnel of committees to obtain broad representation and effective work. It obviously is impracticable to put all the members on committees all of the time, but the desirable thing is to encourage all members to have some committee service. There are always differences in the degree of support which members will give to committee work and committees should always be composed of good workers.

During the past year the Committee of the Board on Personnel has made extraordinary efforts to work out the problem and has made progress in getting changes in personnel, but they need assistance from you as individuals both as to offers of service and suggestion of preferential service.

My opinion is that members should desire to obtain a varied committee service and occasionally shift from committee to committee to broaden their experience and to prevent autocracy in committee policy. A varied committee service is a splendid opportunity for the young man to grow in his profession beyond the confines or limited activities of his own particular branch of the service.

Committees can be too large and fail to function well on that account, but they can be too small as well, and can be composed of too limited a representation geographically and can be so greatly spread as to fail to obtain good attendance.

Committee organization is a very important matter, probably the most important of all, because that is the means by which our work is done.

I would urgently recommend the establishment of joint conference between the Committee of the Board on Personnel and the various Committee Chairmen, both at the beginning and end of the year, to perfect the committee organization. This seems to be the most effective way of developing the fitness of members for committee service and to coördinate the work of the several committees whose work is related.

The responsibilities upon the Committee on Personnel are rapidly increasing because of the growth of the Association and the tendency toward the greater technical character of the work and it needs the help of the working committee chairmen in counsel and suggestion.

To afford opportunities to a larger number of members to have a share in committee-work, it has been proposed to establish what might be termed "Corresponding Members" of committees. Many members of the Association are so situated geographically, or for other reasons, as to make attendance at committee meetings impracticable. Such members could nevertheless contribute materially to the value of committee-work by correspondence. The Board Committee on Personnel is giving the suggestion further thought.

Committee Service—Outline

Here also is an important phase of our work.

Two features of it I would specially mention—

(1) Coördinating the work of different committees whose subjects are inter-related, and

(2) Character of reports.

The first seems to become increasingly important as the subjects expand and one of the real difficult duties of the Board Committee on Outline of Work is to assign the subjects requiring coördination.

I believe one of the most effective ways to assign this work is for there to be, at the close of the Convention or soon thereafter each year, a joint conference of the Committee Chairmen and the Board Committee on Outline of Work and at the joint meeting perfect the plan for the year.

Such a method systematizes the work and obtains the benefits from conference in expression of views and will result in a clearer understanding as to what is wanted, and minimizes duplication of effort and recommendations.

The matter of character of reports is one which has caused concern to the Board on account of the rapidly increasing size of committee reports due to the natural expansion of the subjects and the increasing costs of reproduction.

The thought I try to convey is to consider the material collected during the research period and see if there cannot be a curtailment of volume without sacrificing the value of the report. It is a delicate and difficult thing to suggest anything that might be considered a plea to limit the scope of research and investigation and such is the farthest from our thoughts—I would only ask conservation in the reproduction of data by printed report until the final report is made and permit the progress data to remain in the Association files in the interim, but abstracted however in progress reports.

I believe too we have come to the point of doing more experimental work by sub-committee organization and less dependence be placed upon personal viewpoint in majority expression without actual supporting data from organized demonstration or test.

And in this connection I want to suggest that we avoid too great a speed in trying to conclude research for the purpose of definite recommendation, sometimes at a sacrifice of thoroughness. This is not said in criticism of past practice but to call attention to the increasing complication of the many questions before committees.

University Coöperation

During the year the Association was asked to send to the University of Illinois and Purdue University, committees to look over their facilities and methods with the ultimate idea that we might give such assistance as we could in the further development of their courses.

In accordance with that request such committees were appointed—did visit the Universities and reported favorably upon their work and methods.

These invitations permit the opportunity I have anticipated for some time to offer the recommendation that the Association should make systematic effort to establish and extend contact with technical schools. This is desirable not only for the purposes which have brought about the relations with those with whom we have had coöperation in committee-work, such as Impact Tests and Stresses in Track, but for the larger matters of University work in which we as future employers of Engineers are interested. I have no doubt that a definite and permanent contact of this kind will be of mutual benefit. I believe we can assist the University in occasionally showing the needs of the professional man for his business career. I believe we can give freely of the knowledge of our experience and in turn I believe the University will cheerfully give of their research facilities and some student help in some of our expermintal work.

Such contact can best be maintained probably by appointing committees of resident Alumni and charged with the duty of visiting the University once or twice a year and report upon the courses with which we are desirous of having a contact and let these committees be the means of developing the things which may be of mutual interest.

We should try to make the University feel that we come to them in a spirit of helpfulness solely in matters upon which they want practical help.

This I commend to you for serious consideration, feeling that it opens up a field of fruitful possibilities which will be of mutual benefit.

Offer of Assistance to the Interstate Commerce Commission in Accounting Matters

Your Board of Direction, realizing the increasing need and importance of correlating the Engineering and Accounting to the fullest degree in filling the requirements of the Commission, has tendered to the Interstate Commerce Commission the services of the Association in any manner or matter that may be within its power, which offer has been most cordially and appreciatively received.

The development of the Federal Valuation work has more prominently shown the interdependence of these Departments in perfecting accounting accuracy and the securing of proper cost data for the Engineer and Operating man.

In particular the enforcement of Order No. 3 has advanced and emphasized this need and I am hopeful out of this offer of assistance may come some new and constructive service for our Association committees. Our work heretofore has been confined mostly to a study of forms; matters of greater importance are confronting us of joint interest to both departments, not in trying to re-form the basic principle of Accounting, but to make them of greater value to both the Railroad and the Government, which under the new powers granted by Congress call for new data and measures.

The Interstate Commerce Commission has just asked us, by letter, to coöperate in the development of methods for charging Depreciation and their application to existing accounting rules.

I believe all concerned feel that in Accounting classification we have drifted into a class of detail which has bedimmed the light and caused us to lose the greater and broader view and that out of the coöperative study contemplated by our offer we can all be benefited in simplifying but making more useful the records of such great importance. I would urge that the offer we have made be aggressively followed up.

Coördination of Service with Other Committees

Through the activities of the American Railway Association, for whom we perform the work of the Engineering Division, there has been established already contact with the Mechanical Division and with the Purchases and Stores Division.

The work of correlating the study of Roadway and Track Structure with Motive Power and Equipment is of increasing interest and importance. The tendency of the past for these two Departments to work more and more independently has not been the ideal manner of procedure. Increasing wheel loads and the need for maximum clearances requires careful consideration as to the demands upon track, roadway and structures and likewise certain track and roadway details require consideration from the standpoint of equipment clearances.

Likewise Transportation conditions, changed as they are by new regulations as to hours of service, working conditions, the penalty from idle power, all call for new values to be ascribed to speeds, gradients, train loads, terminal delays, etc.—requiring greater coördination between the Engineering, Mechanical and Operating Divisions.

This coördination is made easier by reason of the present organization of the American Railway Association and should be encouraged.

Relations with Other Engineering Bodies

During the year the Association became a member of the Engineering Council, a federated body composed of the four founder societies and several other technical bodies, the purpose being to coöperate in matters affecting the welfare and progress of the profession and of interest to all Engineers. The Board felt that such affiliation was desirable and proper.

In the interim, however, a body of different origin and character has been proposed to take the place of Engineering Council and has been organized. The majority of the members of Engineering Council have voted to become members of the new body and by such action the greater elements of support were taken away from Engineering Council, rendering it inoperative.

The American Railway Engineering Association was invited to become a charter member, but having agreed to support Council, your Board felt it inexpedient to do so because it felt it could not commit your Association to the financial burden at this time and because it felt the plan of organization to be objectionable and by such action also urged that the Engineering Council be continued.

The opportunity to become a charter member was of limited duration but the way is still open for the Association to become a member and which action should be by a referendum vote if it appears desirable and financially possible to consider such connection.

New Problems Confronting the Association

I have briefly referred to new conditions surrounding the construction, maintenance and operation of railways as a result of the many changes of the past two or three years.

It is not necessary to discuss causes, but the practical effects—and their influence upon our work.

The Association has already sensed the need of giving relatively more attention to Economics and committee assignments for two or three years past embody prominent references thereto.

This necessity has increased by reason of the existing wage schedules and working conditions—whereby different values are given to the various operations of railway service.

These changes affect all activities and call for new formulae—new values and new ideals.

Greater costs of equipment with greater loss from idleness—higher values for speed against tonnage performance, where overtime is excessive—affecting grade revision economics and designs of terminals, both locomotive and yard.

Increased Per Diem needing higher average daily car movement—affecting design of yards and terminals, and track and line capacity.

Application of the shorter working day and the adverse and wasteful effect upon that class of work requiring the transportation of employees—affecting the study of organization and labor-saving devices as well as the matter of contracting repair work.

These things all must be related to transportation economics and developed coöperatively.

I want to take this opportunity to express upon behalf of the Board the splendid work and loyal support which you have given in the conduct of the year's work. The year has been a difficult one in many ways. The change from Federal control to private control meant a great deal of confusion in the reorganization of the railway service, particularly disturbing the work of the Engineering Department and your Association work has been done under hardships, but you have done well and I commend that service to my successor with a feeling of deep personal gratitude. [Applause.]

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

Secretary E. H. Fritch presented the following reports:

REPORT OF THE SECRETARY

March 15, 1921.

To the Members:

Pursuant to the requirements of the Constitution, a report covering the activities of the Association, in condensed form, is respectfully submitted:

Financial Statement

The detailed Financial Statement for the calendar year 1920 (Exhibit A) shows:

Receipts from all sources	$37,631.37
Disbursements	38,386.55
Excess of Disbursements over Receipts	$ 755.18
Investments and Cash Assets, January 1, 1921	$42,989.22

Publications

Ten numbers of the Bulletin and the annual volume of Proceedings were issued during the year.

The Proceedings for 1920 contain 1,500 pages, exceeding the volume of the preceding year by more than 500 pages of printed matter.

The Revised Manual

The republication of the Manual has been deferred until this year in order to include in the revision the important changes and additions submitted by the several Committees for action at this convention. The Manual will be issued as promptly as practicable after the annual meeting.

The revised Manual will contain the net results of the Association's work for the past twenty-two years. It is estimated the new volume will contain approximately one thousand pages.

Membership

The campaign for increasing the membership has resulted in the largest addition to the membership roll within a like period in the history of the Association.

Since the inauguration of the campaign—January 27, 1920—521 applications have been received. A portion of this increase was included in the report made last year.

The credit for this gratifying condition is due primarily to the earnest efforts of Mr. L. A. Downs, Chairman of the Special Committee on Increase of Membership; and, secondly, to the hearty coöperation of the individual members of the several roads.

The following is a report on the present membership of the Association:

Membership at last annual meeting			1,638
Deceased members	18		
Resignations and dropped	33		
		51	
Additions during the year		364	
Net gain			313
Total membership March 1, 1921			1,951

Deceased Members

Eighteen members were lost by death during the year, as follows:

O. W. Albee, Consulting and Inspecting Engineer, Detroit, Mich.

Sir James B. Ball, Chief Engineer, London, Brighton & South Coast Railway, London, England.

Major W. A. Cattell, Consulting Engineer, San Francisco, Cal.

P. S. Hildreth, Consulting Engineer, New York City.

A. S. Markley, Master Carpenter, Chicago & Eastern Illinois Railroad, Danville, Ill. (Charter Member.)

W. H. Moore, Engineer of Structures, New York, New Haven & Hartford Railroad, New Haven, Conn.

John G. Shillinger, Chief Engineer, Rutland Railroad, Rutland, Vt.

Major A. T. Tomlinson, Canadian Military Service, Lindsay, Ont., Can.

William Travers, Division Engineer, Oregon Short Line, Pocatello, Idaho.

J. W. Wilkinson, Office Engineer, New York, Chicago & St. Louis Railroad, Cleveland, Ohio.

Paul L. Wolfel, formerly Chief Engineer, American Bridge Company, Pittsburgh, Pa.

R. C. Sattley, Valuation Engineer, Chicago, Rock Island & Pacific Railway, Chicago.

E. S. Draper, Principal Assistant Engineer, Boston & Albany Railroad, Boston, Mass.

T. H. Hickey, Inspector Track, Michigan Central Railroad, Detroit, Mich.

L. J. Putnam, Chief Engineer, Chicago & Northwestern Railway, Chicago.

G. W. Vaughan, Engineer Maintenance of Way, New York Central Railroad, New York. (Charter Member.)

T. H. Sears, General Superintendent, Atchison, Topeka & Santa Fe Railway, Amarillo, Texas.

E. V. Smith, Superintendent, Baltimore & Ohio Railroad, Wheeling, W. Va.

Approval of Recommendations by American Railway Association

Following the precedent established in 1919, the subjects acted on at the 1920 convention of your Association were transmitted to the American Railway Association for endorsement at its annual session in November, 1920.

The subjects receiving the endorsement of the American Railway Association at that session are as follows:

(a) Proper depth of ballast.

(b) Form for cross-tie statistics.

(c) Specifications for carbon steel rail; rail sections—90-lb.; 100-lb.; 110-lb.; 120-lb.; 130-lb. and 140-lb.; standard drilling of rails.

(d) Plans for frogs, switches and fixtures; specifications—design and dimensions of manganese steel-pointed switches; cut track spike; screw track spike; steel tie-plates; wrought-iron tie-plates; malleable iron tie-plates; relayer rail for various uses.

(e) Lighting of passenger station interiors, surroundings and platforms; toilet facilities at small stations where water supply and sewers are lacking.

(f) Specifications for plain and reinforced concrete and for steel reinforcement; methods of depositing concrete under water.

(g) Approach warning sign on public highways.

(h) Forms for reporting progress in construction and maintenance work; authority for expenditure; monthly report of expenditures; final record cost of work.

(i) Rules for inspection of bridges, trestles and culverts.

(j) Definitions of terms used in railway water service; water service organization; impounding reservoirs for railway purposes; water meters for railway water service; specifications for wooden water tanks; specifications for tank hoops.

(k) Rules for the location, maintenance, operation and testing of railway track scales.

(l) Specifications for steel railway bridges; column formula.

(m) Curve resistance—freight cars.

(n) Specifications for preservative treatment of wood—creosote oil and zinc-chloride; demarcation line between the use of creosoted and zinc-treated ties.

Joint Committee on Automatic Train Control

A joint committee composed of twenty railroad officials, representing the Operating, Engineering, Signal and Mechanical Departments, has been appointed by the American Railway Association to study and report on automatic train control devices, and, in coöperation with the Bureau of Safety of the Interstate Commerce Commission, to work out the details of a practical plan for carrying out the provisions of the Interstate Commerce Act. Ten members of your Association are members of this joint body.

Monographs

A series of valuable and interesting monographs were contributed to the Bulletin during the past year. It is hoped that members having suitable material will favor the Association with the data for publication in future Bulletins.

Among the special articles published in recent months are the following:

"The Standing Committees of the Association"—by J. L. Campbell (Bulletin 227, July, 1920).

"Greater Application of Recommended Practice to Individual Railroads"—by C. A. Morse (Bulletin 227, July, 1920).

"Some Essential Features of Committee Organization"—by Hadley Baldwin (Bulletin 227, July, 1920).

"Increasing the Value of the Work of the Association"—by E. E. R. Tratman (Bulletin 227, July, 1920).

"The Relative Merits of Metal Versus Wooden Ties"—Special Report of Committee on Ties (Bulletin 227, July, 1920).

"The Leaching of Zinc Chloride from Treated Wood"—by Ernest Bateman (Bulletin 227, July, 1920).

"Committee Work—Its Value to the Individual"—by E. H. Lee (Bulletin 228, August, 1920).

"Committee Work"—by Edwin F. Wendt (Bulletin 228, August, 1920).

"The Value of Varied Committee Service as an Educational Feature"—by Edwin F. Wendt (Bulletin 228, August, 1920).

"The Function of the Association in Coördinating the Work of the Transportation and Engineering Departments in the Design and Use of Facilities"—by J. M. R. Fairbairn (Bulletin 228, August, 1920).

"More General Use of Recommended Standards by Railroad Companies"—by A. S. Baldwin (Bulletin 228, August, 1920).

"Rules and Unit Stresses for Rating Existing Bridges"—by Warrick R. Edwards (Bulletin 228, August, 1920).

"Discussions of Specifications for Movable Bridges"—by Committee on Iron and Steel Structures (Bulletin 228, August, 1920).

"The Manual"—by Edwin F. Wendt (Bulletin 229, September, 1920).

"Superpower Survey Under Way"—by William S. Murray (Bulletin 229, September, 1920).

"Manual of Instructions for the Guidance of Engineering Field Parties"—by H. H. Edgerton (Bulletin 229, September, 1920).

"The Manual"—by C. P. Howard (Bulletin 230, October, 1920).

"Note on Rail Inclination"—by W. C. Cushing (Bulletin 235, March, 1921).

"Rail Laying with Locomotive Cranes"—by W. C. Barrett (Bulletin 235, March, 1921).

Coöperation with Other Organizations

Your Association has continued to actively coöperate with other technical bodies in the study of problems of mutual interest. The extent and scope of such coöperation has been clearly and comprehensively set forth in the address of the President.

Committee Reports

The reports of the twenty-five Standing and Special Committees have been printed and distributed to the membership in advance of this meeting.

The quality of the several reports is fully up to the high standard of former years. The reports presented for your consideration form a valuable contribution to the common fund of knowledge.

The Chairmen, Vice-Chairmen and members of Committees deserve credit for their good work.

Respectfully submitted,

E. H. Fritch, Secretary.

Exhibit A

FINANCIAL STATEMENT FOR CALENDAR YEAR ENDING DECEMBER 31, 1920

Balance on hand January 1, 1920 .... $43,744.40

RECEIPTS

Membership Account	
Entrance Fees	$ 4,070.00
Dues	8,168.75
Subscription to Bulletins	8,168.75
Binding Proceedings and Manual	781.45
Badges	41.00
Sale of Publications	
Proceedings	2,695.60
Bulletins	1,127.88
Manual	360.95
Specifications	323.00
Leaflets	14.15
General Index	24.75
Advertising	
Publications	2,883.10
Interest Account	
Investments	1,677.50
Bank Balance	97.38
Annual Meeting	
Sales of Dinner Tickets	1,136.00
Miscellaneous	102.31
American Railway Association	
Rail Committee	5,958.80
Total	$37,631.37

DISBURSEMENTS

Carried forward:

Balance on hand January 1, 1920		$43,744.40
Salaries	$ 6,373.75	
Proceedings	6,621.24	
Bulletins	10,176.06	
Manual	23.80	
Stationery and Printing	1,344.56	
Rents, Light, etc.	850.00	
Telegrams and Telephone	27.41	
Equipment	89.10	
Supplies	126.19	
Expressage	579.11	
Postage	941.72	
Exchange	84.00	
Committee Expenses	57.97	
Officers' Expenses	48.60	
Annual Meeting Expenses	1,726.23	
Refunds Dues Account Duplicate Payments, etc.	44.00	
Audit	150.00	
Engineering Council	1,099.77	
Contribution to Joint Committee on Reinforced Concrete	100.00	
Rail Committee	7,681.95	
Miscellaneous	241.09	
Total	$38,386.55	
Excess of Disbursements over Receipts		$ 755.18
Balance on hand, December 31, 1920		$42,989.22

Conissting of:

Bonds	$40,565.65
Cash in S. T. & S. Bank	1,752.97
Cash on hand	645.60
Petty Cash	25.00
	$42,989.22

Exhibit A1

STRESSES IN TRACK FUND

Balance on hand January 1, 1920		$ 1,036.29
Received from interest during 1920		28.36
		$ 1,064.65
Disbursements:		
Transportation	$ 8.20	
Hotel and Meals	2.40	
Supplies	99.20	$ 109.80
Balance on hand in Standard Trust and Savings Bank, December 31, 1920		$ 954.85

Respectfully submitted,

BOARD OF DIRECTION.

REPORT OF THE TREASURER

Balance on hand January 1, 1920		$43,744.40
Receipts during 1920	$37,631.37	
Paid out on audited vouchers, 1920	38,386.55	
Excess of disbursements over receipts		$ 755.18
Balance on hand December 31, 1920		$42,989.22

Consisting of:

Bonds	$40,565.65
Cash in S. T. & S. Bank	1,752.97
Cash on hand	645.60
Petty Cash	25.00
	$42,989.22

STRESSES IN TRACK FUND

Balance on hand January 1, 1920	$ 1,036.29
Received from interest during 1920	28.36
Total	$ 1,064.65
Paid out on audited vouchers during 1920	109.80
Balance on hand December 31, 1920	$ 954.85

The Securities listed above are in a safety deposit box of the Merchants' Loan & Trust Safe Deposit Company, Chicago.

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, 1920, and find them in accordance with the foregoing financial statements.

CHARLES CAMPBELL,
Auditor.

GENERAL BALANCE SHEET

December 31, 1920

	1920	1919
ASSETS		
Due from Members	$ 3,865.85	$ 3,142.00
Due from Sale of Publications	542.67	542.27
Due from Advertising	495.00	985.00
Due from American Railway Association	2,300.12	575.97
Due from American Railway Express Co., Claim.	250.00	250.00
Furniture and fixtures (cost)	997.40	997.40
Gold Badges	49.00	73.50
Publications on hand (estimated)	6,000.00	6,000.00
Extensometers	500.00	500.00
Investments (cost)	40,565.65	40,565.65
Interest on Investments (accrued)	896.84	739.99
Cash in Standard Trust and Savings Bank	1,752.97	2,977.83
Cash in Secretary's Office	645.60	175.92
Petty Cash Fund	25.00	25.00
Total	$58,886.09	$57,550.53
LIABILITIES		
Members Dues paid in advance	$ 1,539.45	$ 2,272.50
Impact Test Fund on Electrified Railways	285.46	285.46
Advertising paid in advance	60.00	
Due for Printing	7,679.52	1,845.00
Due for Expressage	270.89	183.67
Due for Miscellaneous		39.00
Surplus	49,050.77	52,924.90
Total	$58,886.09	$57,550.53

On motion of Mr. L. A. Downs, the reports of the Secretary and of the Treasurer were approved.

The President:—We have a large program ahead of us for these three days, and I would like to urge that the members be in their places promptly at the designated time for convening, that our discussion of the reports be to the point—I hesitate to say brief, as we do not want to restrict the discussion in the slightest, but we should confine our discussion to the relevant features, and continue the practice which has been established some years back to avoid discussion of definitions and minor matters, such as punctuation and things of that kind.

It will help the record of the convention very much, as well as the other members, if each speaker upon rising will give his name and the railroad with which he is connected.

The Chair would also call attention to the fact that this meeting is considered as a concurrent meeting, as far as its work is concerned, of the Engineering Division of the American Railway Association, and the results and recommendations as affecting practice will be submitted as the work of the Division to the Board of Directors of the American Railway Association.

The first report to be presented is that of the Committee on Signals and Interlocking, Mr. W. J. Eck, Chairman.

(For report, see pp. 65-74.)

The President:—The Ballast report will be presented by the Chairman, Mr. H. L. Ripley.

(For report, see pp. 75-106.)

The President:—The Committee on Entertainment request me to say they are in a receptive mood for the sale of tickets for the dinner tomorrow night, and are anxious that reservations should be made as quickly as possible so that they may give the hotel a proper estimate. The Committee has made an effort to have an unusually good dinner this year, with good entertainment, and it is hoped that the subscription list will be large.

The Chair will call attention, as usual, to the exhibit at the Coliseum, which we understand to be equal to, if not better than, any other previous exhibit, and we urge the members some time during their visit here to spend a little time there. It is expected that the session can be closed this afternoon a little earlier, so as to give you an opportunity for attendance to-day in the latter part of the afternoon.

I am asked to announce a special luncheon of the Purdue Alumni Association in honor of the Purdue men and members of the faculty attending the convention, which will be held at the University Club tomorrow (Tuesday) at 12:45.

The President:- The report on Electricity will be submitted by Mr. Edwin B. Katte, Chairman.

(For report, see pp. 109-196.)

AFTERNOON SESSION

The President:—Prof. A. N. Talbot, Chairman, will present the report on Stresses in Railroad Track.

(For report, see page 107.)

The President:—The report of the Track Committee will be presented by the Chairman, Mr. W. P. Wiltsee.

(For report, see pp. 649-694.)

The President:—In the absence of the Chairman and Vice-Chairman of the Rail Committee, the report will be presented by Mr. J. M. R. Fairbairn.

(For report, see pp. 197-234.)

WEDNESDAY, MARCH 16, 1921

MORNING SESSION

The President:—The report on Standardization will be presented by the Chairman, Mr. E. A. Frink.

(For report, see pp. 243-246.)

(Vice-President Campbell in the Chair.)

The Vice-President:—In the absence of the Chairman, the Vice-Chairman, Mr. C. A. Wilson, will present the report on Uniform General Contract Forms.

(For report, see pp. 247-266.)

(President Safford in the Chair.)

The President:—The report on Signs, Fences and Crossings will be presented by the Chairman, Mr. Arthur Crumpton.

(For report, see pp. 267-314.)

The President:—At this point we will depart from the program for a few moments to welcome a gentleman I see in the audience who has honored this meeting and this Association by his acceptance of our invitation to attend. He has honored this Association in being here, and also in being largely instrumental in extending an invitation to us to send a committee to the University which he represents and of which you have all been informed. This committee visited the University and spent a day of extreme interest in looking over the plant and the methods employed, and were particularly impressed by a number of things which he has undertaken to do which makes for a broader and better engineering course and that means a greater asset to a business of this kind. I have a great deal of pleasure in introducing Prof. A. A. Potter of the School of Engineering of Purdue University, and will ask him to come to the platform and make a few remarks on the subject which I may not give a proper title to, but I believe it may be called "The Humanizing of the Engineering Profession."

Dean A. A. Potter:—Mr. Chairman and Gentlemen, I greatly appreciate this privilege of coming before the members of the American Railway Engineering Association in order to bring before them in a few words some of the ideas which educators in the United States are at present carrying out in connection with the problem of humanizing engineering education.

The engineering schools of this country can be of greatest service to the American Railway Engineering Association and to the industries of the country by constantly improving their methods of instruction and by carrying on researches and experiments which are of value to the railroads and other industries of the country.

In connection with engineering education, best results are produced by the teaching of men and not subjects. This means great attention should be paid to the testing and sorting of students before they are assigned to any particular course of study and that their progress must be very carefully watched.

More attention should be given to the teaching of students how to study and how improve their personal efficiency. They should be rated not only on their academic performance, but also on personal traits. Every effort should be exerted to develop not only their memory, but also their knowledge of technique, and such traits of personality as initiative, judgment, leadership and other qualities which are so essential for success in engineering and in industry.

At Purdue University we feel that we ought to pay more attention to the younger students, to the young high school graduates when they enter the University as freshmen.

It is recognized by us that failure on the part of the student to carry a certain subject may not be due entirely to his indifference, but may be caused by poor teaching or because the student is not interested in the subjects which he is studying. In order to correct this, engineering schools at the present time are introducing in the freshmen year certain subjects which are very closely related to engineering. At Purdue we are giving to every freshman student a course in engineering problems, by the medium of which we are trying to acquaint the freshman student with certain engineering problems of particular interest to his community. In this course he solves problems dealing with pavements, roads, water supply, sewage disposal, power generation and transmission, manufacturing processes, etc. To teach a student how to use a level and how to read a topographical map does not require advanced mathematics.

We also find it desirable to make modern languages elective for the reason that many students who decide to study engineering are of the analytical turn of mind and do not like to substitute memory for thought. The student has an opportunity to pursue either modern languages or other subjects which are equally valuable from the educational standpoint, and which at the same time prove of greater interest to him in his course.

We are greatly interested in stimulating the college student to good work by giving recognition to his efforts and by rewarding him. We are all familiar with the effect of publicity upon athletics. We all know the effect upon athletics by having space given to athletic events in the dailies, by having the pictures of the contestants appear in the paper—we know what a great stimulus that type of publicity gives to athletics. It seems to some of us that if a student is relegated to the brain squad, the results of his studies should be given some publicity. We have found from experience that the Associated Press will accept articles concerning such matters as eagerly as they accept articles concerning athletics. If a student excels in surveying, science, mechanics, drawing, mathematics, or in any other subject, we make it a point to send a little story about it to his home paper, as well as to the college paper. We find that type of publicity is of great advantage in keeping the student interested in doing good work.

We are also making a very careful study of the student's character and personality and are having our students graded on accuracy, application, attitude, coöperation, courtesy, efficiency, initiative, judgment, leadership, habits of work, outlook, tact, dependability and other qualities not only by their teachers, but by their chums, classmates and people in their home towns. We are using this information to some extent in advising the student concerning the selection of the course of study.

We feel that the efforts I have mentioned should tend to stimulate the student's interest in his work and to better prepare him for the engineering profession. [Applause.]

The President:—I am sure we have all enjoyed and appreciated Dean Potter's remarks. As I said before, whatever is done to develop and expand the engineering courses in our schools means ultimate value for us.

The report of the Tie Committee will be presented by Mr. F. R. Layng, Chairman.

(For report, see pp. 315-374.)

The President:—The report on Iron and Steel Structures will be presented by the Chairman, Mr. O. E. Selby.

(For report, see pp. 375-404.)

The President:—The Chair will announce the following appointees for Tellers for the election of officers. They are asked to meet with Mr. Fritch immediately after the close of this session: A. M. Van Auken, Walt Dennis, J. J. Baxter, Wm. E. Hawley, C. H. Spencer, Noah Johnson, H. S. Blake.

AFTERNOON SESSION

(The consideration of the report on Iron and Steel Structures was resumed.)

The President:—The report of the Water Service Committee will be submitted by the Chairman, Mr. A. F. Dorley.

(For report, see pp. 405-441.)

(Vice-President Downs in the Chair.)

The Vice-President:—The report of the Committee on Economics of Railway Labor will be presented by the Chairman, Mr. C. E. Johnston.

(For report, see pp. 235-242.)

(President Safford in the Chair.)

The President:—The report of the Committee on Economics of Railway Operation will be presented by the Chairman, Mr. L. S. Rose.

(For report, see pp. 723-792.)

The President:—The report of the Committee on Economics of Railway Location will be submitted by the Chairman, Mr. C. P. Howard.

(For report, see pp. 565-584.)

The President:—The Tellers appointed at the morning session have just made their report. The Chair will announce the result of the election of officers:

President, L. A. Downs.

Vice-President, E. H. Lee.

Secretary, E. H. Fritch.

Treasurer, G. H. Bremner.

Directors, C. F. W. Felt, G. J. Ray, Col. Geo. H. Webb.

Nominating Committee, J. R. W. Ambrose, R. H. Ford, E. A. Hadley, J. V. Neubert, A. F. Robinson.

The President:—The report of the Committee on Shops and Locomotive Terminals will be presented by the Chairman, Mr. F. E. Morrow.

(For report, see pp. 585-647.)

THURSDAY, MARCH 17, 1921

MORNING SESSION

The President:—The Chair desires to express very deep regret, and I know that the members of the Association join in that feeling, in announcing that Dr. Frank W. Gunsaulus, who was to be at our dinner last night for the invocation, died this morning at 4:30 o'clock. It was a matter of great regret that he could not be with us last night, and a matter of greater regret to know that he has passed away.

The report of the Committee on Buildings will be presented by Mr. W. T. Dorrance, Chairman.

(For report, see pp. 843-888.)

The President:—The report of the Masonry Committee will be submitted by the Chairman, Mr. J. J. Yates.

(For report, see pp. 543-564.)

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

(For report, see pp. 695-722.)

The President:—The report on Wood Preservation will be submitted by the Chairman, Mr. C. M. Taylor.

(For report, see pp. 443-480.)

The President:—I have asked to take a seat on the platform, so that he may see the operation of the convention from this side of the room, the Honourable William Renwick Riddell, who so pleasantly entertained us last night at dinner. The Justice explained to us last night that he intended to be a Civil Engineer, that he graduated as such, and reformed early in life and took up the law, and thereby I am satisfied from what I have seen of him that this profession lost a very valued member. He is a lawyer, but I charge you that you need not be fearful of expressing yourselves before him, as I understand there is no danger of the evidence being used against you.

Hon. Mr. Justice William Renwick Riddell:—Mr. President and Brother Engineers: It has been a very great delight to me to be at this meeting even for the short time I have been able to attend your sessions. The subjects of your discussions and the discussions themselves are of very great interest and value to my country, and of peculiar interest, and I may say also of peculiar value to myself at the present time. Whether by reason of the fact that I am supposed to be a mathematician and once was very nearly an Engineer—only that an inscrutable dispensation of Providence shoved me off the track, there being no guard rail—for some reason I was recently appointed the presiding officer of a Royal Commission in the Province of Ontario, for the purpose of examining into our timber resources; and we have found (amongst other things) an alarming diminution of the available tie timber, with which a great part of our Province was originally clothed. To come to particulars, we found that ties are selling for $1.75 and $1.90; though I have known of hundreds of thousands being sold for 30 cents or less. We have been and are particularly interested in the subject which you have just been discussing, and it has been of advantage to me that I had the pleasure of hearing some of the discussion—I hope to be able to read your transactions, which I have not done in the past, and to avail myself of the great and exact technical knowledge which your members have and have displayed.

The objection of my friend, Mr. Mountain, to certain words in a particular definition, reminds me of a story; and as last night I was not permitted to tell stories, being personally conducted to speak on a serious subject, perhaps I may be permitted to tell you one this morning.

There was a fish dealer who put a magnificent sign over his fish shop, "Fresh fish sold here"; a friend came along and he said to him, "What do you think of my sign?" He answered, "I do not think much of it. Are you advertising somebody else's shop or your own? Of course they are sold here. What is the sense of having that word 'here' on the sign?" The fishman agreed, and "here" was marked out. The next day the man came along and the fishman asked him, "What do you think of the sign now?" "Why do you say 'fish are sold'? Of course you are not giving them away; of course they are sold." So off came the "sold." The next day the man came along again and saw the sign, "Fresh fish." He said, "Nobody supposed they were rotten," and off came "fresh." The next day the man was asked, "What about the sign now?" For answer the friend held his nose, and said: "By heavens! you don't need to have any sign at all."

Early in my student career I learned the Latin maxim, *"Ne sutor ultra crepidom,"* which translated into English means "Shoemaker, stick to your last"; and therefore being only a lawyer, and not a practicing Engineer, God forbid that I should advise you in any of your proceedings.

Gentlemen, I thank you for listening to me as you have, and thank you for the invitation to be here, and thank you for the kindly and courteous manner in which you received me last evening. Had it not been kindly, I should have been disappointed and would have had a new experience in the United States of America. I cannot help but think, as I said last night, we are all one people, a little different in our manner of government, a little different in our international relations and allegiance, and a little different sometimes in our pronunciation; but after all we all speak the English language—at least we do, and I know you think you do, which again reminds me of another story, and this will be the very last. The second offense may be pardoned, but I know a third offense is always fatal. There was a young lady from Maine visiting in Boston, who was taken around by her friends to see the beauties of the city, paintings and otherwise. When, in looking at the mural paintings, she insisted in calling them mooral paintings, her Boston friends said, "Don't say mooral; that u sounds 'mu' as in 'cat.'" The difference between you and us, after all, is just "mu" as in cat. [Applause.]

The President:—The report of the Committee on Wooden Bridges and Trestles will be presented by the Chairman, Mr. W. H. Hoyt.

(For report, see pp. 481-542.)

AFTERNOON SESSION

(The consideration of the report on Wooden Bridges and Trestles was concluded.)

The President:—The report of the Committee on Yards and Terminals will be presented by the Chairman, Mr. B. H. Mann.

(For report, see pp. 889-900.)

The President:—The report of the Committee on Rules and Organization will be submitted by the Chairman, Mr. W. C. Barrett.

(For report, see pp. 793-841.)

The President:—Mr. H. M. Stout, Chairman of the Committee on Records and Accounts, will present the report of the Committee.

(For report, see pp. 901-924.)

The President:—The report of the Committee on Conservation of Natural Resources will be submitted by the Chairman, Mr. W. F. Ogle.

(For report, see pp. 925-940.)

The President:—In dismissing this Committee, I think it quite proper to express, on behalf of the Board, appreciation for the character of the reports that were submitted here this year, the manner in which they have been presented, and to say that this is the first Convention, I believe, in the history of the Association where no work was turned back by the Association. There was one part of a report which was voluntarily taken back by a Committee, but I believe this is the first time that the committee-work has been adopted in entirety.

The Committee on Outline of Work are anxious that the membership should undertake during the coming year to a greater extent than ever before constructive criticism by letter, as well as in committee service.

This concludes the work of presenting the Committees' reports, and the meeting is now open for New Business, if there be any.

Mr. A. S. Baldwin (Illinois Central):—Mr. President, I have a resolution that I desire to offer:

> "*Resolved,* That the members of the American Railway Engineering Association, in convention assembled, desire and do hereby place on record their appreciation of the admirable manner in which this Convention has been presided over by Mr. H. R. Safford, 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 this meeting, and an engrossed copy be presented to Mr. Safford."

(Motion duly seconded, put to a vote by President-Elect Downs, and adopted by a rising vote.)

The President:—Gentlemen, I greatly appreciate the resolution, but the success of this meeting rests with the floor, not with the Chair. I appreciate especially the large attendance that we have had this year, and I especially appreciate the interest that has been taken in the discussions, and as I go out of office I can say that every minute this past year will create a memory of pleasure. Thank you.

Mr. J. R. W. Ambrose (Toronto Terminals Railway) :—Mr. President, I move you the following resolutions:

> "*Resolved*, By the American Railway Engineering Association, in convention assembled, that its thanks are hereby extended to the Honourable William Renwick Riddell, Doctor David Kinley, and John Findley Wallace, Esq., for their excellent addresses at the Annual Dinner on the evening of March 16th;
>
> "To the Chairmen, Vice-Chairmen and members of the several committees for their labors during the past year and for valuable reports presented to the meeting;
>
> "To the Committee on Arrangements for the splendid manner in which all arrangements for the convention have been carried out;
>
> "To the Technical Press for courtesies extended during the year and also during the convention;
>
> "To the National Railway Appliances Association for the comprehensive and instructive exhibit of railway devices used in the construction, operation and maintenance of railways, and for courtesies extended to the officers and members of the Association."

(The resolutions were seconded, put to vote, and carried unanimously.)

The President:—Is there any other new business to be introduced? The Chair will again announce the officers who were elected yesterday:

REPORT OF THE TELLERS

To the Members:

We, the Tellers appointed to canvas the ballots for the election of officers for the ensuing year, report the following result:

President:

L. A. Downs	1,094
E. A. Frink	1

Vice-President:

E. H. Lee	1,093
C. F. W. Felt	1
J. L. Campbell	1

Secretary:

E. H. Fritch	1,095

Treasurer:

G. H. Bremner	1,095

Directors (Three to be elected):

A. M. Burt	388
C. F. W. Felt	598
J. V. Hanna	209
F. G. Jonah	345
B. H. Mann	189
G. J. Ray	556
A. O. Ridgway	133
H. L. Ripley	383
Geo. H. Webb	410
L. L. Beall	2
J. R. W. Davis	1

Members Nominating Committee (Five to be elected):

J. R. W. Ambrose	623
R. H. Ford	563
E. A. Hadley	724
C. P. Howard	414
R. H. Howard	461
C. E. Johnston	417
A. Montzheimer	444
J. V. Neubert	542
Frank Ringer	360
A. F. Robinson	661
Scattering	14

Respectfully submitted,

A. M. VanAuken, *Chairman;*
Walt Dennis,
J. J. Baxter,
Wm. E. Hawley,
C. H. Spencer,
Noah Johnson,
H. S. Blake,

Tellers.

I will ask Mr. Morse and Mr. Baldwin if they will be good enough to escort the incoming President to the platform.

(President-Elect L. A. Downs was escorted to the platform.)

The President:—Mr. Downs, you have been unanimously elected by this Association President for the coming year. You may take that to be a recognition of good service, and you may take it also to be an expression of confidence in your ability to direct the work of this body in a successful manner, about which there could be no doubt. It is a pleasure to me to turn over to you the symbol of your office, and in doing so I want to say to you that your success is going to depend a great deal upon your own efforts, true, but it depends a great deal upon the support of your associates, and I can assure you from an experience of one year that that support is always to be had, and it has been helpful in this, the most successful meeting we have ever had. I am glad to present you with the symbol of your office and to say that I am at your service at any time in any way possible.

(President Downs assumed the chair.)

President Downs:—Mr. Safford and Gentlemen: I appreciate more than I can tell you the honor conferred upon me in electing me President of this Association. I cannot let the opportunity go by without mentioning how closely Mr. Safford's and my life has been associated. We were born in the same State, less than a hundred miles apart, less than two years apart. We were college boys together, we were rodmen together, transitmen together, Assistant Engineers together. We were Roadmasters together for a number of years on the same railroad, and neither one of us thought we would ever get away from it.

We finally got to the head of the Maintenance of Way Department on the Illinois Central Railroad. I say "we." Mr. Safford was Chief Engineer and I was the Top Sergeant. We then separated in 1910, and for four years now we have both been Directors of this Association.

I mention all these things from the fact that now we have passed through the best year the Association has ever had, with its peak in attendance. I feel that the coming year, with the inspiration of the long history behind the Association, that I will do nearly as well as my predecessors. I assure you that I will serve you to the best of my ability.

If there is no further business, the Twenty-second Annual Meeting of the American Railway Engineering Association has now come to a close.

(Thereupon the Twenty-second Annual Convention of the American Railway Engineering Association adjourned *sine die.*)

The Twenty-third Annual Convention of the American Railway Engineering Association will be held at the Congress Hotel, Chicago, March 14, 15 and 16, 1922.

E. H. Fritch,
Secretary.

COMMITTEE REPORTS

REPORT OF COMMITTEE X—SIGNALS AND INTERLOCKING

W. J. Eck, *Chairman;*
Azel Ames,
H. S. Balliet,
A. M. Burt,
C. E. Denney,
F. L. Dodgson,
W. H. Elliott,
G. E. Ellis,
J. G. M. Leisenring,
H. K. Lowry,
W. M. Vandersluis, *Vice-Chairman;*
J. C. Mock,
F. P. Patenall,
J. A. Peabody,
A. H. Rudd,
A. G. Shaver,
T. S. Stevens,
B. Wheelwright,
E. E. Worthing,

Committee.

To the American Railway Engineering Association:

The following subjects were assigned the Committee on Signals and Interlocking for study and report:

1. Make thorough examination of the subject-matter in the Manual, and submit definite recommendations for changes.

2. Report on colors for signals.

3. Report on the specifications adopted by the Signal Section of the Engineering Division of the American Railway Association which warrant endorsement, conferring with Committees on Track, Buildings, Iron and Steel Structures, and other appropriate committees, on appliances affecting track or structures.

4. Report on the desirability of providing in connection with an automatic signal system:

(a) An overlap or preliminary section.

(b) Approach restricting speed indications.

5. Report on the various types of light signals for day and night indications.

6. Make final report, if practicable, on the feasibility of separating into distinct types of their own signals for train operation and the markers or signs which indicate the location or position, or both, of information signs and switch signs for conveying information to trainmen, and designs suitable for day and night (if necessary), markers or signs for switches, derail switches, stop signs, slow signs, resume speed signs, water station and trackpan markers, highway crossing signals, etc.

7. Report on requisites of signal locations for automatic block signals for single-track roads.

8. Report on automatic train control.

9. Report on the extent to which methods are in use for short-circuiting track circuits for the display of signals for the protection of track workers.

10. (a) Report on application of aspect indicating that train must take siding at a non-interlocking switch.

(b) Report on application of aspect indicating that "19" or "31" orders are to be delivered.

(A)

13. Study and report on the subject of proper time interval for the release of electrical and mechanical devices, applied to signal or switch apparatus.

16. Report on the effect of electrical locomotive headlights on signals.

Committee Meetings

Meetings of the Committee were held in Chicago on April 15th, and September 16th, with practically the entire personnel of the Committee present at each meeting.

(1) Revision of Manual

In Appendix A proposed changes in the Manual are given.

(8) Automatic Train Control

In Appendix B Committee submits extracts from the report of the Automatic Train Control Committee of the United States Railroad Administration as information. Its recommendations are given under the heading of Conclusions.

(9) Methods for Display of Signals for Protection of Track Workers

In Appendix C the Committee submits the results of its study on the subject of methods for display of signals for protection of track workers. Its recommendations are given under the heading of Conclusions.

(13) Time Releases Applied to Signal or Switch Apparatus

In Appendix D the Committee submits the results of its study on the proper time interval for releases applied to Signal or Switch Apparatus. Its recommendations are given under the heading of Conclusions.

PROGRESS REPORT

The Committee reports progress on subjects:

(2) Report on colors for signals.

(3) Report on the specifications adopted by the Signal Section of the Engineering Division of the American Railway Association which warrant endorsement, conferring with Committees on Track, Buildings, Iron and Steel Structures, and other appropriate committees, on appliances affecting track or structures.

(4) Report on the desirability of providing in connection with an automatic signal system:

(a) An overlap or preliminary section.

(b) Approach restricting speed indications.

(5) Report on the various types of light signals for day and night indications.

(6) Make final report, if practicable, on the feasibility of separating into distinct types of their own signals for train operation and the markers or signs which indicate the location or position, or both, of information signs and switch signs for conveying information to trainmen, and designs suitable for day and night (if necessary), markers or signs for switches, derail switches, stop signs, slow signs, resume speed signs, water station and trackpan markers, highway crossing signals, etc.

(7) Report on requisites of signal locations for automatic block signals for single track roads.

(10) (a) Report on application of aspect indicating that train must take siding at a non-interlocking switch.

(b) Report on application of aspect indicating that "19" or "31" orders are to be delivered.

(16) Report on the effect of electrical locomotive headlights on signals.

CONCLUSIONS

1. The Committee recommends that the changes in the Manual in Appendix A be approved and the revised matter be substituted for the present recommendations in the Manual.

2. The Committee recommends that the matter shown in Appendix B be accepted as information.

3. The Committee recommends the following for approval and publication in the Manual on the subject of methods for display of signals for protection of track workers:

(1) If temporary protection by signal is desired for track workers or for dangerous track conditions it should be provided by disconnecting the signal circuits so that the proper indication will be displayed. Disconnections should be made by signal forces.

(2) If permanent arrangements are desired for protection, by signal, of track workers or for dangerous track conditions, this may be provided by:

(a) Opening track relay through knife switch.

(b) Opening circuit wires through circuit controllers.

(c) Shunting track by circuit controller or knife switch.

(3) Information may be provided by means of indicators to advise track workers of the approach of trains.

NOTE.—On an emergency a shunt wire with clips to attach to bond wires may be used, provided prompt action is taken thereafter to arrange for proper disconnection as prescribed.

4. The Committee recommends the following for approval and publication in the Manual on the subject of Time Releases Applied to Signal or Switch Apparatus:

For average conditions the proper time interval for the release of electrical and mechanical devices applied to signal and switch apparatus should be the time required for a train running thirty miles per hour to travel from a point 1000 feet before reaching the distant signal to a point 10 feet beyond the home signal.

In interpreting and applying this recommendation, it should be distinctly understood that it is only a guide and that the particular local conditions must, in the final analysis, govern the determination of this time interval.

Recommendations for Future Work

The Committee recommends the continuation of Subjects 1, 2, 3, 4, 5, 6, 7, 8, 10 and 16.

Respectfully submitted,

THE COMMITTEE ON SIGNALS AND INTERLOCKING,

W. J. ECK, *Chairman.*

Appendix A

(1) REVISION OF MANUAL

W. M. Vandersluis, *Chairman*, Sub-Committee.

1. Definitions, pages 319 to 322. Reprint.

2. Conventional Signs and Symbols for Signals and Interlocking, pages 322 to 326. Reprint.

3. Indications Conferring or Restricting Rights, page 326. Reprint.

4. Division of Expense of Installation, Renewal and Maintenance of Joint Interlocking Plants, page 326. Reprint.

5. Signal Indications and Aspects, pages 327 to 329. Reprint.

6. Requisites for Switch Indicators, Including Conveying Information or Condition of the Block to Conductors and Enginemen, pages 330 to 331.

Eliminate and substitute the matter entitled "Requisites of Switch Indicators," on pages 74 and 75 of A.R.E.A. Bulletin, Vol. 19, No. 197 of July, 1917.

7. List of the Findings, Conclusions, Standards and Specifications contained in the Manual of the Railway Signal Association. (Published for the information of the American Railway Engineering Association.)

Eliminate all matters under this head in 1915 Manual and also in Bulletins 189, 197, 207 and 217, A.R.E.A., and substitute in lieu thereof the data furnished the Secretary.

8. For pages 401 to 421 of the 1915 Manual substitute the following as shown in the R.S.A. Manual:

Symbols, Signal—Plates 1 and 2, Plate 3, revised 1914, Plate 4, revised October, 1917, Plate 5, revised October, 1917, Plate 6 revised October, 1917, Plates 7, 8, 9, 10, 11 and Plate 12 revised October, 1917, and Plate 13, revised October, 1917. This revision is referred to on pages 47 to 52 of Vol. 20, No. 207, A.R.E.A.

Also add drawings 1 to 11 as shown on pages 53 to 63 of Vol. 20, No. 207, A.R.E.A. These drawings should be headed "Signs or Markers for Conveying Instructions to Enginemen."

Appendix B

(8) AUTOMATIC TRAIN CONTROL

Sub-Committee: W. H. Elliott, *Chairman*; W. J. Eck, F. P. Patenall, Automatic Train Control Committee, U. S. R. A.

The Automatic Train Control Committee of the Railroad Administration, appointed January 14, 1919, made its report to the Director General of Railroads on November 29, 1919, and the following extracts from that report are submitted as information.

The Committee's instructions were:

"The Committee will proceed at once to make a study of, and report upon, the automatic train control devices now undergoing test upon various lines of railroad or available for test, with their recommendations for the installation and further practical test of any devices now or during their investigation made available for that purpose, which they may consider practicable and reasonably conforming to the purposes to be accomplished.

"The report of the Committee will include their recommendations upon the requisites of automatic train control and their conclusions upon the mechanical or economic features of such of the devices as the Committee may find available for practical use."

"Classification of Train Control Devices

Character of Control.	Class of Device.	Types of Device.
1. Intermittent	A. Contact	1. Plain mechanical trip. Ground or overhead.
		2. Electrically controlled mechanical trip. Ground or overhead.
		3. Intermittent electrical contact.
	B. Track rail contact	1. Insulated track with short track circuit section.
	C. Non-contact	1. Induction.
		2. Inert roadside element.
		3. Non-magnetic rail.
2. Continuous	A. Contact	1. Third rail or special conductor.
	B. Non-contact	1. Induction.
		2. Wireless.

Speed control or cap signals may be applied to most of the above types.

The following are some of the conditions under which speed control devices may be used:

"1. To prevent a predetermined speed being excessed regardless of track conditions.

2. To permit a train to proceed at a predetermined low speed after having been stopped by an automatic brake application.

3. To permit a train to pass a brake application point at a predetermined speed without receiving an automatic brake application.

4. To permit a train to pass an approach indication point without an automatic brake application providing the engineman properly observes the approach indication.

5. To permit a train to proceed without an automatic application of the brakes as long as the speed of the train is controlled in accordance with the signal indications."

The following conclusions are made:

"1. That the relative merits of the various types of automatic train-control can not be determined until further tests have been made.

2. That more extended service tests, including complete records of performance, are necessary before a decision can be reached on the availability for general practical use of any of the devices that have been brought to the attention of the Committee.

3. That on a large part of the railroad mileage in the United States with a given amount of money available for protection purposes, a greater degree of safety can be obtained by installing block signals than by installing automatic train control devices.

4. That on lines of heavy traffic, fully equipped with automatic block signals, the use of train control devices is desirable.

5. That complying with its instructions and without implying endorsement, the Committee finds 17 devices available for further test.

6. That it does not appear necessary to make tests of all the devices of a type to determine the availability of that type for general practical use.

7. That a committee on automatic train control should be continued.

It is recommended that tests undertaken should be made under the supervision of the Committee on Automatic Train Control and the following records made of each test:

A. Record of performance.

B. Record of installation cost, separated between roadside and train apparatus, and into unit costs.

C. Record of cost of modifications of the existing signal system to accommodate the test installation.

D. Record of direct operation and maintenance costs."

The report includes a list of definitions of terms used and states that over 300 more or less complete plans or devices were examined and examinations were made of 37 other devices that were in various stages of development.

Appendix C

(9) DISPLAY OF SIGNALS FOR THE PROTECTION OF TRACK WORKERS

T. S. STEVENS, *Chairman*, Sub-Committee.

It is not recommended that temporary protection by signal shall be provided by means of short circuiting track circuits because of the unreliability of such protection. Even when substantial connections are provided, they are so easily torn loose that no absolute protection is afforded.

If temporary protection by signal for track workers or against some emergency trouble is desired, it should be provided by having the signal forces disconnect the signal circuits so that the signal will display the desired indication. After the necessity for protection has ceased, the circuits should again be connected by signal forces.

Where it is desired to install permanent arrangements for providing protection for other than purely train operations, any of the following methods, which are now in use on several railroads, seem to take care of the situation:

(a) Open track relay connections at the relay.

(b) Open track relay connection by knife switch.

(c) Open signal circuit wires by knife switch or provide convenient way to cut wires with pliers.

(d) Shunt track by circuit controller operated by switch stand.

(e) Double shunt and break track circuit by knife switch.

(f) Shunt track circuit by circuit controller operated by hand.

(g) Control line circuits by staff instruments operated by track or other maintenance of way forces.

(h) Special indicators to give information of the approach of trains.

Conclusions

1. If temporary protection by signal is desired for track workers or for dangerous track conditions it should be provided by disconnecting the signal circuits so that the proper indication will be displayed. Disconnections should be made by signal forces.

2. If permanent arrangements are desired for protection, by signal, of track workers or for dangerous track conditions, this may be provided by:

(a) Opening track relay through knife switch.

(b) Opening circuit wires through circuit controllers.

(c) Shunting track by circuit controller or knife switch.

3. Information may be provided by means of indicators to advise track workers of the approach of trains.

NOTE.—On an emergency a shunt wire with clips to attach to bond wires may be used, provided prompt action is taken thereafter to arrange for proper disconnection as prescribed.

Appendix D

(13) TIME RELEASES APPLIED TO SIGNAL OR SWITCH APPARATUS

T. S. STEVENS, *Chairman;* B. WHEELWRIGHT, G. E. ELLIS, Sub-Committee.

In considering this question, the important and determining factor is that of "Safety." All electric locking devices are applied to promote safety in operation and in considering any device for nullifying such features, safe operation must still remain the principal consideration.

It is obvious that with a given train, the proper time interval for the release of electric locking devices should be the time required for such a train to travel from the point of clear vision of the distant signal (or sighting distance) to a point just in advance of the track circuit controlling the derails or switches.

There is difficulty in formulating any one rule that will govern all the various classes of traffic operating over any one interlocking plant. As either the speed or weight or both of trains increases, the longer should be the sighting distance and the longer the distance signal block. The question then really resolves itself into determining the speed of traffic upon which the recommended rule should be based.

Your Committee does not recommend that this should be based upon the speed of the slowest train operating over the plant, for the reason that this train can stop in a lesser distance than other traffic.

For average conditions your Committee recommends that a speed of thirty miles per hour and a sighting distance of 1000 feet be assumed.

Upon these assumptions the rule will take the following form:

> "For average conditions the proper time interval for the release of electrical and mechanical devices applied to signal and switch apparatus should be the time required for a train running thirty miles per hour to travel from a point 1000 feet before reaching the distant signal to a point 10 feet beyond the home signal."

In interpreting and applying this recommendation, it should be distinctly understood that it is only a guide and that the particular local conditions must, in the final analysis, govern the determination of this time interval.

REPORT OF COMMITTEE II—ON BALLAST

H. L. RIPLEY, *Chairman;*
F. J. STIMSON, *Vice-Chairman;*
C. W. BALDRIDGE,
O. F. BARNES,
J. S. BASSETT,
W. J. BERGEN,
F. W. BETTLE,
THEO. BLOECHER, JR.,
H. E. BOARDMAN,
C. J. COON,
T. W. FATHERSON,
H. E. HALE,
PAUL HAMILTON,
G. H. HARRIS,
A. G. HOLT,
F. A. JONES,
J. S. MCBRIDE,
S. B. RICE,
D. L. SOMMERVILLE,
PAUL STERLING,
D. W. THROWER,
R. C. WHITE,
W. D. WILLIAMS,

Committee.

To the American Railway Engineering Association:

The Committee on Ballast respectfully presents the following report:

The following subjects were assigned to the Committee on Ballast for study and report:

(1) Make thorough examination of the subject-matter in the Manual and submit definite recommendations for changes.

(2) (a) Make final report, if practicable, on the instructions to govern ballasting on an operated line.

(b) Continue time and cost studies relative to the application of ballast. Urge railroads to collect such data in accordance with forms presented in Appendix D of Ballast report (see Vol. 21) and furnish the information to the Committee. Report on methods and comparative cost of applying ballast, giving special attention to the organization of the ballast gang.

(3) Make final report, if practicable, on specifications for stone ballast material.

(4) Study and recommend standards for ballast tools with plans, diagrams, sketches or specifications necessary to illustrate the narrative.

(5) Prepare general summary of previous reports made by Ballast Committee of the A.R.E.A.

The numbers opposite the subjects assigned correspond to the numbers of the sub-committees.

Committee Meetings

Three general meetings of the Committee were held in Pittsburgh on June 17th, October 14th, and November 18th. The names of the members in attendance at each of the meetings have been furnished to the Secretary and printed in the Bulletin.

CONCLUSIONS

The Committee recommends that the revision and rearrangement of the subject-matter in the Manual as made in accordance with Appendix A be approved and the revised matter be substituted for the present recommendations in the Manual.

The Committee recommends that the instructions to govern ballasting on an operated line, as outlined in Appendix B, be approved and printed in the Manual as recommended practice.

The Committee recommends that Specifications for Stone Ballast Material, as outlined in Appendix C, be approved and printed in the Manual as recommended practice.

The Committee recommends that Specifications for Washed Gravel Ballast, as outlined in Appendix D, be adopted and printed in the Manual as recommended practice.

The Committee recommends that the standard ballast tamping bar, tamping pick, and ballast fork, as outlined in Appendix E, be printed in the Manual as recommended practice.

It recommends that time and cost studies be reassigned and that the report on methods and comparative cost of applying ballast be recommitted, giving special attention to the organization of the ballast gang and having particular reference to the organization of a small emergency ballast gang.

It recommends that standards for ballast tools be recommitted, paying particular attention to the ballast shovel and consulting with the Committee on Roadway.

Recommendations for Future Work

The Committee recommends that a general review of previous reports be made and important matters not contained in the Manual be summarized convenient for ready reference.

Respectfully submitted,

THE COMMITTEE ON BALLAST.
H. L. RIPLEY, *Chairman.*

Appendix A

REVISION OF MANUAL

C. J. Coon, *Chairman;*
S. B. Rice,
Paul Sterling,
O. F. Barnes,
Sub-Committee.

Sub-Committee (1) was instructed to make a comprehensive review of the Manual, rearranging the contents in logical sequence, adding to the number of terms defined and restating and reconstructing matter now appearing in the Manual to make the meaning clear or to state in better form that which has been developed through the process of amendments and additions.

Several meetings of this sub-committee were held during the year and with one exception, all members were present.

New definitions were added for Foul Ballast, Dust, Shoulder, Crib, as these terms were used in various places in the data already in the Manual.

Under "Kinds of Ballast," Pit Run, Screened, Washed Gravel have been added.

Under "Choice of Ballast" the recommendations or attempted revisions had left the matter obscure and it has been restated to define more clearly the Committee's intent without changing the substance.

The paragraph appearing in the old Manual under heading "Specifications for Stone Ballast" has been given a new caption "Characteristics of Stone Ballast," as this more clearly indicates the subject-matter following the caption, and there has been presented for your consideration and adoption at this meeting a comprehensive specification for stone ballast material.

The caption "Specification for Gravel Ballast" has been changed to read "Specifications for Pit Run Gravel Ballast."

A "Specification for Washed Gravel Ballast" will be presented to this meeting for adoption.

It is hoped that the "Specifications for Stone Ballast" will be approved this year and inserted in the Manual and the Committee recommends also that some valuable information, which is in the hands of the Secretary regarding the matter of Stone Crushing and Gravel Washing Plants, be inserted in the Manual at some later date.

Definitions

General

Ballast.—Selected material placed on the roadbed for the purpose of holding the track in line and surface.

Sub-Ballast.—Any material of a character superior to that in the adjacent cuts, which is spread on the finished sub-grade of the roadbed and below the top-ballast, to provide better drainage, prevent upheaval by frost, and better distribute the load over the roadbed.

Top-Ballast.—Any material of a superior character spread over a sub-ballast to support the track structure, distribute the load to the sub-ballast, and provide good initial drainage.

Foul-Ballast.—Ballast which has lost its porosity through the filling up of the voids by cinders, coal dust, dirt or other foreign matter.

Dust.—Fine particles of sand, clay, loam, or other earthy matter which will pass through a No. 50 screen.

Shoulder.—That portion of the ballast between the end of the tie and the toe of the ballast slope.

Crib.—That portion of the ballast between two adjacent ties.

Depth.—The distance from the bottom of the tie to the top of the sub-grade.

Kinds

Chats.—Tailings from mills in which zinc, lead, silver, and other ores are separated from the rocks in which they occur.

Chert.—An impure flint or hornstone occurring in natural deposits.

Cinders.—The residue from the coal used in locomotives and other furnaces.

Clay (Burnt).—A clay or gumbo which has been burned into material for ballast.

Granite (Disintegrated).—A natural deposit of granite formation, which on removal from its bed by blasting or otherwise, breaks into particles of size suitable for ballast.

Gravel.

(a) Pit Run.—Worn fragments of rock and sand occurring in natural deposits.

(b) Screened.—Worn fragments of rock, occurring in natural deposits, that will pass through a 2½-inch ring and be retained upon a No. 10 screen.

(c) Washed Gravel.—A gravel from which foreign matter has been washed and the relative proportions of gravel and sand have been determined.

Gumbo.—A term commonly used for a peculiarly tenacious clay, containing no sand.

SAND.—Any hard, granular, comminuted rock which will pass through a No. 10 screen and be retained on a No. 50 screen.

SLAG.—The waste product, in a more or less vitrified form, of furnaces, for the reduction of ore; usually the product of a blast furnace.

STONE.—Stone broken by artificial means into small fragments of specified sizes.

Comparative Merit of Material for Ballast

The following sets forth the relative order of effectiveness of various kinds of ballast:

(1) STONE
- (a) Trap rock.
- (b) Limestone.
- (c) Sandstone.

(2) WASHED GRAVEL

(3) BROKEN SLAG (not granulated).
- (a) Precious metal slag.
- (b) Open-hearth slag.
- (c) Blast furnace slag.

(4) SCREENED GRAVEL

(5) PIT RUN GRAVEL
- (a) River or stream gravel.
- (b) Hill gravel (not cementing).
- (c) Hill gravel (cementing).

(6) CHATS
- (a) Chats from zinc ore, which is coarse.
- (b) Chats from lead ore, which is fine.

(7) BURNT CLAY OR GUMBO

(8) CINDERS
- (a) Hard coal cinders.
- (b) Volcanic cinders.
- (c) Soft coal cinders.

Choice of Ballast

Natural ballast materials vary greatly in quality, and the choice must often be determined by availability and expediency under the particular existing circumstances.

Financial considerations may control the choice or there may be only one suitable material readily available.

Crushed stone is a manufactured article and the process being under control, it is practicable to make the product conform to specifications.

In the choice of ballast where gravel is available, it should receive careful consideration as it has given excellent results, especially when properly screened, crushed and washed.

Proper Depth of Ballast

(a) On a roadbed material such as clay, loam, etc., subject to deformation by the application of live load, the proper depth of ballast under the tie to produce approximately uniform pressure on the roadbed would be not less than the spacing center to center of the ties. For Class A Track, see Ballast Sections, adopted March, 1918.

(b) On material that approximates the character of good sub-ballast (which will not be deformed by the application of live load), the minimum depth of ballast under the bottom of the tie should be twelve (12) inches.

(c) These depths are required, under the conditions named, to support the track structure; to provide good initial drainage; to provide against upheaval by frost; to serve as a cushion for the track.

(d) A combination of a good Sub-Ballast eighteen (18) to fourteen (14) inches, and Top-Ballast six (6) to ten (10) inches, making a total of approximately twenty-four (24) inches under the tie in the aggregate, will produce nearly the same result as though the superior material was used for the full depth.

(e) Until sufficient tests are made under normal traffic conditions, the proper depth of ballast under the tie must rest on opinion, based on experience and supported by such tests as are available, notably the test made by Director Schubert of the German Railways and the "Altoona Test" made by the Pennsylvania Railroad.

(f) Proper drainage of the sub-grade is essential to success with any kind of ballast.

Characteristics of Stone Ballast

(1) Stone ballast should be sufficiently durable not to disintegrate in the climate where used, hard enough to prevent pulverizing unduly under the action of tools or traffic, and should break with an angular fracture when crushed.

(2) It should be broken into pieces of such size that they will in any position, pass through a 2½-inch ring and will not pass through a ¾-inch ring.

(3) It should be free from dirt, dust or rubbish.

Attention is called to the physical test of stone for ballast given below, which is recommended as a guide in connection with the specifications, or where a quick test must be substituted for a more complete examination.

Physical Test of Stone for Ballast

Other things being equal, the maximum or minimum results, as indicated, will govern in selecting stone for ballast:

(a) Weight per cubic foot, maximum.
(b) Water absorption in pounds per cubic foot, minimum.

(c) Per cent. of wear, minimum.
(d) Hardness, maximum.
(e) Toughness, maximum.
(f) Cementing value, minimum.
(g) Compression test, maximum.

The above physical tests are made uniformly and free of charge by the Department of Agriculture, U. S. Government, Washington, D. C. Much valuable information in regard to tests already made and tabulated can also be obtained from this Department.

(For the description of the physical tests of stone for ballast, as recommended by the Association and full instructions as to how the samples should be obtained and shipped to the Government, see Proceedings of the American Railway Engineering and Maintenance of Way Association, Vol. 11, Part 2, pp. 910-914, and report of the Ballast Committee of 1912. If blueprints of the machines used in making the tests are desired they can be obtained from the Department of Agriculture.)

The results of a large number of "Physical Tests of Road Building Rock" (88 pages), by the U. S. Department of Agriculture, are given in their Bulletin 370 and contains very valuable data on the study of stone for ballast.

Specifications for Pit Run Gravel Ballast

For Class A Railways: Bank gravel, which contains more than two (2) per cent. dust or forty (40) per cent. sand, should be washed or screened.

For Class B Railways: Bank gravel, which contains more than three (3) per cent. dust or sixty (60) per cent. sand, should be screened or washed. Screened gravel should not contain less than twenty-five (25) per cent, nor more than fifty (50) per cent. sand.

For Class C Railways: Any material which makes better track than the natural roadbed may be economically used.

Method of Testing Quality of Pit Run Gravel for Ballast

(1) The size of the sample to be tested should be approximately 1 cubic foot.

(2) Five average samples of about 1 cubic foot each should be selected from various parts of the pit which is to be tested. The five samples should then be thoroughly mixed and about 1 cubic foot of the mixture selected for testing.

(3) To separate the gravel from the sand and dust, use a No. 10 screen, ten (10) meshes to the inch, made of No. 24 wire, B. & S. gage. To separate the sand from the dust, use a No. 50 screen, fifty (50) meshes to the inch, made of No. 31 wire, B. & S. gage.

(4) Measure the percentage of gravel, sand and dust taken from the sample by volume, giving the percentage of each ingredient compared to the volume of the sum of the ingredients, as follows:

$$\text{Per cent of sand} = \frac{S}{G + S + D}$$

Where S = Volume of sand
G = Volume of gravel
D = Volume of dust.

(5) When sample is shipped for test it should be carefully and securely marked with name and location of the pit from which it was taken.

Cinder Ballast

The use of cinder as ballast is recommended for the following conditions: On branch lines with light traffic; on sidings and yard tracks near point of production; as sub-ballast in wet, spongy places; as sub-ballast on new work where embankments are settling, and at places where the track heaves from frost. It is recommended that provision be made for wetting down cinders immediately after being drawn.

A sub-ballast blanket of cinders not less than 12 inches thick is effective in most cases in preventing mud and similar material working up into the top-ballast.

Specifications for Burnt Clay Ballast

Kind of Material

1. Good ballast clay is heavy and plastic, free from sand, gypsum or other impurities. It must not crumble when exposed to air or when brought in contact with heat.

Location

2. The pit should be located on level or moderately sloping ground, not subject to overflow. A water supply is desirable and it should be borne in mind that the sulphurous and carbonaceous gases liberated during the burning period, damage the surrounding vegetation and make habitation in the near vicinity very disagreeable.

Test

3. The location site should be thoroughly tested to determine quality of clay, depth and uniform consistency of deposit, and small quantities should be burned in test kilns to show the quality of ballast to be secured

Burning

4. Fuel should be fresh, clean slack, and arrangements should be made to secure constant supply. One ton of slack coal is generally sufficient for the perfect burning of four cubic yards of acceptable ballast. From one to one and one-half-inch layer of slack is alternated with from ten to twelve-inch layer of clay, a new layer of slack and clay being applied to the fire every five or six days.

Fires once started must be kept steadily and uniformly burning.

To insure thorough and proper burning of the clay, the top and face of the fire should be frequently raked down, to avoid clinker or black spots, caused by too much or too little air.

When fully burnt a proper ballast clay becomes red in color, when the clay contains iron; when under-burnt, the clay will show a yellow color.

Size

5. Burnt clay ballast should be crushed or broken, if necessary, so that the largest piece will pass through a 4-inch ring.

Density

6. The finished product should absorb not to exceed 15 per cent. of moisture by weight.

Cleaning Foul Ballast

Under usual conditions no ballast, except stone or hard slag, should be cleaned.

Ballast should be cleaned when foul enough to prevent proper drainage.

Clean with ballast forks or screens.

Clean shoulder down to sub-grade.

Clean crib to bottom of ties.

Clean space between tracks to depth of six (6) in. or more below the bottom of ties.

Clean the berme to bottom of ballast, preferably not less than twelve (12) in. below bottom of tie.

Clean cross ditches between ties approximately every rail length or thirty-three (33) ft. Cross ditches should not be under rail joints.

Return ballast when cleaned and apply sufficient new ballast to produce the standard section.

Tests, fully described in the report of the Committee on Ballast for 1914, indicate stone ballast can be cleaned by use of screens for approximately one-half cost of cleaning stone ballast with forks. (For diagram showing details of collapsible screens, see 1914 report.)

Stone ballast should be cleaned: In terminals, at intervals of one (1) to three (3) years. Heavy traffic, at intervals of three (3) to five (5) years. Light traffic lines, at intervals of five (5) to eight (8) years.

Per cent. of new stone ballast to be applied: Fifteen (15) to twenty-five (25) per cent.

Use and Limitation of Mechanical Tools

Mechanical devices used to save labor and expense and to expedite the work fall naturally into sequence from the pit, quarry or ballast pile to the finished track.

Cars for transporting ballast should be carefully chosen with regard to the work to be done—whether it is to be on track already laid or for an additional parallel track.

If for raising track, hopper cars should be used with the ballast plow or tie drag. If for parallel track, side dumps are to be preferred, especially when air operated. Convertible cars where the sides swing out and up, when used with the side plow and unloading engine-drum and cable, are fairly satisfactory when dump cars are not available, which is usually the case when stone ballast is furnished from a private quarry.

Anchoring the train and pulling the plow through the train by cable from the locomotive is a poor substitute for the unloading engine. It does beat unloading by hand.

The spreader car, especially when air-operated, is effective and should be in general use. With this car, ballast for new second track work previously dumped alongside the running track from side dump cars or unloaded by side plows, can be spread out to a grade two inches below the bottom of tie and to the outside shoulder at a speed of eight miles per hour. When not in use on ballast work the spreader can be used on a grading dump and in wet clay or rock, will do the work of fifty men and remain idle most of the time at that.

The mechanical tamper has passed the stage where its usefulness under favorable circumstances needs further defense.

Around terminals and yards where there is a large amount of frog and switch work, so far as this Committee knows there is no disposition to question the expediency of its use based on its merits alone, entirely apart from any question of scarcity of labor.

Ballasting by Contract

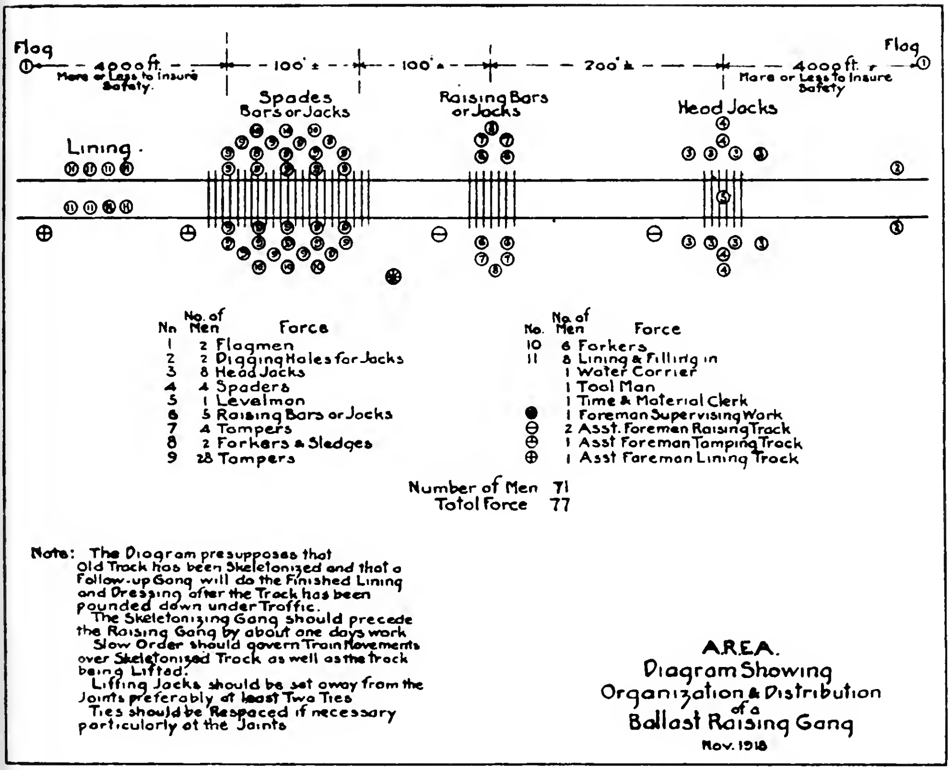
The consensus of opinion is strongly against ballasting by contract in normal times and especially so on operated track.

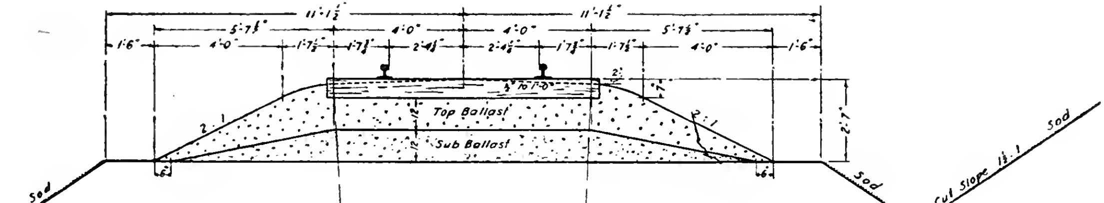
Advocates of ballasting by contract do so largely as an emergency measure because of the greater flexibility of a contractor's organization in changing the rates of pay and so securing labor in times of stress.

Reinforcement Under Ballast

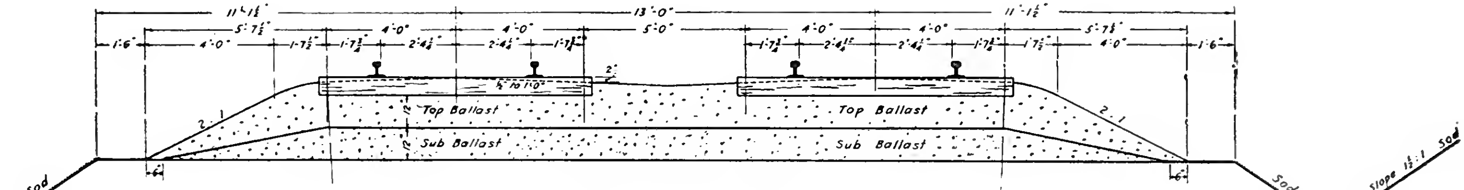
Concrete slabs placed under the ballast on soft roadbed where traffic is heavy, and at times under other exceptional circumstances, indicate that a considerable degree of success may be expected from their use, and at reasonable expense. (See Vol. 21, pp. 447 to 465.)

Diagram for Organization and Distribution of a Ballast Raising Force of 77 Men

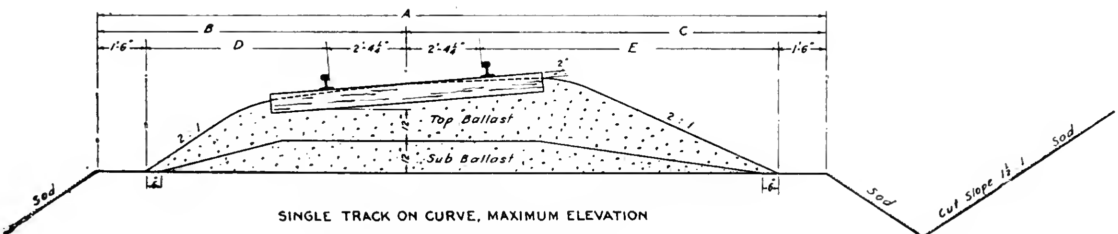




SINGLE TRACK ON TANGENT



DOUBLE TRACK ON TANGENT



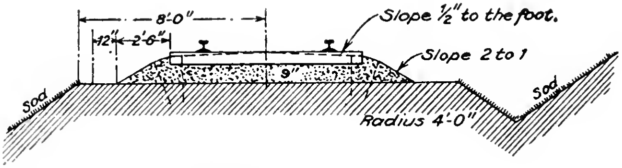
SINGLE TRACK ON CURVE, MAXIMUM ELEVATION

Distances A, B, C, D & E vary with Elevation

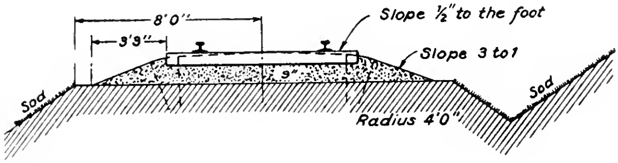
A. R. E. A.
COMMITTEE ON BALLAST
DEVELOPMENT OF OUTLINE OF RECOMMENDED BALLAST SECTION
FOR STONE BALLAST ON CLASS A ROAD
DEPTH OF BALLAST 24 IN.

CLASS B.

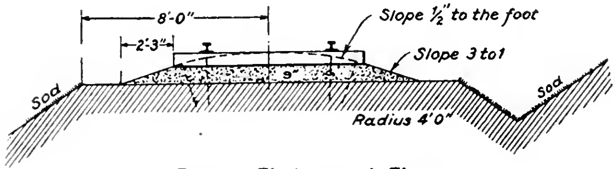
The Sections for Class B track are intended to show minimum depth under ties and are recommended for use only on the firmest, most substantial and well-drained subgrades.



Crushed Stone and Slag.

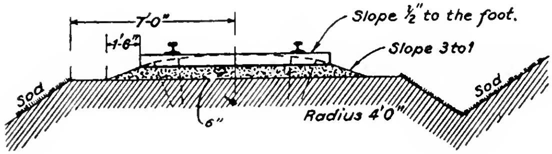


Gravel, Cinders and Chats.

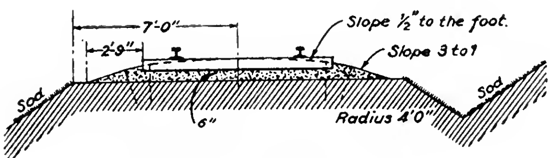


Gravel, Cinders and Chats.

CLASS C.



Cementing Gravel and Chert.



Cementing Gravel and Chert.

Ballast Sections, with Particular Reference to Sub- and Top-Ballast.

Class "A" section should have 24 inches of ballast under the tie.

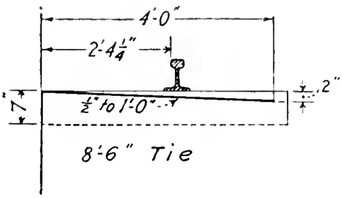


FIG. I

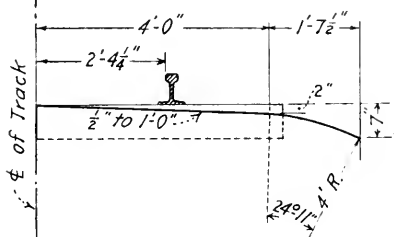


FIG. II

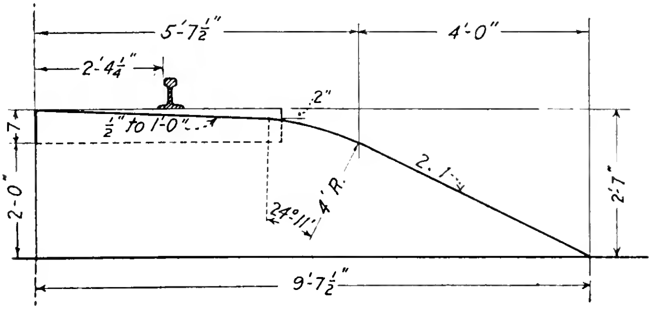


FIG. III

Appendix B

INSTRUCTIONS TO GOVERN BALLASTING ON AN OPERATED LINE

C. W. Baldridge, *Chairman;*
G. H. Harris,
A. G. Holt,
J. S. Bassett,
W. D. Williams,
Sub-Committee.

This report was presented as a report of progress in 1920, was printed in the Bulletin and has been before the Association for a year. It has received further consideration by the general Ballast Committee, and in accordance with the instructions of the Association has been put in final form for adoption.

Authority

Decision of the kind and amount of ballast to be applied having been made by the proper officials, the work should be handled as follows:

Plans

The Division Engineer or Roadmaster, whichever is to have responsible charge, shall lay his plans for work train movements and service before the Trainmaster and Chief Dispatcher, in order that they may have a clear understanding of what is desired to be done, and that they may be able to assist the movements to be made with as little delay as possible.

Ballast Supply

If the ballast is to be furnished by the Company or from a pit for which the Company is responsible, a careful inspection of the pit tracks and appurtenances shall be made and everything put into serviceable condition.

Equipment

All equipment, such as steam shovel, mechanical unloader, unloading plows, material spreader, ballast plow, or spreader, etc., shall be gone over and put into working order.

Protection

Speed restrictions shall be arranged for in accordance with operating rules before the track is disturbed, and shall be maintained until the track is in safe condition for schedule speed.

Preparation of Roadbed

Preparatory to placing ballast, the roadbed shall be widened, if necessary, to bring it to the A.R.E.A. standard width, by dumping material alongside of the track and spreading it to the required width and slope, preferably by the use of a material spreader. Where necessary to raise the roadbed level, porous material must be used to avoid the forming of water pockets by burying in of old ballast.

Bank Widening

All bank widening shall be done far enough in advance of the ballasting work so that there will be no interference between work-trains or gangs.

Skeletonizing

After the banks have been widened, the track shall be skeletonized. Where the material is suitable for sub-ballast and the grade will permit, the track shall be raised and the old material spread under and between the ties, and to the proper width, as uniformly as is practicable.

Where conditions do not permit of raising the track, the old material shall be removed to the required depth and disposed of as directed.

Where not suitable for sub-ballast, the old material shall be removed to the plane of the bottom of the ties, or deeper, if necessary, to preserve grade line, and shall be placed on the outer shoulder of the roadbed, preferably at such points as will tend to even up the line of the shoulder.

Use of Jacks

In using jacks, they must be placed outside the rail and close enough together to prevent undue bending of the rail or overstrain of the joints. Where the roadbed material is heavy or holds to the ties tenaciously, it is sometimes necessary to place three or more jacks per rail length. Jacks should be worked in pairs directly opposite each other, and a sufficient number should be used simultaneously, so that no jack will raise the rail more than four inches above its level at the next succeeding jack or place of support.

Tie Renewals

Following the skeletonizing of the track, such tie renewals shall be made as the Company's standards require. All ties must be properly straightened and spaced.

The track must be fully gauged as the new ties are being spiked up. Old ties must be disposed of as directed.

Grade Stakes

Ballast grade stakes shall preferably be set after the bankwidening, skeletonizing and re-tieing have been done and before the ballast material has been dumped and spread.

It is desirable to avoid, as far as possible, interference with the stakes, yet to have them available as a guide for the unloading of ballast.

Drains

All tile, box or other drains required to take care of water from between tracks, shall be placed before the ballast material is unloaded.

Unloading of Ballast

Ballast shall be unloaded by dumping or plowing as the means provided permit.

If the ballast be in center dump cars, it shall be unloaded by having one or more cars opened a little at a time and allowing the required or desired amount of ballast material to flow out as the train is slowly moved along. If the material be on flat or open-side cars, it shall be plowed off by means of an unloading machine while the train is standing or moving at such a rate of speed as to provide the desired amount of material as uniformly distributed as possible.

The unloaded materials shall be leveled down by means of a ballast plow, or of a spreader, consisting of a heavy timber with wheel skids attached to it, and placed in front of the leading pair of wheels of the rear truck. Care must be taken not to destroy or disturb the grade stakes.

Parallel Tracks

Where a new track is being built parallel to an existing track, ballast material can be advantageously handled in body dump cars which dump the entire load to the side desired, after which the ballast material may be spread to the required width and depth by the use of a material spreader, and the track laid after the ballast is in place.

Preliminary Surfacing

The first lift shall be a filling lift.

The filling, or preliminary surfacing gang, shall follow the unloading as closely as the regularity of the ballast supply will permit.

The amount which the track should be raised at one lift will depend upon the depth of ballast to be applied. Usually, track should not be raised more than six inches at a lift, but if the total lift of the track is to be be not more than ten inches, a first lift of seven to eight inches may be made, if traffic conditions will permit, leaving the remainder of the raise for the finishing lift. A sufficient number of jacks must be used simultaneously to avoid damage to rails. The raise on any one jack shall not be greater than four inches above the next jack, or point of support. Both rails must be raised at one time, and as nearly uniformly as is practicable.

The "filling lift" shall be made by jacking the track up to the required height, and the ballast material then forked or shoveled in and worked to as uniform a surface as possible by the use of spades. It shall then be left to be compacted by traffic, but a small "lookout" gang shall go over it after a few trains have passed, and pick up any spots that show too great an inequality of settlement.

After a few days, depending upon the amount of traffic over the track, another lift shall be made, either another filling lift or a finishing lift, according to the depth to which the track is to be ballasted. If another filling lift, it shall be made in the same manner as the first one.

Finishing Lift

When the track has been raised to within two or three inches of the final grade and properly compacted, a finishing lift shall be made by jacking up the track to the exact height provided for by the grade stakes and the necessary ballast forked or shoveled in and then driven to place by the tamping machines, tamping picks or bars, if rock or heavy ballast is used. Shovel tamping should be used with gumbo, cinder or light sandy gravel ballast. In making the finishing lift, the spot board and level board must be used with care, and the track brought to as true a surface as possible.

Alinement

The track shall be placed in good alinement before the finishing lift is made, but a lining gang shall follow one or two days' work behind the finishing lift and shall spot up all places found not to be holding up to proper surface and shall line the track to as accurate alinement as possible.

Center stakes shall be set for the alinement before the finishing lift is made, and the final alinement must conform to the center stakes.

Dressing

Following as closely as possible behind the lining gang, the dress-up gang shall finish the work by filling the track center to the required fullness and then dressing it toward the toe of ballast, preserving the proper clearance under the rail and proper curve and slope of the shoulder. The toe of ballast shall be made a true line, parallel to the center line of track, and any surplus material shall be raked far enough from the toe line to permit of its being forked or shoveled up without fouling or disturbing the finished ballast.

No ballast material or refuse out of the ballast or roadbed material which would interfere with a mowing machine when cutting grass and weeds shall be cast off of the roadbed or be left where it will interfere with the use of mowing machines or scythes.

Clean-up

When the dress-up gang leaves any part of the track as completed, it shall be in first-class line and surface. The ballast shall conform to the ballast sections as adopted by the A.R.E.A. All surplus ballast shall have been loaded, and all refuse and rubbish shall have been removed, loaded or destroyed, so as to leave the right-of-way and shoulders of roadbed in condition to be mowed without interference.

Appendix C

SPECIFICATIONS FOR STONE BALLAST MATERIAL

F. J. Stimson, *Chairman;*
H. E. Hale,
F. W. Bettle,
T. W. Fatherson,
D. L. Sommerville,
Sub-Committee.

Specifications for Stone Ballast Material were presented in tentative form to the Association at its meeting in 1920 and were referred back to the Committee with instructions to put them in final form for adoption.

For the annual meeting in 1921, the Committee has reconsidered the specifications and presents them to you in final form for adoption.

In writing specifications for Stone Ballast Material, the Committee recognizes the fact that while this material is a manufactured product, and consequently, to a considerable extent, susceptible of definite specifications, it is not feasible from a practical standpoint in many cases to obtain ideal stone from which to manufacture the ballast. Consequently, no such hard and fast mechanical or chemical requirements can be made as in the case of steel products. The road must depend upon obtaining the raw stone from quarries with a reasonable limit of haul.

In writing the specifications, actual figures showing the characteristics of the stone have been left blank and a note has been inserted showing what characteristic is desirable and the figure which a high quality of stone for ballast should show. This will permit the road using the specifications to make its test of the best ballast material available, insert its own units, and at the same time know how these units compare with a stone entirely desirable for ballast purposes. In this way your Committee has endeavored to overcome the difficulty which the road will meet in being obliged to use available material.

Physical Qualities

General

Stone for use in the manufacture of ballast shall break into angular fragments which range with fair uniformity between the maximum and minimum size specified herein; it shall test high in weight, hardness, strength and durability, but low in absorption, solubility and cementing qualities.

Tests

Tests shall be made as follows:

Weight.—Not less than one-half cubic foot of the stone accurately measured, and dried for not less than twelve hours in dry air at a temperature of between 125 and 140 deg. Fahr. shall be weighed. The weight shall be not less than..........lb. per cubic foot.

(NOTE.—Of the stone available, that having the maximum should be used; a high quality stone for ballast will weigh 168 lb. per cubic foot.)

(NOTE.—If approved by the Association, to be inserted in the Manual preceding Specification for Pit Run Gravel.)

STRENGTH.—Two-inch cubes of the stone shall be sawed to reasonably accurate dimensions and the top and bottom faces made accurately parallel. For the primary tests, the test specimens shall be dried for two hours in dry air at a temperature of between 120 and 140 deg. Fahr. and at the time of test the temperature of the specimen shall be not less than 50 degrees. Tests shall be made in a testing machine of standard form and the stone shall have a compressive strength of .... lb. per square inch.

(NOTE.—Of the stone available, that having the maximum compressive strength should be used; a high quality stone for ballast will have a strength of 10,000 lb. per square inch.)

A secondary test shall be made on specimens the same in all respects as for the primary test except that the blocks shall have completely immersed in clean water, of a temperature between 35 and 90 degrees, for 96 hours, the test to be made within 30 minutes of removal from the water.

If the compressive strength shall have decreased more than .... per cent from the primary tests, the rock shall be deemed unsuitable for ballast purposes.

(NOTE.—Of the stone available, that showing the least difference between the results of the primary and secondary test should be used; a high quality stone for ballast should show not over 1 per cent difference.)

SOLUBILITY.—One-fourth cubic foot of the rock shall be crushed and thoroughly washed. The particles shall then be placed in a glass vessel and covered with clear water. The vessel shall be thoroughly shaken for five-minute periods at 12 hour intervals for 48 hours. If any discoloration of the water occurs, the rock shall be deemed soluble and undesirable for use as ballast.

WEAR OR DURABILITY.—*(Test No. 1).* One-half cubic yard of washed stone, which will pass through the maximum and be retained on the minimum screen, shall be spread over a wire mesh or iron surface to a depth of not more than 3 in., and exposed to a dry heat of from 125 to 140 deg. Fahr. for a period of two hours. After the dried stone is carefully weighed it shall be given 10,000 revolutions in a tumbler approximately four feet in diameter, of not less than two cubic yards capacity, and operating at 25 revolutions per minute.

The sample shall then be passed over a screen of the minimum dimension provided for sizing the ballast, again washed and dried in the same manner as before the test, and again carefully weighed.

If the decrease in weight shall be more than .... per cent of the original weight of the sample, the stone shall be deemed unfit for use as ballast.

Outside of the breakage, which is exhibited by the small particles which will pass through a minimum screen but will not pass a sieve of 20 meshes to the inch, the wear should not exceed .... per cent.

(Note.—Of the stone available, that showing the smallest loss in weight should be used; a high quality stone for ballast will show a loss of not more than 1 per cent in fragments which will pass a screen of 20 meshes to the inch, and not more than 3 per cent. in those passing the minimum sizing screen.)

Test No. 2 (Quick Weathering Test). One-half cubic yard of stone shall be dried and weighed as for Test No. 1. It shall then be immersed in water for six hours and then while still wet, be placed in a refrigerating plant and subjected to a temperature of approximately zero Fahr. for two hours. It shall then be removed and the temperature gradually raised in two hours to 100 degrees and that heat continued for two hours, when it shall be immersed as before and again subjected to approximately zero temperature.

The freezing and thawing shall be repeated to a total of ten exposures. If any tendency to disintegrate is observable the stone should be considered unsuitable for ballast. Otherwise the material shall again be subjected to a wear test as provided under Test No. 1. If in this wear test the maximum decrease in weight shall be in excess of .... per cent, it shall be deemed unsuitable for use as ballast.

(Note.—Of the stone available, that showing the minimum average decrease in weight should be used; a high quality stone for ballast will not show a decrease in fragments which will pass the minimum sizing screen of more than 4 per cent.)

Absorption.—One-half cubic yard of washed stone, which will pass through the maximum and be retained on the minimum screen, shall be spread over a wire mesh or iron surface to a depth of not more than 3 inches, and exposed to a dry heat of from 125 to 140 deg. Fahr. for a period of 6 hours. After the dried stone is carefully weighed it shall be submerged in clean water for a period of 96 hours. It shall then be removed from water and exposed to a normal air in the shade and at a temperature between 40 and 80 degrees, and allowed to drip for 30 minutes, when it shall again be weighed and the difference in weight shall be used to determine the rate of absorption. Stone showing an absorption of more than .... lb. per cubic foot is unsuitable for ballast.

(Note.—Of the stone available, that showing the minimum absorption should be used; a high quality stone for ballast will have an absorption of not more than 0.50 lb. per cu. ft.)

Cementing Quality.—A five-pound sample of the rock thoroughly washed and dried shall be crushed until it will pass through a screen of one-fourth inch mesh. This material shall be placed in a ball mill which contains two steel shot weighing 20 lb. each, and the mill revolved at the rate of 30 revolutions per minute, until it has made 2000 revolutions for each pound of sample in the mill.

Sufficient clean water shall be added to make a consistent mortar, which shall then be moulded into one-inch cubical briquettes, formed under 10 lb. pressure. All of the briquettes shall then be allowed to dry 20 hours in air, when one-third of them shall be tested for compressive strength.

One-third shall be kept for four hours in a steam bath, and the remainder shall be immersed for four hours in clean water at a temperature between 50 and 60 deg. Fahr. and then tested for compressive strength.

If in any of these tests a compressive strength greater than .... lb. per square inch is developed, the material shall be deemed unsuitable for ballast.

(Note.—Of the stone available, that from which the briquettes show the minimum strength should be used; a high quality stone will show not to exceed 4 lb. per square inch.)

Requirements

Breaking.—Stone for ballast shall be broken into fragments which range with fair uniformity between the size which will in any position pass through a 2½-in. ring and the size which will not pass through a ½-in. ring.

Test for Size.—*(Maximum)*. A sample weighing not less than 150 lb. shall be taken from the ballast as loaded in the cars and placed in or on a screen having round holes 2¾ in. in diameter. If a thorough agitation of the screen fails to pass through the screen 95 per cent of the fragments, as determined by weight, the output from the plant shall be rejected until the fault has been corrected.

(*Minimum*). A sample weighing not less than 150 lb. shall be taken from the ballast as loaded in the cars; weighed carefully and placed in or on a suitable screen having round holes ½-inch in diameter. The screen shall then be agitated until all fragments which will pass through the screen have been eliminated. The fragments retained in the screen shall then be weighed and if the weight is less than 95 per cent of the original weight of the sample the output of the plant shall be rejected until the fault is corrected.

Handling.—Broken stone for ballast must be delivered from the screens directly to the cars or to clean bins provided for the storage of the output of the crusher. Ballast must be loaded into cars which are in good order and tight enough to prevent leakage and waste of material and are clean and free from sand, dirt, rubbish or any other substance which would foul or damage the ballast material.

INSPECTION.—Inspectors representing the purchaser shall have free entry to the works of the manufacturer at all times while the contract is being executed, and shall have all reasonable facilities afforded them by the manufacturer to satisfy them that the ballast material is prepared and loaded in accordance with the specifications and contracts.

In case the inspection develops that the material which has been or is being loaded is not according to specifications, the inspector shall notify the manufacturer to stop further loading and to dispose of all cars under load with the defective material.

As the quarry deepens or is enlarged, further tests shall be made of the material whenever conditions indicate a change in the quality of the stone, or where in the judgment of the Engineer for the Company, a further test is advisable. Should such tests show that the stone fails to meet the provisions of these specifications, it shall not be used for the manufacture of ballast.

MEASUREMENT.—Ballast material may be reckoned in cubic yards or by tons, as expedient. Where ballast material is handled in cars, the yardage may be determined by weight, after ascertaining the weight per cubic yard of the particular stone in question by careful measurement and weighing of not less than five cars filled with the material, or the tonnage may be determined for subsequent cars by measurement and converting the yardage into tonnage by use of the weight per yard as determined above.

Appendix D

SPECIFICATION FOR WASHED GRAVEL BALLAST

F. J. STIMSON, *Chairman;*
H. E. HALE,
F. W. BETTLE,
T. W. FATHERSON,
D. L. SOMMERVILLE,
Sub-Committee.

Your Committee presents for your consideration and attention, Specifications for Washed Gravel Ballast. It feels that this subject is becoming one of increasing importance and several members have had somewhat extensive experience in connection with the use of this material.

The requirements of the specifications are well within the limits of tolerance which can be met by a properly constructed commercial plant.

The Committee believes that it is desirable, where practicable, to combine the preparation of material for commercial use with the preparation of material for ballast.

It asks for the adoption of these specifications.

Specifications for Washed Gravel for Ballast

1. 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.

Test No. 1. Dust, Dirt or Loam

2. 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.

Test No. 2. Large Aggregate

3. A sample weighing not less than 150 lb. shall be placed in or on a screen having round holes 2¾ in. 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 from the plant shall be rejected until the fault has been corrected.

Test No. 3. Sand

4. 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 exceeds 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.

5. 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.

6. 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.

7. 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.

(NOTE.—If approved by the Association, to be inserted in the Manual following specifications for Pit Run Gravel.)

Appendix E

STANDARDIZATION BALLAST TOOLS

J. S. McBride, *Chairman;*
F. A. Jones,
D. W. Thrower,
R. C. White,
Sub-Committee.

Plans and specifications for tamping bars, tamping picks, ballast forks and ballast shovels were prepared and sent by the Secretary to the carriers and manufacturers, with request for discussions, suggestions and criticisms. A number of replies were received from the carriers, but no replies were received from the manufacturers.

The Sub-Committee has made some corrections in view of the suggestions received and is submitting herewith specifications and plans for tamping bars, tamping picks and ballast forks, which are recommended for insertion in the Manual.

The Committee is not ready to make a recommendation on standard ballast shovel, and is submitting plan which it requests be considered as a progress report.

Specifications for Ballast Tools

Scope

1. These specifications cover tamping bars, ballast forks and tamping picks.

Material

2. These tools, other than straps, shall be high-grade tool steel made by the Open-Hearth or Crucible process.

3. Straps for forks shall be of soft Open-Hearth steel or wrought-iron.

4. Handles shall be smooth and well seasoned, of the best grade straight grained ash or hickory, bent to shape.

Chemical Properties

5. The steel shall conform to the following chemical composition:

	Tamping Bars and Picks *Per Cent*	*Forks* *Per Cent*
Carbon	0.55 to 0.75	0.90 to 1.05
Manganese	0.40 to 0.60	Not more than 0.50
Phosphorus	Not more than 0.04	Not more than 0.04
Sulphur	Not more than 0.04	Not more than 0.04

Design

6. The dimensions of tools shall conform to the plans which are made a part of these specifications.

Physical Properties

7. All tools shall be free from defects and finished in a workmanlike manner.

8. Tools must be properly tempered to provide the maximum toughness and strength to perform the service for which they are intended.

9. Tamping bars, picks and tines, head and tongue of ballast forks shall be of one piece, no welding being permissible.

10. Tools shall be marked as shown on the plans.

Inspection

11. Inspection of tools shall ordinarily be made at the place of manufacture. The manufacturer shall notify........................ of the Railroad Company at least .... days in advance when tools will be ready for shipment. However, when so directed, in regard to a particular shipment, the manufacturer shall make shipment on his own inspection, subject to requirements of Paragraph 15.

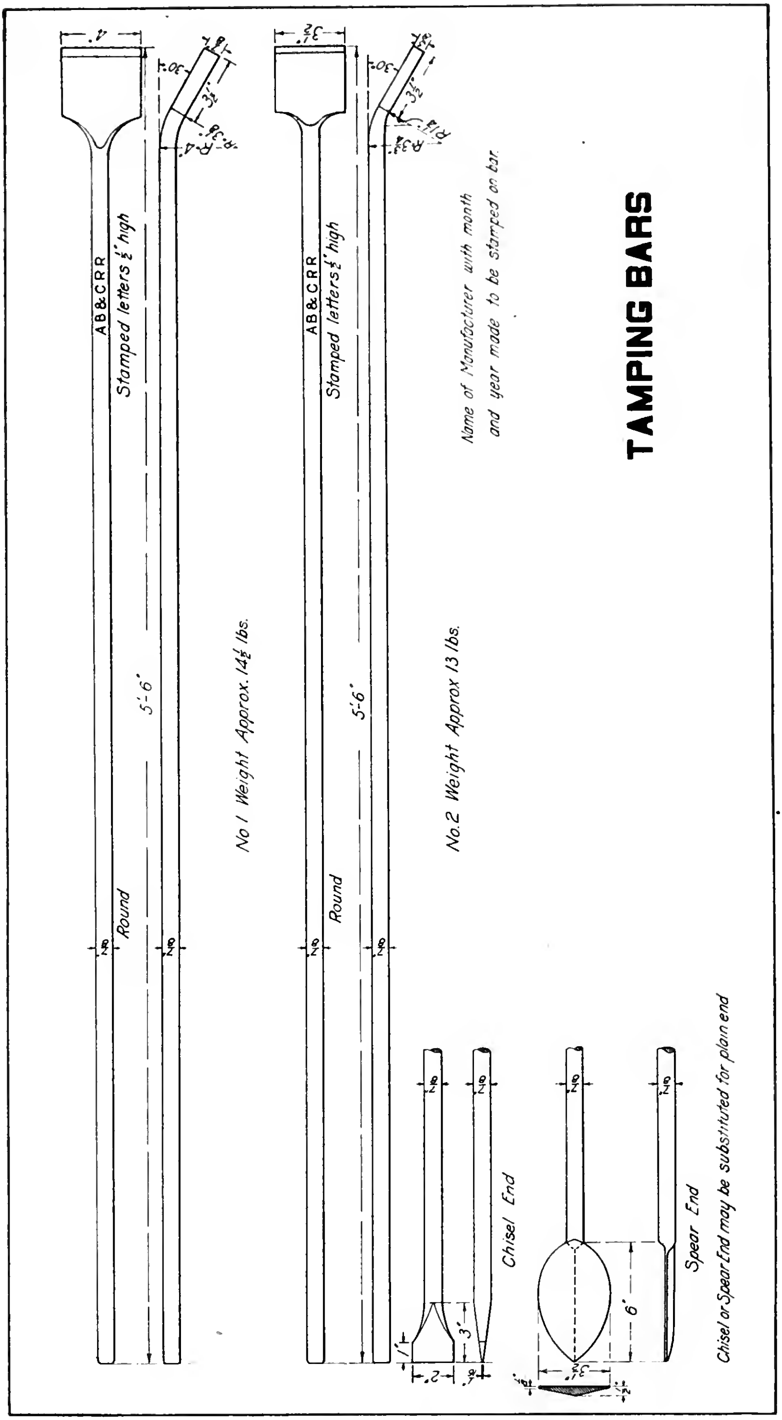
12. The manufacturer shall allow the Railroad Company's inspectors such access to the work as may be necessary to satisfy them that the provisions of these specifications are carried out.

13. The manufacturer shall furnish, without charge, all necessary facilities and assistance for making thorough inspection and tests at the works.

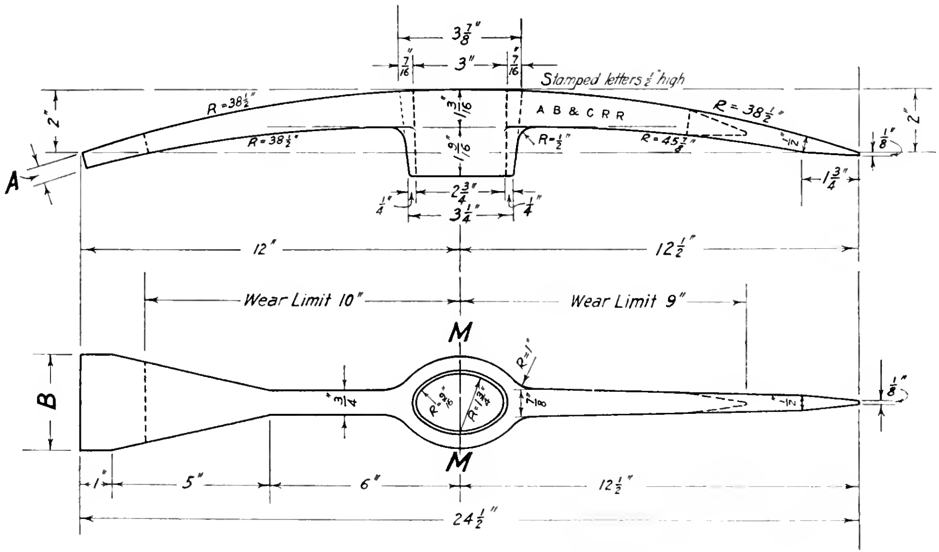
Rejection

14. Individual tools, defective in any respect, and lots of tools not meeting above requirements, shall be rejected.

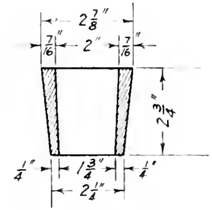
15. All tools shipped on manufacturer's inspection, as provided in Paragraph 11, which on arrival at destination are found defective and all tools which develop flaws and defects in the usual and necessary service, shall be rejected and replaced at the entire expense of the manufacturer or seller.



TAMPING BARS



Name of Manufacturer with month and year made to be stamped on pick

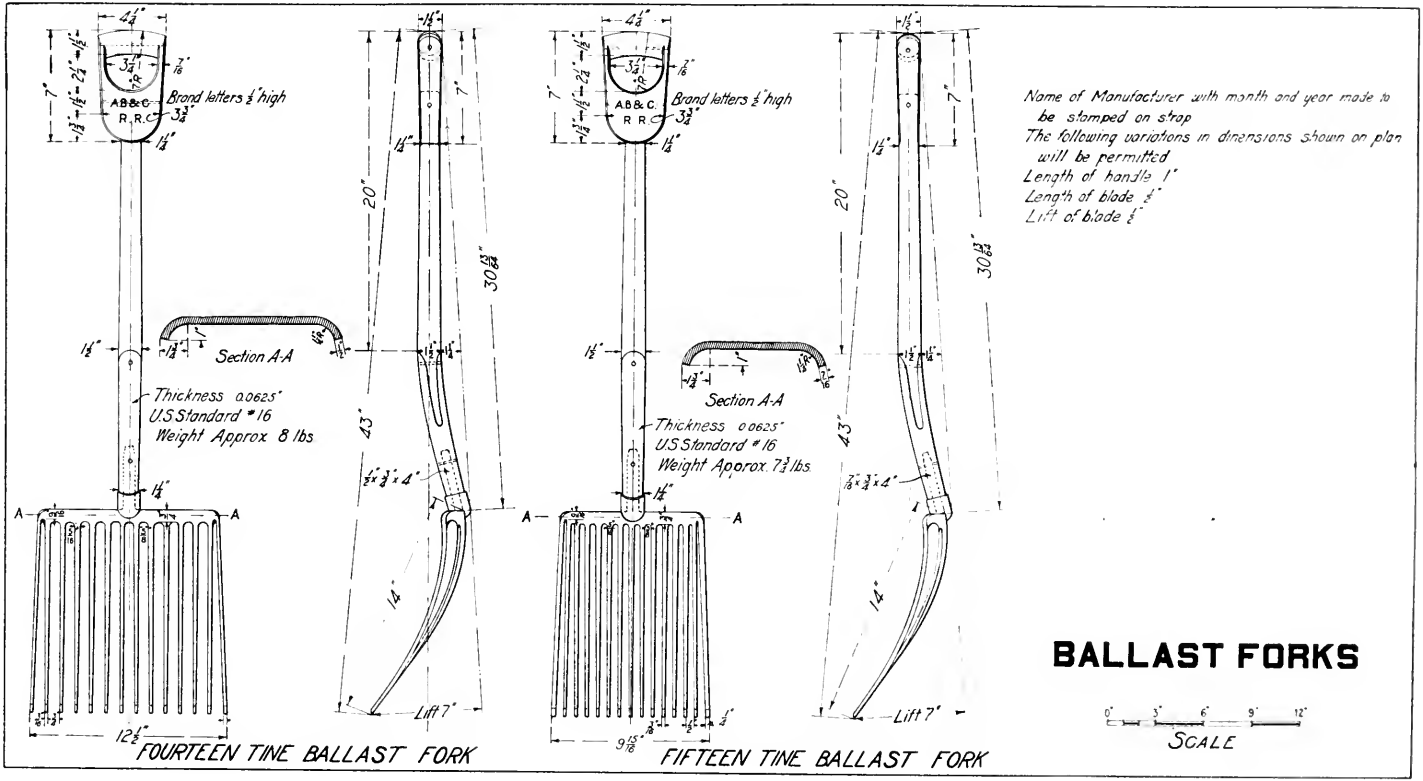


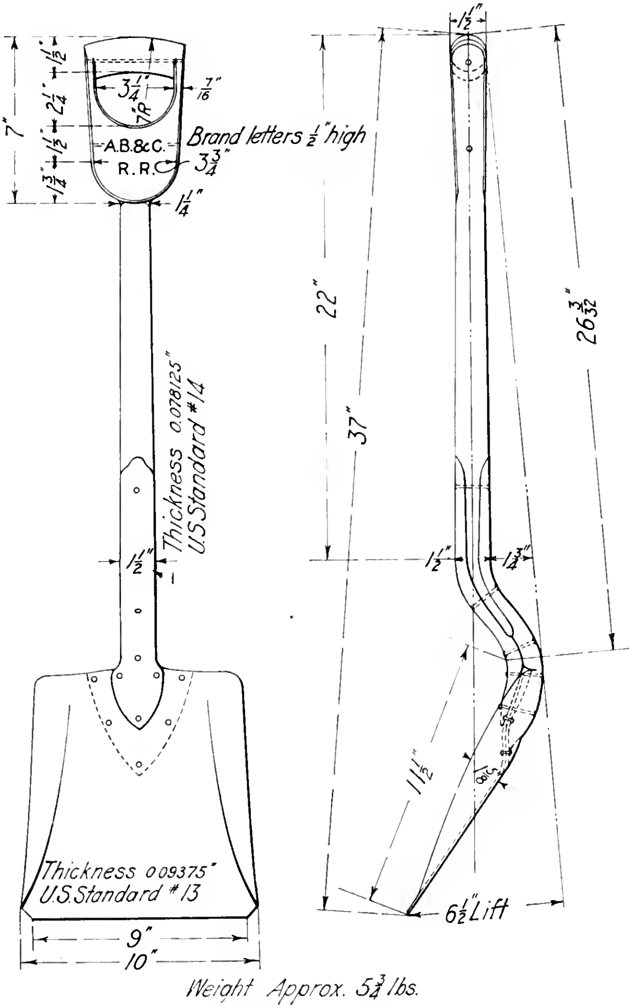
SECTION M-M

SIZE	A	B	WEIGHT
1	1/2"	3"	7 1/2 lb
2	5/8"	3"	7 2/3 lb
3	3/4"	2 1/2"	7 7/8 lb

SCALE

TAMPING PICKS


BALLAST FORKS
Name of Manufacturer with month and year made to be stamped on strap
The following variations in dimensions shown on plan will be permitted
Length of handle 1"
Length of blade ½"
Lift of blade ½"
Brand letters ½" high
A.B.& C. R.R.
Section A-A
Thickness 0.0625"
U.S.Standard #16
Weight Approx 8 lbs
Weight Approx. 7¾ lbs.
Lift 7"
FOURTEEN TINE BALLAST FORK
FIFTEEN TINE BALLAST FORK
SCALE



Weight Approx. 5 3/4 lbs.

Name of Manufacturer with month and year made to be stamped on strap.

The following variations in dimensions shown on plan will be permitted

Length of handle 1"

Length of blade 3/8"

Width of blade 1/4" less

Lift of blade 1/2"

BALLAST SHOVEL

0" 3" 6" 9" 12"

SCALE

REPORT OF SPECIAL COMMITTEE ON STRESSES IN TRACK

A. N. Talbot, *Chairman;*
W. M. Dawley, *Vice-Chairman;*
A. S. Baldwin,
G. H. Bremner,
John Brunner,
W. J. Burton,
Chas. S. Churchill,
W. C. Cushing,
Dr. P. H. Dudley,
H. E. Hale,
Robt. W. Hunt,
J. B. Jenkins,
Geo. W. Kittredge,
Paul M. LaBach,
C. G. E. Larsson,
G. J. Ray,
Albert Reichmann,
H. R. Safford,
Earl Stimson,
F. E. Turneaure,
J. E. Willoughby,

Committee.

To the American Railway Engineering Association:

The Special Committee on Stresses in Track, coöperating with a similar committee of the American Society of Civil Engineers and the American Railway Association, presents the following report of progress:

In continuation of the program of the Committee, field tests on railroad track were carried on during the summer season. The tests were conducted on the tracks of the Illinois Central Railroad in Illinois, the Delaware, Lackawanna & Western Railway in New Jersey, and the Atchison, Topeka & Santa Fe Railway in New Mexico and Iowa. The tests were made on tangent track and on curved track, several different curvatures being used. A principal purpose of the tests was to find the effect of curvature of track upon the stresses in the rail (including lateral bending stresses) caused by locomotives of different types run at different speeds, as compared with the stresses developed in straight track. Several types of locomotives were used—Pacific, Mountain, Santa Fe, Mikado, Ten-Wheeler, etc. Work of a preliminary nature was also done to find the effect of the flat spots of wheels upon the stress in the rail. All the tests were carried on in much the same way as were the tests described in the reports of the Committee already presented to the Association. A large amount of data has been accumulated, and it will require several months to reduce these data and a further time to study the results. Preliminary work on the data indicates that the tests will give important information on stresses developed in curved track.

The Committee is continuing work on other phases of the subject assigned to it.

Respectfully submitted,

The Special Committee on Stresses in Track,

By A. N. Talbot, *Chairman.*

REPORT OF COMMITTEE XVIII—ON ELECTRICITY

Edwin B. Katte, *Chairman;*
D. J. Brumley, *Vice-Chairman;*
H. M. Bassett,
R. Beeuwkes,
R. D. Coombs,
J. C. Davidson,
Walt Dennis,
R. H. Ford,
A. H. Hogeland,
G. W. Kittredge,
C. E. Lindsay,
H. K. Lowry,
W. L. Morse,
A. E. Owen,
R. S. Parsons,
J. R. Savage,
M. Schreiber,
E. B. Temple,
W. M. Vandersluis,
S. Withington,

Committee.

To the American Railway Engineering Association:

The following subjects were assigned to the Committee on Electricity for study and report:

1. Make thorough examination of the subject-matter in the Manual, and submit definite recommendations for changes.

2. Continue collecting statistical data relative to the clearance of third rail and overhead working conductors.

3. Study and report on electrolysis and its effect upon reinforced concrete; report upon methods of insulation and guarding against electrolysis, and coöperate with the American Committee on Electrolysis in the preparation of its future report.

4. Report on the study of maintenance organization and its relation to track structures.

5. Report upon the utilization of water power for electric railway operation, conferring with the Committee on Conservation of Natural Resources.

6. Submit specifications for insulated wires and cables.

7. Study and report on electrical interference with telephone and telegraph lines caused by propulsion circuits, enlarged to include a report recommending practice for eliminating, so far as practicable, interference with signal, telephone and telegraph lines caused by propulsion circuits and adjacent transmission lines.

8. Study and report on underground conduit construction with a view of preparing plans and specifications for underground conduit and splicing chamber construction for transmission and power distribution cables, working in conjunction with appropriate committees from the Signal Section and the Telegraph and Telephone Section of the American Railway Association.

9. Coöperate with the United States Bureau of Standards in the revision of the National Electrical Safety Code and other codes of similar character.

Committee Meetings

Meetings of the Committee were held in Chicago on May 19th and September 15th, and in New York City on July 13th and October 21st and 22nd. The names of the members in attendance have been given in the Minutes of the meetings which have been forwarded to the Secretary.

(1) Revision of Manual

Included in Appendix E are given additional electrical definitions recommended for the Manual in connection with the Specifications for Underground Conduit Construction.

(2) Clearances for Third Rail and Overhead Conductors

No revision is recommended in the tables giving Data Regarding Third Rail Clearances or in tables giving Data Regarding Overhead Clearances. These tables were revised and brought up to date last year and it is thought that if similar revision occurs every two years it will be sufficient.

(3) Electrolysis

In Appendix A the Committee reports on the subject of Electrolysis and its effect on reinforced concrete, and its recommendations are given under the conclusions.

(4) Maintenance Organization

The Committee has no report to offer in regard to Maintenance Organization and its relation to track structures. The matter has been under consideration and a questionnaire has been prepared but the re-study has not advanced sufficiently far to warrant at this time revisions in the previous reports.

(5) Water Power

In Appendix B the Committee reports on the subject of Water Power for electric railway operation, and its recommendations are given under the conclusions.

(6) Specifications for Insulated Wires and Cables

In Appendix C the Committee submits Railroad Specifications for Electric Wires and Cables for approval and printing in the Manual as recommended practice.

(7) Electrical Interference

In Appendix D the Committee reports on the subject of Electrical Interference, and its recommendations are given under the conclusions.

(8) Underground Conduit Construction

In Appendix E the Committee submits Railroad Specifications for Underground Conduit Construction for Power Cables for approval and printing in the Manual as recommended practice; also submits definitions of additional electrical terms for printing in the Manual; also submits a memorandum descriptive of "Stone Ducts" for underground conduit construction.

(9) National Electrical Safety Code

In Appendix F the Committee reports the results of its work in collaboration with the United States Bureau of Standards in the revision of the National Electrical Safety Code.

(10) Standards

In Appendix G the Committee submits a report on Standards and submits for printing in the Manual as recommended practice a list of Standard Incandescent Lamps.

CONCLUSIONS

1. The Committee recommends for inclusion in the Manual the additional electrical definitions enumerated in Appendix E.

2. The Committee recommends that the report on Electrolysis and Insulation, being Appendix A, be accepted as information and published in the Proceedings, the subject to be continued and the Committee be authorized to continue its representation on the American Committee on Electrolysis.

3. The Committee recommends that the report on Water Power, being Appendix B, be accepted as information and published in the Proceedings and the subject continued.

4. The Committee recommends that the Railroad Specifications for Wires and Cables, being Appendix C, be approved and printed in the Manual as recommended practice.

5. The Committee recommends that the report on Electrical Interference, being Appendix D, be accepted as information, published in the Proceedings and the subject continued.

6. The Committee recommends that the Railroad Specifications for Underground Conduit Construction for Power Cables, being Appendix E, be approved and printed in the Manual as recommended practice.

7. The Committee recommends that the report on the National Electrical Safety Code, being Appendix F, be accepted as information, published in the Proceedings and that the Committee be authorized to continue its coöperation with the United States Bureau of Standards.

8. The Committee recommends that the Railroad Specifications for Incandescent Lamps, being Appendix G. be approved and printed in the Manual as recommended practice, and that the subject of Standardization of Electrical Objects be continued.

Recommendations for New Work

The Committee recommends that in addition to continuing the present uncompleted assignments as above enumerated, the following new subjects be added:

1. In addition to the report on the utilization of water power for electric railway operation, coöperate with the United States Geological Survey in connection with the "Superpower Survey." Allso with the "Water Power League of America," with the object of keeping the Association advised with regard thereto.

2. Study and report on overhead transmission and distribution line construction for railroad use, with the view of preparing plans and specifications for aerial construction, working in conjunction with appropriate committees from the Signal Section and Telegraph and Telephone Section of the American Railway Association.

Respectfully submitted,

THE COMMITTEE ON ELECTRICITY,

EDWIN B. KATTE, *Chairman.*

Appendix A

ITEM (3) ELECTROLYSIS AND INSULATION

M. Schreiber, *Chairman;*
E. B. Katte, *Vice-Chairman;*
W. M. Vandersluis,
A. E. Owen,
Sub-Committee.

The Committee was instructed to report on the study of Electrolysis and its effect upon reinforced concrete and to report upon methods of insulation for guarding against electrolytic action, and, further, to coöperate with the American Committee on Electrolysis in the preparation of its future reports. The Committee reports as follows:

(1) Study of Electrolysis and Its Effect on Reinforced Concrete

Your Committee on Electrolysis of reinforced concrete structures exposed to sea water suggested in 1919 four methods of prevention of the electrolytic troubles and disintegration of concrete structures. Since that time, with the assistance of Doctor Alleman, of Swarthmore College, we made a further study of the four suggestions as outlined in the last year's report, and now wish to submit our conclusions that the three first methods as proposed are not practical on account of the high cost. The fourth method, consisting of protecting the concrete structure with a waterproof shell, is, in our opinion, the most plausible because this arrangement does not only protect the reinforcing bars from moisture and later oxidation, but also protects the concrete surrounding the rods from abrasion and eventually exposure of the iron.

Your Committee also wishes to call attention to the necessity of using the proper waterproofing material on the inside of the protecting shell. This waterproofing pitch should be material that would remain flexible for an indefinite time; it should have a melting point in the neighborhood of 200 deg. Fahr., and be elastic and stretch at least one-half inch at a temperature that was freezing or less, and have approximately an inch stretch at 60 deg. Fahr. If the pull is gradually applied, the stretch of the pitch should be approximately six or seven inches at 60 deg. Fahr. It is rather a surprising fact that such material has been manufactured for twelve or fifteen years but has not generally been used for waterproofing, but used for roofing material and in pavements. It was made by distillation of an asphalt base and oxidized by blowing with air. This latter process is what gives the material its stretching quality.

We have examined samples after twelve years' exposure and find they are still elastic. Waterproofing material with practically the same characteristics has also been found in a natural state in asphalt beds in

France and Texas. Unfortunately, even this asphaltic petroleum pitch is not stable since the advent of automobiles, because the pitch is soluble in gasoline, which is liable to be present in modern city sewerage. Recently experiments have been performed at the Swarthmore College laboratories that show an elastic waterproofing pitch may be made from coal tar, with all the characteristics of the asphaltic petroleum pitch, and it is insoluble in gasoline. So it is anticipated that it will not be so long before not only the asphalic petroleum pitch will be available in a commercial way, but also pitch made from coal tar.

The reason this material could not be obtained in this country from coal tar in the past, is on account of the fact that the ordinary still causes cracking or burning and a multiple continuing still is required to get the necessary results.

It is necessary not only to enclose the sides of the reinforced concrete structure with a waterproof shell, but also is it necessary to protect the top or any other portion of the concrete structure that is exposed with a waterproof pitch, otherwise the salt air or moisture will penetrate the concrete and sooner or later the rods will oxidize and burst the structure.

(2) American Committee on Electrolysis

The American Committee on Electrolysis is made up of twenty-seven engineers, three from each of the following organizations:

American Railway Engineering Association,
American Electric Railway Engineering Association,
American Institute of Electrical Engineers,
American Telephone and Telegraph Company,
American Waterworks Association,
National Electric Light Association,
American Gas Association,
National Gas Association,
United States Bureau of Standards.

The purpose of this Committee is to promote coöperation among the several component organizations and by studies, investigations, research and discussion to secure ultimately a reasonable solution of the electrolysis problem and to suggest methods of mitigation. A brief description of the prior work of this Committee is contained in last year's report of the Committee on Electrolysis. This year the Committee on Electrolysis held one meeting in New York City on March 5th, the various sub-committees reporting very little progress in the preparation of the report. Since that date, however, the Research Sub-Committee has been active and has held meetings monthly. The principal work has been the field investigation of electrolysis at high resistance joints in gas and water mains. Much valuable information has been obtained and considerable progress is being made.

The Chairman of the Committee on Electrolysis, Mr. Bion J. Arnold, on June 30, 1920, wrote to the Chairmen of the sub-committees as follows:

"In view of the fact that there is considerable activity on the part of various municipal and state bodies on the question of electrolysis, and that some of these bodies are likely to adopt rules or enact laws on the subject, I deem it important that the work of the sub-committees (with the exception of the Research Sub-Committee which has been for some time and is now active) become immediately more active so that their reports may be presented to the Main Committee in time to enable the latter to issue a report by the end of the present year, viz., not later than December 31, 1920."

Your representatives of the Committee on Electricity have drafted that portion of the report entrusted to them. There have been no recent meetings of the American Committee on Electrolysis and the subject is waiting the preparation of text by the various sub-committees.

Appendix B

ITEM (5) WATER POWER

G. W. KITTREDGE, *Chairman;*
W. L. MORSE, *Vice-Chairman;*
D. J. BRUMLEY,
R. BEEUWKES,
R. D. COOMBS,
J. C. DAVIDSON,
R. H. FORD,
Sub-Committee.

In the preparation of the report on Water Power for the generation of electrical energy for the operation of trains, the Committee this year selected the electrification of the Norfolk & Western Railway for consideration, since this railway derives a part of its electric energy from water power, although its main source of supply is a steam operated power station.

NORFOLK & WESTERN RAILWAY ELECTRIFICATION

(1) General

In the spring of 1915, the Norfolk & Western Railway Company put into operation what is known as the "Elkhorn Grade Electrification," extending west from Bluefield, West Virginia, to Kimball, West Virginia. The electrically operated territory includes about thirty miles of main line, in addition to branch lines. The maximum grades against eastbound tonnage are 2 per cent. The miles of single track electrically equipped are:

Main track and cross-overs	56.98
Yards and sidings	30.58
Branches	18.69
Total	106 25

The section electrified forms part of the Pocahontas Division of the railway in the heart of the Pocahontas coal field, and is essentially a gathering section where heavy coal or "tonnage" trains are made up for movement east to tidewater at Norfolk, and west to the industrial centers in the Middle West and to the Great Lakes. The grades are heavy and the curvature severe, and movement under steam conditions was further restricted by the single-track tunnel at the summit of Elkhorn Mountain. Electrification was decided upon primarily to secure greater facility of movement in a given time. It also developed that the economy of electric operation was an important factor.

The system of electrification in use is 11,000 volt, 25 cycle, single-phase, using an overhead catenary trolley. In addition to the main trolley system, there is a duplicate 44,000 volt, single-phase transmission system feeding power from the power house to the line through five transformer substations. Power is generated in a steam plant located near Bluestone, with an installed generating capacity of 36,000 kilowatts in four generators of 9,000 kilowatts each. There is also in interchange for emergency purposes with the Appalachian Power Co. at Switchback, which provides for a transfer of power when necessary of about 10,000 kilowatts.

(2) Types and Characteristics of Locomotives

Movement of heavy coal trains being the most important function of this electrification, the locomotives were designed mainly for this purpose, and twelve engines were built of the double cab, or two-unit design. Each cab is carried on two trucks, each truck being equipped with two motors operating through gears, jack shafts and side rods. The distinctive electrical feature of these locomotives is the provision of means whereby single-phase 11,000 volt current received from the trolley is changed by means of a transformer and phase converter in each cab to three-phase, 750-volt current for use in the motors. The motors are of the induction type, so designed as to operate with either four-pole or eight-pole connection, giving two operating speeds, which are fourteen and twenty-eight miles per hour, the lower speed being used for heavy tonnage work while the higher speed handles passenger and merchandise freight service. The use of induction motors makes the question of electric braking on grades a simple one and the regenerative feature in this operation has been entirely successful. The main dimensions and characteristics of the locomotives are:

Length between coupler faces	105′ 8″
Total wheel base	83′ 10″
Rigid wheel base	11′ 0″
Total weight in running order	308 tons
HP. maximum, accelerating at 14 m.p.h.	4500
HP. " " " 28 m.p.h.	6400
HP. 1-hour rating at 14 m.p.h.	3300
HP. " " " 28 m.p h.	4500
HP. continuous rating at 14 m.p.h.	2600
HP. " " " 28 m.p.h.	3000
Tractive effort, maximum accelerating	125,000 lb.
Tractive effort, 1-hr. rating 14 m.p.h.	87,000 lb.
Tractive effort, 1-hr. rating 28 m.p.h.	44,000 lb.
Tractive effort, continuous at 14 m.p.h.	68,000 lb.
Tractive effort, continuous at 28 m.p.h.	40,000 lb.

(3) Power House Curves

Two charts marked "A" and "B" are submitted showing power house output for two particular days, October 11, 1918, and April 21, 1920. The first shows a heavy day as regards power house conditions caused by emergency supply of 117,000 K.W.H. to the Appalachian Power Company. The second shows heavy load caused by freight conditions but without emergency power supply. The following summary of operating data is submitted:

A.C. K.W.H. Generated	(1) Oct. 11, 1918	(2) Apr. 21, 1920
25 cycle	353,500	249,800
60 cycle	936	1,056
Totals	354,436	250,856
Total A.C. load for 5 minutes	18,500	21,000
Average power factor, per cent	70	65
Load factor, per cent—5 minutes	79.6	49.5
Load factor, per cent—1 hour	85.6	72.7

These loads were carried by two generators, the other two being held in reserve. Note the high load factor on No. 1 due to the fact that supply of emergency power to the Appalachian Power Company helped to fill in the low points of the curve.

It is also important to note that these curves are irregular in the sense that no periodical peaks are shown. This is noticeably different from operation such as is met with on other heavy traction systems where regular morning and evening peaks of known amount are encountered. This will be commented on further. To illustrate the variation in load, a section of the power house wattmeter curve is submitted covering a period of three hours from 9:00 p. m. to 12 midnight on a typical day.

(4) Operating Conditions

The outstanding features of the Norfolk & Western Electrification are the irregular spacing of trains and the ability of the generating equipment to supply large blocks of power on short notice, this being made necessary by the fact that all heavy freight trains are run as extras. These heavy trains are made up in the electrified territory and may start up on very short notice. There have been instances where the power house load has increased from 2,000 K.W. to 25,000 K.W. in less than five minutes, due to this condition.

One of the outstanding results of electrification has been the greatly reduced round trip time of engine and train crews. Previous to electrification, a standard tonnage train of 3250 tons required three Mallet locomotives up the two per cent grade, making an average speed of 7½ miles per hour, while with electric locomotives the same train is handled by two engines at a uniform speed of 14 miles per hour. Under steam conditions, the round trip time of a crew out of Bluefield averaged 12 hours, while with electric operation, the round trip time averages 7 hours. Another important point is the reduction in time to prepare engine for its next trip. Under steam conditions, the time required to prepare a Mallet locomotive, including inspection, light repairs, cleaning fires, etc., is from ten to twelve hours, while in the case of the electric locomotives, forty minutes is allowed. As regards the handling of trains, with electric locomotives, the acceleration is smoother than with steam, which reduces the number of break-in-twos to a minimum. The regeneration feature which provides electric braking on downgrades is most valuable, as it leaves the air brakes in reserve for emergency and provides for smooth operation in descending long, heavy grades with trains of empties up to one hundred cars. There have been no failures reported of the regeneration feature.

Delays to operation through failure of power house transmission, sub-station, trolley or track bonding have been relatively few. For the year 1919, the percentage of engine hour delays due to all the foregoing was 0.3 per cent.

(5) Electrical Interference

(See Appendix D, item (6)).

(6) Purchasing Power

The question has been frequently asked why the railway company installed a steam-driven plant for power generation when hydro-electric power was available. At the time when plans for electrification were being perfected, this subject was studied in detail and the decision to generate by steam was arrived at after careful consideration. There were two main factors involved; first, the question of cost; second, continuity of supply. In 1913 and 1914, power station coal could be placed in the railway company's bunkers at less than one dollar per ton, and on this basis power could be produced more cheaply than it could be purchased. With the present high prices of this coal, the comparison is on an entirely different basis. As to continuity of power, hydro-electric concerns in the vicinity are affected materially by shortage of water at certain seasons of the year, and at the time electric operation was decided upon, very little steam reserve power was available. It was felt that it would be unwise for the railway to rely upon an outside source of power which was liable to interruption from shortage of water or other causes. The history of the electrification has justified the decision. Through the emergency connection with the Appalachian Power Company, the railway has frequently had to supply power to enable the hydro-electric company to maintain its service. For instance, in the month of June, 1920, the railway out of a total output of 8,768,000 kilowatt hours, furnished the power company 2,540,000 kilowatt hours, or about 27 per cent of the total. However, in the case of future extension of electrification, the situation will require careful study and consideration as to the possibility of a mutual arrangement whereby either party to the agreement would benefit from the available installed capacity of the other.

(7) Contractual Relation with Power Company

In 1916, a reciprocal agreement was effected between the railway company and the Appalachian Power Company whereby, in emergency, either company would supply the other with power. Under the terms of this agreement, the power company installed at its own cost in its plant at Switchback, a frequency changer with connections to the railway company's substation at Maybeury. The amount of power which can be transferred is, of course, limited by the capacity of the frequency changer, which is 10,000 kilowatts. All power exchanged is metered at the power company's side of the apparatus and consequently the railway stands all loss of transmission and conversion. As a partial compensation, the power company paid for power supplied 33 per cent more than the railway company paid for power received. Payments originally were based on a flat rate per kilowatt hour.

Due to the great advance in cost of coal, a supplementary agreement was put into effect in 1918, whereby a sliding scale adjustment was applied to the price charged the power company to cover increase in cost of coal. No change was made in the price for hydro-electric power received from the power company, but provision was made that in the event of steam generated power being received from the power company from their steam reserve plants, the railway company would pay for this steam power on the same basis as the power company pays the railway. No adjustments has yet been made to cover increased cost of labor and material.

Under present conditions, the advantages of this emergency connection are slight insofar as the railway company is concerned. The amount of power available at any time is insufficient for traction purposes without keeping the railway company's Bluestone plant in complete operation. At times, it has been possible to use the power company's supply and shut down one machine.

There is, however, a distinct advantage due to the fact that the operation of the frequency changer can be handled so as to improve the system power factor of the railway. The use of the frequency changer as a condenser increases the power factor by 10 to 15 per cent.

(8) Operation Costs

As the electric service now maintained is on an entirely different basis from the former steam service, it is impossible to give a direct comparison of cost. It has therefore been considered advisable to give the following comparison between steam and electric freight locomotive operation, using the records and figures compiled for use in the company's annual report. In this comparison, all costs entering into operation as well as interest and depreciation have been taken into account and while the figures are necessarily approximate, it is believed they are sufficiently close to be representative:

Comparative Cost Per Million Tractive Miles

Items	*Steam*	*Electric*
Interest and depreciation	$4.36	$12.16
Repairs	7.64	6.40
Fuel of elec. power at loco	13.00	6.19
Lubricants and waste	.16	.05
Supplies	.16	.16
Engine house expenses	2.18	.56
Water	.51	.00
Wages	1.89	.70
Total per million tractive-miles	$29.90	$26.20
Per cent saving	12.5 per cent	

Attention is called to the unit of comparison, "Tractive-miles," which is the product of the maximum tractive power in pounds and total miles run. This affords a direct comparison.

In explanation of the table given above, it will be noted that the interest and depreciation figure for electric locomotives is much higher than that given for steam. This is because all of the electric cost has been charged against the number of engines in service, i. e., each engine carries its share of power house transmission, distribution, etc. The actual electrification installation costs have been increased in this table over 100 per cent to adjust the values to those prevailing in 1919.

The cost of electric locomotive repairs has been reduced below the actual figures in order to eliminate charges which have been due to the development of a new design. In other words, the electric locomotives now in service have been experimental, and could they be replaced today by new equipment it is entirely reasonable to expect the figures shown for repairs would be representative. In this connection it is pointed out that the power house, substations and transmission lines generally are designed for considerably larger service than is now given, or in other words, with the provision of three or four more locomotives and a relatively small expenditure in the power house the service could be much increased; consequently, the figure for interest and depreciation would be considerably reduced.

(9) Conservation of Fuel and Saving in Wages

An important question today in connection with the general movement towards conservation of fuel is how much actual fuel can be saved by electric operation, and in this connection the Norfolk & Western Railway has found that with the modern Mallet, compound superheating steam locomotive, equipped with all improvements excepting feed-water heater, about 5.4 pounds of fuel are required per drawbar H.P. hour, taking into account road conditions and allowing for standby losses. It should be noted that these figures assume the engine to be in thoroughly good operating condition. With electric operation, about 3.3 pounds of fuel are required per drawbar H.P. hour in the present electric service, which gives a direct saving in the fuel bill of about 40 per cent. This amounts to a total saving for the present "Elkhorn Grade" Electrification of about 60,000 tons of fuel coal per year. Applying the same ratio of saving to the whole Norfolk & Western System, it is estimated that with complete electric operation the net saving in amount of fuel used would be nearly one million tons per year.

In the case of crew wages, it will be noted that on the "Tractive-mile" basis the saving in crew wages is over 60 per cent. A comparison on another basis can be made by comparing the round trip times. The average round trip time for an electric crew between Bluefield and the coalfield is somewhat under seven hours, whereas the best average time under steam conditions formerly was somewhat over twelve hours. Therefore, to make a direct comparison, the seven crew hours in electric operation should be compared with fourteen hours in steam operation, taking into account punitive overtime. This in itself would show a saving of 50 per cent in the crew cost, but as there is of course a certain amount of overtime made by electric crews, the net saving is between 35 and 40 per cent.

One important point is that with the present facilities and volume of traffic, it is problematical whether the tonnage could be moved at all with steam. The only possible way to do so would be to increase the number of engines per train so that a schedule speed could be maintained equal to the present electric speeds. This would require probably four Mallet steam engines per train as compared with the two electrics on the heaviest grades, which would increase the operation costs much beyond those shown in the table, and if the percentage of engine failures were at all unusual, the service would be unreliable.

(10) Mileage of Electric Locomotives

The total electric locomotive mileage made for the six months ending June, 1920, was 224,974, or an average of 34,162 per month. The average number of locomotives in service per day is about eight, which establishes an average figure of 135 miles per locomotive per day. In the case of individual locomotives, this is considerably exceeded.

(11) Energy Per Locomotive and Per 1000 Ton-Miles

The company's records show that the kilowatt hours at the power house per locomotive mile are about 160, while the watt hours per trailing 1000 ton-miles are about 165.

(12) The Application of the Electrification of the Norfolk & Western Railway to Other Railways

In a general way the following statements can be made regarding the utilization of electrical energy for the operation of other railways similarly situated.

(1) That 44,000 volts, single phase, 25 cycle transmission of electric power with 11,000 volts, single phase on the trolley wire are practical and reliable voltages for electric train service for heavy grades and heavy tonnage.

(2) The average daily gross tonnage of freight eastbound over the electrified grade on the Norfolk & Western for 1918 was 47,500 tons as compared with 32,000 tons in 1912, an increase of over 50 per cent. The ultimate capacity based on the present installation is stated as 80 per cent over that of 1912.

(3) That such a system of electrification will probably effect a saving of at least 12½ per cent of the total annual expense as compared with steam operation on a railway with similar characteristics.

(4) That the introduction of electric locomotives with electric brakes (regenerative braking) has made possible higher speeds on heavy grades, with greater safety and reliability under all climatic conditions.

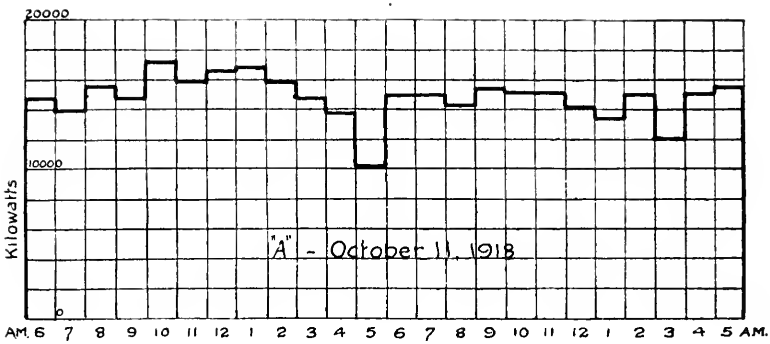
Water Power

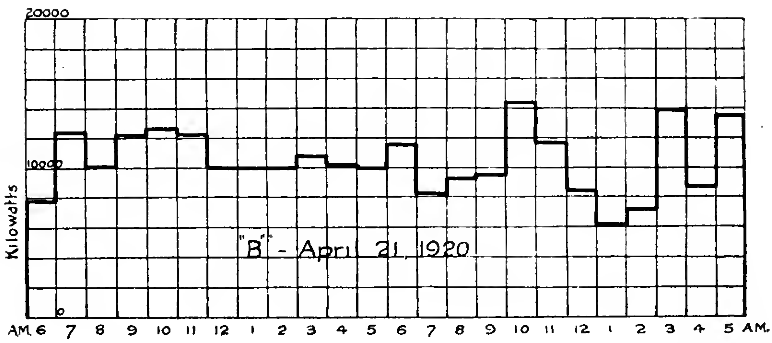
(1) Hydro-Electric Plants Usually Augmented by Steam

An investigation of the larger hydro-electric installations east of the Mississippi River covering fifty-three plants discloses the fact that thirty-three are augmented by steam. In the majority of cases this is to care for the dry season. In considering future development for railway electrification, it is therefore reasonable to suppose that steam augmentation will be necessary.

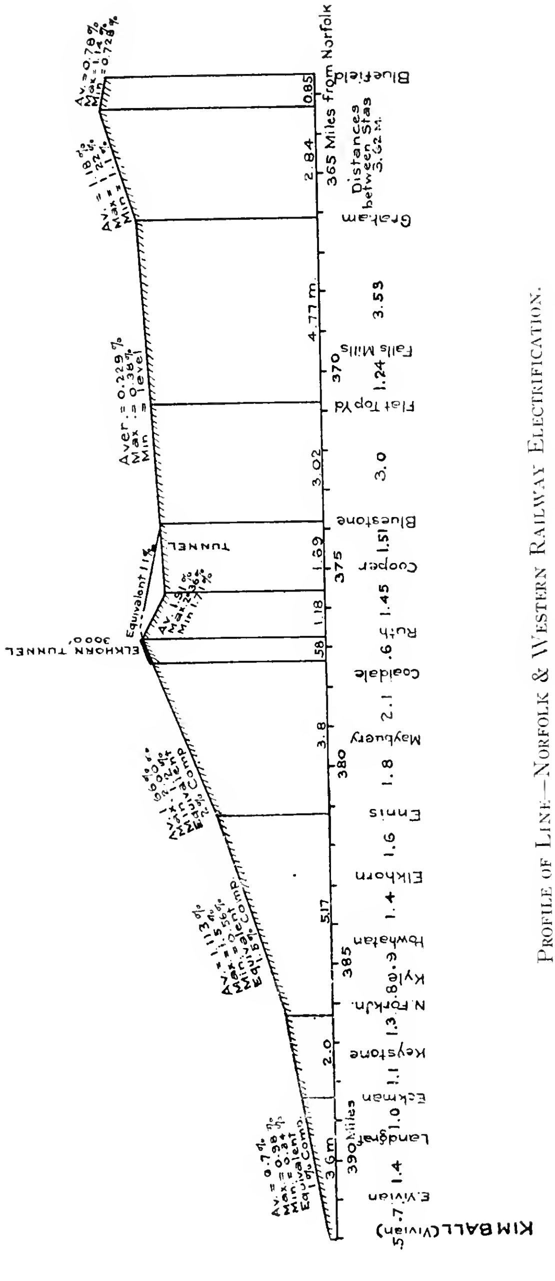
(2) Water Power League of America

Attention is called to the Water Power League of America, incorporated to promote the conservation of water power. The formation of this League should relieve this Committee from attempting to report at large on this subject. From time to time your Committee will advise the Association concerning the activities of this League.

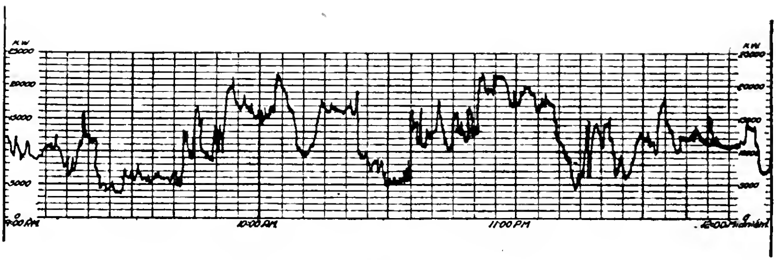




Curves Showing Power House Output—Norfolk & Western Railway Elkhorn Grade Electrification



PROFILE OF LINE—NORFOLK & WESTERN RAILWAY ELECTRIFICATION.



Power Station Wattmeter Curve—Typical Day.

April 21, 1920.

Norfolk & Western Railway.

Appendix C

ITEM (6) SPECIFICATIONS FOR INSULATED WIRES AND CABLES

E. B. Katte, *Chairman;*
J. R. Savage, *Vice-Chairman;*
H. K. Lowry,
S. Withington,
W. M. Vandersluis,
Sub-Committee.

The Committee has completed the Specification for Electric Wires and Cables, coöperating with the Committee on Insulated Wires and Cables of the Signal Section of the American Railway Association. Copies of the specification have been sent to appropriate committees of the American Institute of Electrical Engineers; the American Electric Railway Engineering Association; American Engineering Standards Committee; Committee on Transmission and Distribution, American Institute Electrical Engineers and the National Electric Light Association, with the suggestion that they consider the provisions therein contained with a view of adopting the same or similar requirements to the end that eventually there may be a uniform joint specification for insulated wires and cables; and informed these committees that the Committee of this Association will hold itself in readiness to confer with the purpose of, from time to time, revising and bringing this specification up to date.

It will be noted that the specification is general in its character and is intended for file in the office of the Purchasing Agents and Manufacturers for their information concerning general requirements. On requisitions for wires and cables should be noted that the general requirements of the Specification for Wires and Cables will apply, and, written thereon will be the quantity, dimensions, materials and other characteristics of the particular wire or cable required. This method has been in vogue for many years on several railroads and has proved economical and convenient.

Your Committee recommends the adoption and printing in the Manual, as recommended practice, the Railroad Specification for Electric Wires and Cables, dated September 15, 1920, copy of which is appended hereto.

Appendix D

ITEM (7) ELECTRICAL INTERFERENCE

H. M. Bassett, *Chairman;*
W. M. Vandersluis, *Vice-Chairman;*
J. C. Davidson,
A. H. Hogeland,
E. B. Temple,
R. Beeuwkes,
S. Withington,
Sub-Committee.

This Sub-Committee was charged to report "recommended practice for eliminating, so far as practicable, interference with telephone, telegraph and signal lines caused by propulsion circuits and adjacent transmission lines."

The activities of the Committee during the year have been based primarily on the securing of information requested by a questionnaire framed as follows in order to obtain basic general data from which it is hoped that the Committee may later draw conclusions which will be recommended to the Committee on Electricity, and through them to the Association for approval:

1. Inductive or electrical interference from transmission and distribution systems on telegraph, telephone and signal circuits,
    - (a) Under normal conditions,
    - (b) From short circuits or grounds.
2. Electrical interference as affecting the safety of employees and the public, with special reference to the kind and extent of trouble experienced.
3. What electrical interference troubles have you been able to trace to electrolytic conditions?

In connection with the answers to the above questions, it is desired that complete and detailed data as to interferences, with reference to the specific kind of trouble experienced, be submitted with a view that the Committee may analyze and tabulate the answers submitted by the railway company; and in submitting the above data, the Committee desires that the method employed to overcome these interferences be set out in detail, both in connection with the power systems, the railway telegraph and telephone systems, and the commercial communication systems.

It should be realized that, in order to make an intelligent survey of the data submitted, each railway should forward general information as to the type of installation of electrical apparatus, track construction, local climatic conditions, nature and amount of traffic, and method of controlling power circuits; and the answers should be accompanied by diagrams showing railway circuits and parallel circuits, as far as possible.

The above questionnaire was forwarded to the New York, New Haven & Hartford Railroad, the Pennsylvania System, the Long Island Railroad, the Norfolk & Western Railway, the Southern Pacific Company, the Great Northern Railway, the Erie Railroad, the Chicago, Milwaukee & St. Paul Railway, the New York Central Railroad, and the Public Service Railway (New Jersey).

The information which has been received in answer to the questionnaire to date summarize as follows:

(1) New York, New Haven & Hartford Railroad

The electrified zone of the New York, New Haven & Hartford Railroad extends between New York and New Haven, a distance of about seventy-two miles, of four-track and six-track railroad. Both passenger and freight service is handled electrically, and the traffic is very dense, especially during the early morning and late afternoon hours.

The installation is single-phase, eleven-thousand volt, twenty-five cycle, fed from one power plant, at Cos Cob, with an auxiliary feed-in plant at West Farms.

Auto transformers with a ratio of 1 to 2 at the power stations step up the voltage from 11,000 volts (at the generator terminals) to 22,000 volts. The center point of these transformers is grounded to the rail; one terminal is connected to the trolley wires, and the other to feeders. The voltage between trolleys and feeders is thus 22,000 volts and between feeders or trolleys and ground only 11,000 volts.

At various points along the right-of-way, at intervals of approximately four miles (dependent on the load conditions), auto transformers are connected between the trolley and feeder phases, the neutral point of these auto transformers being connected to the rail.

The system is thus virtually analagous to the common Edison three-wire system, the load being balanced through the line transformers. The benefits of 22,000-volt transmission with 11,000-volt distribution are thus obtained.

In addition to the main line electrification, there is a short stub-end section of single-track branch line, fed from the main line, which has been experimentally equipped with "Boost Transformers." The primaries are connected around section breaks in the trolley and the secondaries around insulated joints in the rails. These transformers act to keep the return current in the rails and have been successful in eliminating interferences from induction. The system is similar in principle to that applied in connection with the Pennsylvania Railroad (Philadelphia to Paoli) and Norfolk & Western Railway electrification.

The communication circuits are cabled in the Electrified Zone.

In order to conform to the requirements of the commercial companies and thus to allow connection with commercial switchboards, this cable line was built with a minimum separation of ten feet from any high tension circuit, and no aerial crossings over or under high tension lines were allowed.

The cable is made up of 45 pair, paper insulated, lead-covered No. 10, No. 13 and No. 16 gage conductors. The lead sheath is thoroughly grounded at frequent intervals which eliminates all trouble from electrostatic induction. The total distance is seventy-two miles, fifty-six miles of which is aerial construction. Where there are physical high-tension crossings or where the right-of-way is so restricted that the required clearance is not obtainable, the cable is run in underground conduit. The aggregate length underground is sixteen miles.

In the cable there are the following classes of telephone service:

(1) Train despatching circuits, equipped with selectors.

(2) Load despatcher (power director) circuits, similarly equipped.

(3) Tie lines for handling general business between New Haven and New York, and from each of these points to intermediate private branch exchanges located at Bridgeport, Stamford and Cos Cob, all connected with commercial outside circuits.

(4) Local telephone circuits connected with all signal bridges more than 1000 feet distant from towers or stations.

The train despatching circuits between New Haven and New York are No. 10 non-loaded circuits. Those operating between New York and South Norwalk and the Load Despatcher's circuits east and west of the Cos Cob power plant are No. 13 non-loaded circuits. The telephone tie lines between New York and New Haven, handling connections between New York and Boston and other points north and east of New Haven, are medium loaded No. 13 gage.

The tie lines from New York to New Haven and intermediate private branch exchanges are No. 16 gage, medium loaded. The local tower circuits are No. 16 gage non-loaded.

Under normal operating conditions all classes of these telephone circuits are quiet, and no trouble of any kind is experienced. However, on occasions of heavy short circuits on the traction system, so-called "acoustic shocks" have been experienced, and in order to minimize these, drainage coils have been installed at various points along the line, these coils consisting of resistance or condensers in series with retardation coils.

Occasional trouble due to high ground potential is experienced during especially severe short circuits in the traction system.

Repeating coils have been installed at each of the private branch exchanges between the cable conductors and the switchboards. The protection on the line side of the repeating coils is the same as that used at way stations on the despatching circuits (2000-volt), while 350-volt protection is installed on the switchboard side of the repeating coils.

Loud-speaking receivers are being installed in the despatcher's offices where acoustic shocks present the greatest difficulty.

Active tests are being made in connection with both the new telephone cable and the high tension transmission system, with a view to obtaining a quantitative analysis, and much valuable data is being collected in connection with these tests.

No difficulty has been experienced affecting the safety of employees or the public, except the above mentioned occasional acoustic shocks.

The electrified zone runs through a particularly thickly settled district with trolley lines paralleling the railroad the entire distance. Some electrolytic trouble has been noted in water pipes and lead-covered cables. This, however, is due entirely to outside stray currents and no difficulty has been noticed in connection with the A.C. traction circuit.

No trouble which can be charged to induction has been experienced in connection with the automatic signals.

PENNSYLVANIA RAILROAD

(2) Paoli Electrification

The Paoli electrification extends for a distance of 21.3 miles from Broad Street, Philadelphia. Power for the operation of the system is obtained from the Philadelphia Electric Company and delivered to the Arsenal Bridge Substation at 13,200 volts, 25 cycle, three phase. At the Arsenal Bridge Substation, which is about a mile west of the electrification, the power is stepped up to 44,000 volts single phase. Step-up transformers are Scott connected, one phase of the high potential side supplying power for the Paoli electrification and the other side for the Chestnut Hill Branch.

There are three step-down substations for supplying power to the Paoli electrification as follows:

West Philadelphia
Bryn Mawr
Paoli

At the above substations the 44,000-volt power is stepped down to 11,000 volts and supplied to the trolley system.

At the Arsenal Bridge substation the middle point of the 44,000-volt windings on the step-up transformers is grounded through a grid resistance which limits the flow of current in case of grounds on the 44,000-volt transmission lines.

The trolley system is sectionalized at each substation.

Booster transformers were installed to prevent the leakage of current from the rails into the earth. The primaries of these transformers are connected across section breaks in the trolley system and the secondaries are connected across impedance bonds used in connection with the signal system. It was found that the booster transformers were of little value and practically all of them have been removed.

All telephone and telegraph circuits are underground.

Tests made showed that under operating conditions it was desirable to provide some means for limiting the amount of current which would flow through relays on the telegraph circuits causing the relays to chatter. A comparatively simple remedy was found in the use of resonant shunts, and with them complete protection with induced voltages as high as 120 volts was provided. These shunts operate also successfully with composite and duplex Morse circuits and with printing relays. The reactance and capacities making up the resonant shunt are so selected that the shunt is resonant to 25-cycle current, thus providing a bypass for current of this frequency and preventing damage to the relay.

On local or way circuits it was found that anti-resonant shunts located at the ends of circuits afforded the desirable protection. This shunt operates as an impedance to 25-cycle current, thus limiting the flow of current through the relay.

In order to provide against the receiving of shock by persons using telephone instruments all metal parts of instruments with which persons could come in contact are insulated. Wooden platforms are provided on which persons using telephones may stand. Magnetic telephone wall sets are used. The protector used on this circuit is reliable between 350 and 700 volts.

Relays are installed in exchanges to balance up circuits to prevent noise. No electrolytic troubles have been experienced.

(3) Chestnut Hill Electrification

The Chestnut Hill electrification extends for a distance of 13.2 miles from Broad Street. Power is supplied from the Arsenal Bridge substation to West Philadelphia substation, 1.1 miles from Broad Street. The North Philadelphia substation is 4.3 miles from West Philadelphia and the Allen Lane substation is located 5.34 miles from the North Philadelphia substation. These substations are supplied with 44,000-volt single phase power, the same as the substations on the Paoli electrification.

Before the Chestnut Hill branch was put into operation extensive tests were made in conjunction with the telephone and telegraph department of the railroad and the American Telephone and Telegraph Company. The result of these tests was that the installation of booster transformers was unnecessary, as sufficient protection against interference could be obtained by the use of the same apparatus as was used in the case of the communicating circuits on the Paoli electrification. The Chestnut Hill branch has been in operation for over two years and no trouble has been experienced on telephone and telegraph circuits.

The telephone and telegraph service at Philadelphia is excellent and, in fact, much better than it is in some locations where there is no electrification. It is not considered that the electrifications into Broad Street are the cause of any interference to the communicating system.

No trouble which can be charged to induction has been experienced in connection with the automatic signals.

During the last year and a half considerable trouble has been experienced on communicating circuits between Camden and Trenton. The railroad between these points is operated by steam, and is paralleled for the greater part of the way with a Public Utilities transmission line operated at 26,000-volt, three-phase, 60-cycle. Power is supplied to transmission lines from the power station about midway between Camden and Trenton. In a great many instances grounds on the transmission lines have caused considerable trouble on the railroad company's communicating circuits. Protectors have been broken down, fuses blown and in some instances operators have received a bad acoustic shock. Trouble has also been experienced on the Postal Telegraph Company's lines. The cause of this trouble is being investigated and it is expected that the installation of suitable relays to provide a very rapid opening of circuit breakers will minimize the trouble experienced.

No electrolytic troubles have been experienced.

(4) New York Terminal

The power for the operation of the Pennsylvania system is supplied from the Power House in Long Island City to four (4) transformer substations similar to those of the Long Island Railroad. The transmission lines are cabled to the substation on the Jersey side and beyond this they are open wires and are not transposed. The telephone and telegraph circuits are cabled to the same point and beyond this they are carried on a pole line as open wires on the opposite side of the right-of-way. No trouble is experienced on the communicating circuits under normal operation and in cases of short circuits or grounds on the transmission lines there has not been any trouble. Considerable trouble has been experienced from electrolysis. Several cables have become defective and it is necessary to constantly watch the potentials of cable sheaths and underground structures to prevent damage. There has been no interference with the signal system.

(5) Long Island Railroad

The power system of the Long Island Railroad consists of three-phase alternating current transmission at 11,000 volts, 25 cycles, rotary converter substations converting this A.C. power to D.C. power at 675 volts and the distribution systems consisting of third rail positive circuits and track rails bonded for return circuit. Power for the entire system is supplied by the Power House of the Pennsylvania Railroad in Long Island City, which Power House also furnishes power for the operation of the New York terminal of the Pennsylvania Railroad. There are 15 rotary converter substations at various points about 3 to 8 miles apart, the most distant substations being located a little over 20 miles from the power house.

The transmission system consists of three-phase circuits operated at 11,000 volts. The neutral of the system is grounded at the power house through a resistance, but is not grounded at any other point. The voltage from each phase to neutral is, therefore, approximately 6,000 volts. The feeders of the transmission system are both overhead and underground and for the most part consist of 250,000 c. m. copper conductors. The underground feeders are three conductor paper insulated lead-covered cables.

The overhead feeders are not transposed. In some cases, the three conductors of a feeder are spaced to form an equilateral triangle. In other cases, the three conductors are arranged in vertical formation, one above the other.

The distribution system consists of over-running contact third rail, the majority being of high capacity equivalent to 1,600,000 or 2,400,000 c.m. The direct current feeders are usually short, being tapped into the third rail directly opposite the substations. The track rails suitably bonded with copper bonds are used for the return circuit.

The transmission feeders are paralleled by telegraph and telephone circuits throughout almost their entire length. Where aerial construction is used, the transmission circuits are carried on a pole line on one side of the right-of-way and communication circuits on a pole line on the other side of the right-of-way, the distance between the two lines varying from 30 feet, with a single or two track right-of-way to 60 or more feet with a four-track right-of-way. In one section, for a distance of approximately four miles, the communication circuits are carried on the same pole line as the transmission circuits. The telephone circuits in this instance are not brought into the main telephone exchange simply as a matter of precaution. The open-wire telephone circuits are transposed at regular intervals, usually about 8 per mile. In some cases telephone and telegraph cables are routed in the same conduit system as transmission cables.

Under normal conditions, there is no perceptible interference of an inductive nature on communication circuits. There are occasional troubles due to circuits becoming unbalanced, due to one cause or another, but these are usually of short duration. The fact that almost the entire load connected to the transmission system consists of three-phase rotary converters tends to keep the transmission system in balance.

Under abnormal conditions, such as short circuits or grounds on the transmission system which are of sufficient proportion to trip out one or more high tension feeders, the unbalanced condition of the transmission line affects the communication circuits to some extent. The chief cause of this trouble seems to be due to the neutral being grounded at the power house. When a ground occurs on a phase of the transmission system, the current seeks a return path through the ground to the power house. In numerous cases it has been found that the potential of the ground has been raised near the scene of trouble to such an extent that the protective devices on the communication circuits are broken down and ground current takes this means of returning to the power house. At times of short circuit or ground excessive noise is always manifest in the telephone circuits caused by induced currents. These currents also ring bells, throw the drops on the switchboards, cause chattering of telegraph relays, etc. When ground is removed through opening of power circuit breakers, conditions again become normal.

No trouble has been experienced on the communication circuits due to electrical interference from the distribution system.

No troubles have been experienced from electrical interference which have affected the safety of employees and equipment.

Considerable trouble has been experienced through failure of paper insulated telephone cables as a result of electrolytic action. These cables run in a conduit system which parallels the electrified tracks for a distance of over eight miles. For part of this distance the conduit system is also paralleled by large water mains. Other water mains as well as tracks of trolley roads cross the conduit system at frequent intervals. Troubles from this source have been reduced through frequent electrolytic tests and surveys and the installation of drainage bonds, etc., but have not yet been entirely overcome.

(6) Norfolk & Western Railway

The Norfolk & Western Electrification is 11,000-volt, single-phase, 25-cycle, using overhead catenary trolley with 44,000-volt duplicate, single-phase transmission circuits feeding power from a steam power house to five substations located at intervals from 6 to 8 miles apart. The electrified territory extends from Bluefield west to Vivian, about 30 miles, with two short branches north and south from Bluestone to Pocahontas and Clift Yard near Simmons. The main power house is located at Bluestone. The line generally is double track with stone ballast, and bonding is maintained in first-class condition. The local climatic conditions are generally favorable as the electrification is located about 2500 feet above sea level where the air is reasonably dry and free from damp, salt atmosphere.

The traffic handled is mostly heavy coal tonnage, the average being from 15 to 20 trains eastbound per day. A certain amount of passenger and merchandise freight movement is assisted by the electric locomotives. Due to the nature of the traffic, all heavy freight trains being run as extras, the power house operation is irregular, the maximum load varying from 2000 or 3000 to 25,000 kw. in a short time. It may be noted that a standard freight train requires 12,000 hp. to accelerate on heavy grades.

The company's telephone and telegraph circuits are open wire along the company right-of-way and form a close parallel to the trolley and transmission circuits.

Under normal conditions, the inductive interference on telegraph circuits has been overcome to a very large extent by installation of 25-cycle, alternating current drainage shunts connected to telegraph relays. This in conjunction with the special booster transformer installation on traction circuits has cut down interference to a minimum.

In company telephone operation, the metallic telephone circuits pick up slight induction from harmonics in the 60-cycle signal transmission circuit, but no such trouble is experienced from the 25-cycle power used in traction. Under normal conditions, this induction is not severe and does not interfere with the operation of telephone circuits. No special provisions are made to prevent interference other than special transposition.

In the case of signal operation it is difficult to separate normal conditions from abnormal conditions, but generally speaking, under normal conditions, very little trouble is experienced.

Even under abnormal conditions, such as flash-overs, or voltage surges, no cases are on record of telegraph protectors being burned out. In telephone circuits, an abnormal condition such as ground or flash-over on the trolley or transmission circuits usually causes a surge creating an induced voltage on telephone circuits sufficient to operate protectors. This surge may rise to a little over 200 volts as compared with a normal induced voltage of 70 or 80.

In signal operation under abnormal conditions, some of the signal appliances such as track relays, track transformers, fuse holders and reaction coils are burned up. Such cases are relatively infrequent.

No trouble of any sort has been experienced which can be attributed to electrolytic conditions.

As previously stated, inductive interference on through telegraph circuits has been overcome very largely by installation of 25-cycle, alternating current drainage shunts, consisting of retarding coils with condensers. Shunts have not as yet been installed in local stations on way wires.

The only direct protection on railroad telephone circuits is transposition.

As regards protection to signal apparatus, experiments are now being carried out with a section of electrification where the structures have been bonded to the running rails and this apparently gives protection to the signal apparatus; however, the experiments are not yet far enough advanced to make a definite decision. While it is believed the operation will be a successful with clean ballast, it is somewhat doubtful whether the results will be as good with excessively dirty ballast, and it has not yet been settled whether the arrangement under trial gives complete broken rail protection.

The general scheme of protection against electrical interference is the installation of track or booster transformers, which are located on signal bridges, the purpose of these transformers being to prevent the current in the rail from flowing into the earth and causing disturbances on adjacent telephone and telegraph circuits.

As regards commercial concerns, the lines of the Bluefield Telephone Company approach within short distances of the truck at various points.

(7) Southern Pacific

No report received.

(8) Great Northern

The power required for the Great Northern Railway is developed at their hydro-electric plant located at Tumwater, Washington. The transmission lines extend from that point to a point a little west of Cascade

Tunnel. This transmission line parallels the pole line which supports the telegraph and signal line circuits, generally at a distance of from 80 to 90 feet.

The transmission line consists of two parallel circuits, each having three conductors operating at 33,000 volts. The trolley is a three-phase system, using two trolley wires and the rail for the three conductors. The working potential is 6,600 volts, 25 cycles. Within the Cascade Tunnel the separation between transmission line and communicating circuits does not exceed 20 feet, and for some time after the installation of the transmission lines trouble was experienced from inductive interference on the telegraph circuits. When electric locomotives were first operated it was found that the interference was so great as to prevent the use of telegraph wires whenever a train moved through the tunnel. The trouble was remedied by installing a new twisted pair, steel armored, communication cable. After installing the new cable no further inductive interference was experienced. The cable removed was parallel laid and had no steel armor.

No inductive interference has been experienced with the electric train staff system installed in this territory.

(9) Erie Railroad

Interference occurs in a section 19 miles north of a transformer station located at Avon, N. Y., and 15 miles south thereof. Specifically, between Rochester, N. Y., and Mt. Morris, N. Y., the railroad is paralleled for 14 miles north of Avon by a 60,000-volt, three-phase, 25-cycle transmission line, and the entire 34-mile section mentioned is equipped with a 11,000-volt, 25-cycle, single-phase distribution line (trolley wire). The telegraph pole line carrying four telegraph wires and one or two telephone circuits has a mean separation from the trolley wire of about 30 feet and from the transmission line of 60 or 70 feet.

Under normal conditions no appreciable disturbance arises from the transmission line, but induction from the 11,000-volt. single-phase line is heavy on all single telegraph wires which come into the section. Three of the wires running south from Rochester leave the electrified section at Avon, one going west 66 miles to Buffalo, and two going southeast 76 miles to Corning, N. Y. All of these carry the induced currents with slight diminution to their terminals. A fourth wire goes through both the section north of Avon and that south, unworkable at times, while a telegraph loop which exists in the southernmost six miles of the section south of Avon, or from Mt. Morris to Geneseo, is not affected. This loop works on a circuit which runs east and west of Mt. Morris on a foreign railroad.

Under abnormal conditions, such as short circuits and grounds, the troubles referred to above are accentuated.

No trouble has been experienced from electrolysis.

(10) Chicago, Milwaukee & St. Paul

No report.

(11) Public Service Railroads (N. J.)

No report.

(12) New York Central Railroad

On the West Shore branch of the New York Central line, for approximately 115 miles, a 60,000-volt, three-phase, 60-cycle, transmission line parallels the railroad communication circuits, generally on the opposite side of the track with an average separation of about 60 feet. There is no inductive interference under normal operations. Originally the transmission line was transposed throughout its length, but recently some of these transpositions have been removed without bad effect. Under abnormal conditions, due to grounds, broken wires, etc., severe surges are induced in railroad communication lines. Communication lines have standard transpositions.

On the Falls Road Branch a transmission line of 11,000-volt, three-phase, parallels the telegraph and telephone lines between Albion and Knowlesville a distance of about 5.6 miles. The two lines are within conflict at certain points and trouble has only occurred due to contact.

On the Walkill Valley branch the railroad communication circuits are paralleled by a 22,000-volt transmission line for a distance of about 20 miles. The power line is on the same side of the railroad right-of-way as the telegraph and telephone lines for a distance of about 3½ miles. This circuit has interfered with normal operations due to irregular power circuit inducing hum on the dispatchers circuit.

On the Phœnix branch, between Woodward and Phœnix, a three-wire transmission line parallels the railroad communication circuits and has been the source of considerable trouble in connection with the maintenance of the railroad communication circuits on account of high induced voltages.

In the electric zone of the Grand Central Terminal from New York to Harmon and from Mott Haven to North White Plains 11,000-volt, three-phase, 25-cycle, alternating current is transmitted to 9 substations; from Bronx Park to North White Plains and from Putnam Crossing to Ossining in aerial lines and the remainder of the transmission line in cables. The telephone and telegraph lines are in cables in the same sections where power line is cabled. In other sections the communication lines are part cable and part open wire on the opposite side of the track from the transmission line. There has been no electrical interference with communication or signal service.

The propulsion circuit, 660-volt D. C., is led through an under-running third rail. By the sectionalizing of the lead sheaths of communication cables the effect of electrolysis has been practically eliminated.

(13) Chicago, Lake Shore & South Bend Railway

The Chicago, Lake Shore & South Bend Railway, an interurban passenger and freight electric railroad, extends from Kensington, Illinois, the junction with the Illinois Central Railroad, to South Bend, Indiana, a distance of approximately 75 miles. The main power plant is at Michigan City. From this point there is a 33,000-volt, single-phase, 25-cycle transmission line east to the substation at Terre Coupee. From Michigan City west there is a 33,000-volt, single-phase, 25-cycle line to the Calumet substation in East Chicago, and on the same pole line as far as the Calumet substation, a 33,000-volt, three-phase, 60-cycle line between the Michigan City power house and the Northern Indiana Gas & Electric Company's power house in East Chicago.

Trolley is energized at 6600 volts, 25 cycles, single-phase, and is fed from the main power house and the two substations.

The railway company's communication and signal circuits are carried on the same pole line as the transmission circuits, and it is stated that no trouble on these communication and signal circuits has been experienced under normal conditions.

The Postal Telegraph & Cable Company's line parallels the Chicago, Lake Shore & South Bend Railway west of Michigan City between West Blair Farm and Baileytown, a distance of approximately 13½ miles with a separation of 90 feet to 375 feet, and between Dune Park and Aetna, a distance of approximately 6 miles with a separation of 75 feet to 600 feet.

Under normal conditions no serious interference is experienced on the Postal Telegraph duplexes.

Under abnormal conditions, however, due to short circuits and grounds, momentary troubles are experienced on telegraph circuits. It is stated that the greatest trouble is experienced when the Chicago, Lake Shore & South Bend cut out their 33,000 volt line and carry the whole load on the system from the 6600 volt, single phase trolley. At such times serious trouble on the telegraph circuits is experienced. Nothing has been done by the Postal Telegraph Company which eliminates these conditions.

It is stated that no trouble has been experienced affecting the safety of employees or the public, nor has any trouble been experienced that could be traced to electrolytic conditions.

(14) Conclusion

The Committee has not completed its examination of the subject and has in its files detailed data available for tabulation and proposes, after obtaining additional information from other sources, to prepare a statement showing comparative results, from which conclusions may be drawn.

Appendix E

ITEM (8) UNDERGROUND CONDUIT CONSTRUCTION

D. J. BRUMLEY, *Chairman;*
E. B. TEMPLE, *Vice-Chairman;*
H. M. BASSETT,
WALT DENNIS,
H. K. LOWRY,
R. S. PARSONS,

Committee.

The Sub-Committee has completed the Specifications for Underground Conduit Construction for Power Cables, a copy of which is hereto attached. A memorandum is submitted as information descriptive of "Stone Conduit" construction used to a great extent with satisfactory results by a large Utility Company. This Memorandum is in the form of a specification and describes the process of manufacture and the method of installation.

The Committee suggests three new electrical definitions as follows:

Duct or Conduit: A unit length of pipe suitable for use in the construction of runways for electric wires or cables.

Manhole: An opening in a splicing chamber through which a man may enter.

Mandrel: A tool used for aligning and cleaning ducts.

Your Committee recommends the adoption and printing in the Manual, as recommended practice, of the Railroad Specifications for Underground Conduit Construction for Power Cables, dated October 22nd, 1920. Also the adoption and printing in the Manual of the three electrical definitions above referred to.

Stone Conduits

One of the large Utility Companies in the Middle West has used for several years "Stone Conduit," and is now using stone conduit of their own manufacture, with very satisfactory results.

The specifications describe the processes of manufacture and method of installation of stone conduit.

1. Material.

Stone conduit shall be made of limestone screenings which will pass through a screen of one-eighth (1/8) inch mesh and approved make of Portland cement in the proportion of four and three quarters (4¾) to one (1) properly moistened with water and shall be formed by tamping in cylindrical moulds.

2. Dimensions.

Conduit shall be made in lengths of five (5) ft. with five-eighths (5/8) inch walls and three and one-half (3½) to four and one-half (4½) inch round bore.

3. Workmanship.

(a) Conduit shall be symmetrical throughout, straight, true, smooth, free from cracks, air holes, uneven surfaces or other imperfections which will injuriously affect it. The ends shall be perpendicular to the bore.

(b) Conduit shall be cured for not less than eight (8) weeks after removal from the mould. For the first six (6) weeks it shall be kept wet by sprinkling and then allowed to dry in the air for at least two (2) weeks.

4. Joints.

(a) Conduit when thoroughly cured shall be turned, for a distance of three-quarters (¾) of an inch on each end, sufficient to secure an exact diameter concentric with the bore, but which shall not reduce the thickness of the wall given in Section 2 by more than one-sixteenth (1/16) of an inch.

(b) With each conduit there shall be supplied a suitable metal sleeve which will fit tightly over the ends of adjacent conduits to hold them in place and to secure perfect alinement.

5. Short Lengths.

Pieces of conduit less than the standard 5 ft. length will be accepted, not to exceed 10 per cent of the total ordered, provided the ends are cut square, dressed and turned for metal sleeves, but no conduit will be accepted less than two and one-half (2½) ft. long.

6. Inspection.

(a) The Railroad may inspect the conduit at any time during the process of manufacture and shall be furnished free of cost the necessary tools and appliances for making such tests as are necessary to determine if the requirements of these specifications have been met.

(b) Conduit offered for inspection shall be factory run from which no conduit of a superior quality has been removed.

(c) The Railroad shall be given advance notice of completion of conduit to permit it to arrange for inspection.

7. Tests.

(a) Conduits shall permit the passage from end to end of a mandrel three (3) ft. long and one-eighth (⅛) inch less than the nominal diameter of the bore.

(b) Samples of five (5) foot lengths of conduit shall be selected at random and after immersion for twenty-four (24) hours in air shall show an increase in weight of not more than nine-tenths (9/10) of one per cent.

(c) The presence of cracks shall be determined by sounding each piece with a steel hammer or its approved equivalent. Pieces which fail to give a clear metallic ring shall be considered defective.

(d) Conduit which fails to meet all of the requirements of these specifications shall be rejected.

8. Installation.

(a) Conduit line shall be encased in concrete four (4) in. thick on top, three (3) in. on the sides and a minimum thickness of four (4) in. for the full width of the trench, except where ledge rock is encountered; in which case the concrete foundation may be omitted and the bottom of the trench leveled with cement mortar. Conduits shall be laid with a minimum separation of one (1) inch both horizontally and vertically and the joints shall be staggered so that the joints of adjacent sections will be separated by at least three (3) inches.

(b) In ending conduits only full lengths shall be used in the lower tier at the entrance to splicing chambers. Short lengths where necessary shall be inserted further out in the section.

(c) Where work is suspended leaving incompleted sections the open ends of the conduits shall be plugged with tapered wood, or other approved plug conforming accurately to the shape of the bore and so formed that it cannot be forced entirely within the opening.

(d) During construction work a mandrel three (3) ft. long and one-eighth (1/8) inch less than the nominal bore shall be drawn through the conduits as they are laid.

(e) In other respects the methods of laying stone conduits shall correspond to the American Railway Engineering Association Specifications for Fiber Conduits.

Appendix F

ITEM (9) COOPERATION WITH THE BUREAU OF STANDARDS

E. B. KATTE, *Chairman;*
D. J. BRUMLEY, *Vice-Chairman;*
R. H. FORD,
A. H. HOGELAND,
R. D. COOMBS,
Sub-Committee.

The Committee was directed to coöperate with the United States Bureau of Standards in the preparation of the National Electrical Safety Code. The United States Bureau of Standards has held no joint meetings for this purpose since our last report, but has circularized for criticism various proposed revisions. These have been reviewed and commented upon by the members of your Committee and suggestions were forwarded to Dr. E. B. Rosa, Chief Physicist, Bureau of Standards, under the following dates: January 8th, 14th, 16th, March 3d, June 8th, 14th, 23d, July 22d, 23d, 24th and Sept. 13th. Some of these communications have been answered and some of the suggestions, we have been informed, have been accepted, but our principal criticisms we understand have not been adopted, namely:

(1) That the Railroad Standards for structural strength be not reduced for the purpose of reducing the cost of the structure.

(2) That the Railroad Requirements for clearances be not lessened for the purpose of reducing the cost of construction to transmission line crossing companies.

We have been advised that the revised edition of the National Electrical Safety Code is in press and will be issued before the first of the year: That the code had been divided into two parts containing respectively the text and the explanations and discussion: That the size has been reduced to five inches wide and seven and one-half inches long, which should add much to the convenience of the code as a reference work.

Appendix G

ITEM (10) STANDARDS

S. Withington, *Chairman;*
M. Schreiber, *Vice-Chairman;*
R. Beeuwkes,
J. C. Davidson,
E. B. Katte,
H. K. Lowry,
E. B. Temple,
Sub-Committee.

The Sub-Committee had assigned to it several electrical objects for standardization. This year it has concentrated its attention upon incandescent lamps and reports as follows:

Many railroads carry in stock a long list of lamps of various kinds, which involves not only a large amount of storage space and storehouse expense, but likelihood of errors in the proper placing of lamps.

The following list has been compiled from data obtained both from railroads and manufacturers, in an effort to obtain a list which should be as short as is consistent with efficiency of operation, taking into account both the illumination efficiency and the life of the lamps. Lamps for signal purposes are not included in this report.

More than 80 per cent of the lamps manufactured are rated at 110, 115 and 120 volts; and the intermediate voltages are being eliminated as rapidly as possible.

With regard to train lighting circuits, the voltage is standardized at 32 and 64 volts. It should not be a difficult matter to so adjust the train circuits as to obtain an average of these potentials and eliminate all lamps of other voltages. Train lighting circuits of the 60-volt range are rapidly disappearing.

With regard to the cab lighting, 33 volts appears to have been recommended by the American Railway Association as standard. The voltage has been standard at 34 volts, but the above recommendation of the A.R.A. will undoubtedly involve a change to 33 volts.

All lamps in the list can be obtained equally readily with clear bulbs, or with frosted or enameled bulbs. For "C" lamps of 100 watts or above, the bulbs, instead of being frosted, should be "bowl enameled."

The "C" lamps are filled with an inert gas, such as nitrogen or argon, while in the "B" lamps the filament operates in a high vacuum.

The diameter of the lamp bulb is measured in eighths of an inch, the shape is indicated by the following letters:

S—Straight side.
G—Round (globular).
P. S.—Pear Shape.

It is realized that the list is not complete, and that probably most railroads will have local requirements which are not met by the list. It is the thought, however, that if the demand can be concentrated on this comparatively small number of styles and sizes of lamps, deliveries will be facilitated, the labor of handling reduced, and manufacturing economies will before long be reflected in prices. It is to be expected that the list will be revised from time to time to take care of developments as they occur.

Wherever possible the voltage of isolated plants operated by the railroads should be changed to permit the use of lamps in the accompanying list. New installations should be designed to take listed lamps.

Your Committee recommends the adoption and printing in the Manual, as recommended practice, the accompanying schedule of Tungsten Lamp Standards.

TUNGSTEN LAMP STANDARDS—1920

Illumination

Size in Watts	*Voltages*	*Type and Size of Bulb*	*Base Type*		*Remarks*
10	110, 115, 120, 125	S. 14	Med. Screw	B	
15	" " " "	S. 17	" "	B	
25	" " " "	S. 17	" "	B	
50	" " " "	S. 19	" "	B	
75	" " " "	P. S. 22	" "	C	
100	" " " "	P. S. 25	" "	C	
150	" " " "	P. S. 25	" "	C	
200	" " " "	P. S. 30	" "	C	
250	" " " "	G. 30	" "	C	Used for flood lighting. Concentrated filament for focusing.
300	" " " "	P. S. 35	Mogul	C	
500	" " " "	G. 40	"	C	do
500	" " " "	P. S. 40	"	C	
750	" " " "	P. S. 52	"	C	
1000	" " " "	P. S. 52	"	C	
25	220, 230, 240, 250	S. 19	Med. Screw	B	
50	" " " "	S. 19	" "	B	
100	" " " "	S. 30	" "	B	
200	" " " "	P. S. 30	" "	C	
300	" " " "	P. S. 35	Mogul	C	
500	" " " "	P. S. 40	"	C	
1000	" " " "	P. S. 52	"	C	

Mill Type

25	110, 115, 120, 125	S. 19	Med. Screw	B	
50	" " " "	S. 19	" "	B	

Car Axle Lighting

15	32-64	(*) S. 17 G. 18½	" "	B	
25	" "	(*) S. 17 G. 18½	" "	B	
50	" "	(*) S. 19 G. 30	" "	B	
25	" "	P. S. 20	" "	C	Will be standardized to replace the type B lamp at a future time.
50	" "	P. S. 20	" "	C	"White" bulb may also be used.
75	" "	P. S. 22	" "	C	
100	" "	P. S. 25	" "	C	

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	" "	B	Series.
36	" " " " "	S. 19	" "	B	"
56	" " " " "	S. 21	" "	B	"
94	" " " " "	S. 24½	" "	B	"
100	32	G. 25	" "	C	Headlight.
250	32	G. 30	" "	C	"

(*) An extra charge of about 30 per cent. is usually made for the "G" style.

RAILROAD SPECIFICATIONS FOR ELECTRIC WIRES AND CABLES

Table of Contents

Separator

72. Separator.

Rubber Filled Cloth Tape

73. Tape.

Braid

74. Weatherproof Braid.
75. Tests.
76. Circular Loom Braid.

Dry Paper Tape

77. Dry Paper Tape.

Miscellaneous Braids

78. Glazed Cotton Braid.
79. Hemp Braid..
80. Colored Braid.
80-A. Flameproof Braid.

Lead Sheath

81. Composition.
82. Thickness.

Galvanized Steel Wire Armor

83. General.
84. Preparation for Armor.
    (a) Cloth, Taped or Braided Cables.
    (b) Lead Sheathed Cables.
85. Thickness of Jut Bedding.
86. Armor Wire.
87. Application of Armor.
88. Covering over Armor.
89. Direction of Lay.
90. Size of Wire.
91. Samples for Test.
92. Tensile Strength and Elongation.
93. Galvanizing.
94. Flexibility.

Steel Tape Armor

95. Application of Armor.
96. Armor Tape.

Galvanizing

97. General.
98. Coating.
99. Cleaning.
100. Test.
101. Quality of Solution.
102. Results of Tests.

Enameled Copper Magnet Wire

103. General.
104. Tests.
105. Preparations for Shipping.

Cable Reels

106. General.
107. Form of Reel.
108. Bushing.
109. Size and Weight.
110. Covering and Lagging.
111. Marking.
112. Chocking.

List of Tables in Specification

RAILROAD SPECIFICATIONS FOR ELECTRIC WIRES AND CABLES

General

1. Scope.

(a) The purpose of these specifications is to describe wires and cables to be used principally for electric lighting, power transmission, and electric traction purposes.

(b) The workmanship and materials shall be the best of their respective kinds and shall be in full accord with the best modern engineering practice.

(c) Provisions in subsidiary specifications which are contrary to these specifications annul the corresponding provisions in these specifications.

2. Inspection.

(a) The wires and cables will be inspected by the Engineer of the Railroad or his authorized representative, who shall be afforded all necessary facilities to ascertain whether the material and processes conform to these specifications.

(b) The outer surface of the insulation of complete insulated wires and cables shall be grounded while being electrically tested. If the insulation is not provided with a conducting covering, and if the covering is not liable to injury by water, the ground shall be obtained by immersing the insulated wire or cable in water for eighteen hours and testing at the end of that period while immersed. If the outer covering is susceptible to injury by immersion, the insulated conductor shall be tested before the application of such covering.

Dry core paper insulated lead covered cables, such as telephone and telegraph cables, for use in water shall be tested after eighteen hours immersion.

(c) In multiple-conductor cables, without waterproof overall jacket of insulation, no immersion test will be made on finished cables, but only on the individual conductors before assembling.

(d) Submarine cables shall be given a final test by immersing the completed cable in water in addition to the immersion test upon the individual conductors. (See Section 59-a.)

(e) All other wires and cables will be inspected in their completed form.

(f) The Inspector will notify the Manufacturer in writing when the preliminary tests are satisfactory. Additional covering applied previous to the receipt of such notice will be at the Manufacturer's risk.

(g) Wires and cables shall not be shipped without being sealed by the Inspector unless permission is given in writing.

The seals are applied for identification purposes only, and shall not be considered by the Manufacturer as evidence of acceptance.

3. Notification.

The Manufacturer shall notify the Railroad sufficiently in advance of the completion of the wires or cables to permit arrangements to be made for the presence of an Inspector.

4. Tests.

The Manufacturer shall furnish suitable facilities for the testing of the wires and cables and shall make the specified tests in the presence of the Inspector. The Manufacturer shall also afford the Inspector every other reasonable facility to ascertain whether the requirements of these specifications have been complied with.

The Railroad will make chemical analysis of the rubber compound or other materials entering into the manufacture of the wires and cables whenever it deems such a step necessary.

When the Railroad desires bending or other mechanical or electrical tests not herein specified, they will notify the Manufacturer and the test shall conform to the requirements of the American Institute of Electrical Engineers.

Except where otherwise specified the results of tests will determine the acceptance of the individual coil or reel on which tests were made.

5. Rejection.

If rejections exceed 20 per cent of the length offered for inspection at one time, the expense of inspection and test of the rejected part shall be borne by the Manufacturer. Freight charges on foreign lines for the return of all wires or cables that may be found defective and rejected after receipt by the Railroad shall be borne by the Manufacturer.

The Railroad may make tests of samples of the wire or cable in its own laboratory or elsewhere, but such tests shall be made at its own expense.

The Manufacturer may retain duplicate sealed samples and, in case of dissatisfaction, may demand a check test upon such sealed samples at any time within two weeks after the date of the test report. (See Section 54.)

6. Patents.

The Manufacturer shall defend and save harmless the Railroad from, and indemnify it against any and all claims which may be made against it on account of alleged infringements of patent rights, and expenses of any kind in connection therewith, arising from the use of the wire or cable furnished by the Manufacturer.

6-A. Wrapping.

Wires and cables shall be securely wrapped as follows:

Package	*Style of Wire or Cable*	*Wrapping*
Coil	National Electric Code.	Paper or burlap.
	Any but Code.	Burlap.
Spool	Any.	Paper or burlap and boxed in a manner satisfactory to the Inspector.
Reel	All.	See Section 110.

7. Marking.

Where wires or cables are shipped in coils or on spools, a tag containing the following information shall be securely attached to the coils or spools and a similar tag fastened to the outside of the wrapping: (a) name of Manufacturer, (b) size of wire or cable, (c) character of insulation, (d) net pounds, (e) gross pounds, (f) number of feet, (g) Railroad's requisition and order number.

8. Terminology.

The terminology used in these specifications is that recommended in the Standardization Rules of the American Institute of Electrical Engineers.

9. Lot.

The word lot shall be understood to refer to all of the wires of one kind and size offered for inspection at one visit of the Inspector.

General Construction

26. Area and Material of Stranded Conductors.

(a) *Sectional Area of Cables:* The cross-sectional area of cables shall be considered to be the sum of the cross-sectional area of its component wires when measured perpendicular to their axis and shall be not less than the specified circular mils or area corresponding to the specified gage. (See Section 33.)

(b) *Annealing:* Unless otherwise specified, conductors shall be of soft or annealed copper.

27. Stranding.

Unless otherwise specified, the stranding of cables shall be concentric, with successive layers wound in opposite directions.

The cables shall have not less than the number of wires specified in Table I or Table II for the type of cable ordered, but cables having a greater number of wires will be accepted.

TABLE I—STANDARD STRANDING OF CONCENTRIC-LAY CABLES

Size (See Note 1)	Number of Wires (See Note 2) A Bare, Insulated or Weatherproof Cables for Aerial use.	Number of Wires (See Note 2) B Insulated Cables for other than Aerial use.	Size (See Note 1)	Number of Wires (See Note 2) A Bare, Insulated or Weatherproof Cables for Aerial use.	Number of Wires (See Note 2) B Insulated Cables for other than Aerial use.
2.0 Cir. Inches.	91	127	0000 A. W. G...	19 or 7 (See Note 3)	19
1.5 " " .	61	91			
1.0 " " .	61	61	00 " ...	7	19
			2 " ...	7	7
0.6 " " .	37'	61			
0.5 " " .	37	37	7 and smaller...	....	7
0.4 " " .	19	37			

1. For intermediate sizes, use stranding for next larger size.
2. Conductors of 0000 A. W. G. and smaller are often made solid and this table of stranding should not be interpreted as excluding this practice.
3. Class A cable, sizes 0000 and 000 A. W. G., is usually made of 7 strands when bare and 19 strands when insulated or weatherproof.

TABLE II—STRANDING OF FLEXIBLE CABLES

Size	No. of Wires	Size of Each Wire A.W.G	Make-up (See Note 1)	Size	No. of Wires	Size of Each Wire A.W.G	Make-up (See Note 1)
2039000...	703	15.5	37 x 19	000	133	19.0	19 x 7
1816000...	"	16.0	"	00.....	"	20.0	"
1617000...	"	16.5	"	0.....	"	21.0	"
1440000...	"	17.0	"	1	91	20.5	Concentric
1284000...	"	17.5	"	2	"	21.5	"
1103000...	427	16.0	61 x 7	3	"	22.5	"
874600...	"	17.0	"	4.....	61	22.0	"
693600...	"	18.0	"	5.....	"	23.0	"
550000...	"	19.0	"	6	"	24.0	"
436200 ..	"	20.0	"	8.....	"	25.5	"
345900...	"	21.0	"	10.....	37	25.5	"
274300...	"	22.0	"	12.....	"	27.5	"
264600...	259	20.0	37 x 7	14.....	"	29.5	"
0000...	"	21.0	"				
Smaller...	To Equal Required Size	30.0	Bunched	Smaller ..	To Equal Required Size	30.0	Bunched

Note 1. "61x7" in the description of a rope-lay cable signifies 61 strands of 7 wires each.

27-A. Repairs of Insulation.

If exigencies of manufacture require repairs or joints in the insulation, the work shall be done in such a way as to leave the repaired part or joint, and all parts affected by it, as strong and durable electrically, as the remainder of the insulation. In the case of rubber insulation the patches shall be properly vulcanized.

28. Triplex, Duplex and Twin Cables.

Unless otherwise specified the conductors of duplex or triplex cables shall be twisted and filled out to make round. Twin cables shall have their conductors laid parallel.

Soft or Annealed Copper Wire and Cable

29. General.

The purpose of these specifications is to secure soft or annealed copper wire of the best commercial quality.

30. Shape.

The wire shall be of circular cross-section unless otherwise specified.

31. Surface Imperfections.

The wires shall be free from all surface imperfections not consistent with the best practice.

32. Specific Gravity.

For the purpose of calculating weights, cross-sections, etc., the specific gravity of copper shall be taken at 8.89 grams per cubic centimeter at a temperature of 20 deg. Cent.

33. Permissible Variations from Dimensions.

The variations from the nominal diameter shall not exceed the following:

(a) *Untinned Wire:* For wire 0.010 inches or over in diameter, one per cent over or under

For wires less than 0.010 inches in diameter, 0.1 mil (0.0001 in.) over or under.

(b) *Tinned Wire:* For wire 0.010 inches or over in diameter, three per cent over and one per cent under.

For wire less than 0.010 inches in diameter 0.3 mils over and 0.1 mil under.

Cables otherwise meeting the specifications but having a cross-sectional area of not over one per cent less than that specified may be accepted by the Railroad upon a satisfactory adjustment in price.

34. Gaging.

The wire on each coil, reel or spool shall be gaged wherever desired by the Inspector, but in the case of coils at not less than three places, one near each end and one approximately at the middle. In the case of spools, not less than twelve feet of wire or cable shall be reeled off, and the wire shall be gaged in six places between the second and twelfth foot from the end. The coils or spools will be rejected if the average of the measurements obtained is not within the limits stated in Section 33.

35. Elongation.

The enlongation of the wire shall be not less than specified in Table IV. Tests shall be made upon fair samples, and the elongation shall be determined as the permanent increases in lengths, due to the breaking of the wire in tension, measured between bench marks placed upon the wire originally ten inches apart. The fracture shall be between the bench marks and not closer than one inch to either mark. If fracture occurs outside the bench marks, or closer than one inch to either mark, the test shall be repeated. If upon testing a sample from any coil, reel or spool of wire, the results are found to be below the specified elongation, tests upon two additional samples shall be made, and if the average of the three results is below the specified elongation, the wire may be rejected. In the case of cables, tests shall be made on the individual wires.

36. Conductivity.

The electric conductivity shall be determined as described in Section 47 and shall be not less than the per cent of the Annealed Copper Standard specified in Tables V and VI.

37. Tinning.

If the wire is to be insulated with rubber compound, it shall be covered with a heavy uniform coating of tin unless otherwise specified on the order.

Tinned wire shall be free from projections and shall successfully pass the following test:

Samples of wire which have not been insulated shall be thoroughly cleaned with alcohol and immersed in hydrochloric acid of specific gravity 1.09 corrected to 60 deg. Fahr. for one minute. They shall then be rinsed in clear water and immersed in a solution of sodium sulphide of specific gravity 1.14 for 30 seconds and again washed. This operation shall be repeated three times and upon the completion of the fourth cycle, the sample shall show no sign of blackening. The sodium sulphide solution shall contain an excess of sulphur and shall have sufficient strength to thoroughly blacken a piece of clean untinned copper wire in five seconds.

38. Joints.

Joints will be permitted if properly brazed.

39. Packing and Shipping.

Table III gives the maximum and minimum weights of bare wire of stated sizes which may be shipped in any one package, whether coil, reel or spool; in the case of wire larger than 0.010 in. in diameter, the maximum and minimum package weights are net, and in the case of wire 0.010 in. and less in diameter, the maximum package weights are gross, and the minimum package weights are net. The table also states the limits of the dimensions of reels and spools on which wire may be shipped. The length and diameter stated for reels and spools are to be measured over all and are maximum sizes; reels or spools smaller than these may be used, provided the minimum weights called for are carried by the reel or spool.

40. End Defects.

To insure the removal of defects from the wire, the Manufacturer shall cut off at least 25 feet of wire, or as much more as may be necessary from each end of every coil, reel or spool.

Table III—Packages of Bare Soft or Annealed Copper Wire

Diameters, In.	Package Weights Pounds		Dimension of Reels and Spools, In.		
	Max.	Min.	Max. Dia.	Max. Length	Diameter of Hole for Rod
0.460 to 0.360	520	290	32	21	1½ to 2½
0.359 " 0.258	430	290	32	21	1½ " 2½
0.257 " 0.129	290	140	24	12	1½ " 2½
0.128 " 0.102	230	95	24	12	⅝ " 1½
0.101 " 0.083	230	75	24	12	⅝ " 1½
0.082 " 0.081	200	75	24	12	⅝ " 1½
0.080 " 0.064	200	50	24	12	⅝ " 1½
0.063 " 0.051	120	50	24	10	⅝ " 1½
0.050 " 0.041	100	50	24	10	⅝ " 1½
0.040 " 0.032	50	20	24	8	⅝ " 1½
0.031 " 0.020	25	15	10	6½	⅝ " ⅞
0.019 " 0.011	10	5	5½	4	⅜ " 11/16
0.010 " 0.008	.5	2½	4	4	⅜ " 11/16
0.007 " 0.0056	2½	1	2½	4	⅜ " 11/16
0.005	1½	⅝	2½	4	⅜ " 11/16
0.004	1½	⅜	2½	4	⅜ " 11/16
0.003	1	¼	2½	4	⅜ " 11/16

Table IV—Elongation of Soft (Annealed) Copper Wire

Diameter, In.	Minimum Per Cent of Elongation in 10 In.		Diameter, In.	Minimum Per Cent of Elongation in 10 In.	
	Tinned	Untinned		Tinned	Untinned
0.460 to 0.290	30	35	0.200 to 0.151	27.5	
0.289 " 0.103	25	30	0.150 " 0.101	25.0	Note: Use these percentages for samples of tinned wires taken from stranded cables.
0.102 " 0.021	20	25	0.100 " 0.061	22.5	
0.020 " 0.012	15	20	0.060 " 0.031	20.0	
0.011 " 0.003	10	20	0.030 " 0.003	17.5	

For intermediate sizes the requirements shall be those of the next smaller size.

Table V—Conductivity of Soft or Annealed Untinned Copper Wire

A. W. G. No.	Conductivity, per cent	A. W. G. No.	Conductivity, per cent
0000 to 8	98.5	20 to 30	97.5
8 to 20	98.0	Smaller than No. 30	97.0

For intermediate sizes the requirements shall be those of the next smaller size.

TABLE VI—CONDUCTIVITY OF SOFT OR ANNEALED TINNED COPPER WIRE

A. W. G. No.	Conductivity per cent	A. W. G. No.	Conductivity per cent
9 and larger	98.0	20	95.8
10	97.8	21	95.6
11	97.6	22	95.4
12	97.4	23	95.2
13	97.2	24	95.0
14	97.0	25	94.8
15	96.8	26	94.6
16	96.6	27	94.4
17	96.4	28	94.2
18	96.2	29	94.0
19	96.0	30	93.8

For intermediate sizes the requirements shall be those of the next smaller size.

HARD DRAWN COPPER WIRE AND CABLE

41. General.

The intention of these specifications is to describe hard drawn copper wire of the best commercial quality.

42. Shape.

The wire shall be of circular cross-section, unless otherwise specified.

43. Surface Imperfections.

The wire shall be free from all surface imperfections not consistent with the best practice.

43-A. Specific Gravity.

For the purpose of calculating weights, cross-sections, etc., the specific gravity of copper shall be taken at 8.89 grains per cubic centimeter at a temperature of 20 deg. Cent.

44. Core.

Standard conductors shall be made of hard drawn wire laid concentrically about a core of material specified in the specifications accompanying the order. Unless otherwise specified the core of seven-wire cables shall be of semi-hard drawn copper.

45. Permissible Variation from Dimensions.

The circumference of any cross-section of the wire shall be a true circle.

The variations from the nominal diameter shall not exceed the following:

(a) *Untinned Wire:* For wire 0.010 inches in diameter and larger, one per cent over and under.

For wire less than 0.010 inches in diameter, 0.1 mil (0.0001 in.) over or under.

(b) *Tinned Wire:* For wire 0.02 inches in diameter, and larger, two per cent over or one per cent under.

For wire less than 0.02 inches in diameter, 0.1 mil under.

Where the area of cross-section of cables is specified, the cables shall be of not less than the area specified.

46. Brazes.

Brazes made before drawing, in accordance with the best practice, will be permitted in wire entering into cables, but no two brazes in a strand may be closer together than 50 feet in wire larger than No. 5 A.W.G., or closer than 100 feet on smaller wires. Brazes will be allowed in single wire conductors only where the length specified exceeds that which can be drawn from an ingot. No joints shall be made in wire after drawing.

47. Conductivity.

Electrical conductivity shall be determined upon fair samples by resistance measurement with a Kelvin bridge or other instrument approved by the Railroad. The use of the Hoops bridge is approved.

Samples shall be cut from not less than ten per cent of the coils in each lot of wire, the number of samples being never less than two. The conductivity shall be not less than the following per cent of the Annealed Copper Standard:

For diameters 0.460 to 0.325 inch, 97 per cent.
For diameters 0.324 to 0.040 inch, 96 per cent.

If the average conductivity is less than specified above, the entire lot may be rejected.

48. Extensometer Test.

If required by the Engineer, fair samples shall be cut from not less than ten per cent of the coils in each lot of wire, the number of samples being never less than two, and extensometer tests shall be made upon them, and the results on each sample plotted as a curve. The point at which the ratio of the elongation to the stress begins to increase, shall be at a stress not less than 55 per cent of the ultimate strength of the sample.

If more than 20 per cent of the samples fail to pass this test, the entire lot may be rejected.

49. Tensile Strength and Elongation.

The tensile strength and elongation of the wire shall be not less than specified in Table VII. Tensile tests shall be made upon fair samples, and the elongation shall be determined as the permanent increase in length, due to the breaking of the wire in tension, measured between bench marks placed upon the wire originally ten or sixty inches apart, as specified in Table VII. The fracture shall be between the bench marks and not closer than one inch to either mark. If the fracture occurs outside the bench marks or closer than one inch to either mark, the tests shall be repeated. Samples shall be cut from not less than ten per cent of the coils in each lot of wire, the number of samples being never less than two. If more than ten per cent of the samples fail to pass this test, the entire lot may be rejected.

TABLE VII—TENSILE STRENGTH AND ELONGATION OF HARD DRAWN COPPER WIRE

A. W. G. No.	Diameter, Inches	Area, Cir. Mils.	Tensile Strength, Lb. Per Sq. In.	Elongation, Per Cent in 10 In.
0000	0.4600	211 600	49 000	3.75
000	0.4096	168 100	51 000	3.25
00	0.3648	133 225	52 800	2.80
0	0.3249	105 625	54 500	2.40
1	0.2893	83 520	56 100	2.17
2	0.2576	66 565	57 600	1.98
3	0.2294	52 440	59 000	1.79
				In 60 in.
4	0.2043	41 615	60 100	1.24
5	0.1819	33 125	61 200	1.18
6	0.1620	27 225	62 000	1.14
7	0.1443	26 245	62 100	1.14
8	0.1285	20 735	63 000	1.09
9	0.1144	17 956	63 400	1.07
10	0.1019	16 385	63 700	1.06
11	0.09074	12 995	64 300	1.02
12	0.08081	10 815	64 800	1.00
13	0.07196	10 404	64 900	1.00
14	0.06408	8 464	65 400	0.97
15	0.05707	8 281	65 400	0.97
16	0.05082	6 561	65 700	0.95
17	0.04526	6 400	65 700	0.94
18	0.04030	5 184	65 900	0.92
19	0.03589	4 225	66 200	0.91
20	0 03196	4 096	66 200	0.90
21	0.02846	3.249	66 400	0.89
22	0.02535	2 601	66 600	0.87
23	0.02257	2 025	66 800	0.86
24	0 02010	1 600	67 000	0.85

For intermediate sizes, the requirements shall be those of the next larger size. A reduction of 10 per cent in the tensile strength of wires taken from stranded cables will be allowed when the wires are tinned and three per cent when untinned.

50. Tensile Strength of Cable.

The tensile strength of cables shall be not less than 90 per cent of the total tensile strength of the component wires, exclusive of the core if the latter is not made of hard drawn copper.

51. End Defects.

To insure the removal of defects from the wire, the Manufacturer shall cut off at least 25 feet of wire, or as much more as may be necessary from each end of every coil, reel or spool.

CLASS "A" RUBBER INSULATION WITH MINERAL BASE

52. Constituents.

Class "A" rubber insulation shall consist of a properly vulcanized compound consisting of not less than 30 per cent fine Para or smoked first latex plantation Hevea rubber with mineral fillers. It shall contain only the following ingredients:

Rubber,
Sulphur,
Inorganic mineral matter,
Refined solid paraffine or ceresine.

It shall not contain either red lead or carbon.

53. Results of Analysis.

The vulcanized compound shall conform to the following requirements, when tested by the procedure of the Joint Rubber Insulation Committee current at the date of order.

(a) Results to be expressed as percentages by weight of the whole sample:

	Maximum	*Minimum*
Rubber	33	30
Waxy hydrocarbons	4	0
Free sulphur	0.7	0

(b) The requirements for intermediate percentages shall be in proportion to the percentage of the rubber found:

Limits allowed for 30% Rubber Compound	*Maximum*	*Minimum*
Saponifiable acetone extract	1.35	0.55
Unsaponifiable resins	0.45	0
Chloroform extract	0.90	0
Alcoholic potash extract	0.55	0
Total Sulphur	2.10	0
Specific gravity	0	1.75

Limits allowed for 33% Rubber Compound	*Maximum*	*Minimum*
Saponifiable acetone extract	1.50	0.60
Unsaponifiable resins	0.50	0
Chloroform extract	1.00	0
Alcoholic potash extract	0.60	0
Total sulphur	2.10	0
Specific Gravity	0	1.67

(c) The acetone solution shall not fluoresce.

(d) The acetone extract (60 cu.cm.) shall be not darker than a light straw color.

(e) Hydrocarbons shall be solid, waxy and not darker than a light brown color.

(f) Chloroform extract (60 cu.cm.) shall be not darker than a straw color.

Failure to meet any requirement of these specifications will be considered sufficient cause for rejection.

(g) Contamination of the compound by the use of impregnated tapes will not excuse the Manufacturer from conforming to these specifications. The use of fine Para or first quality plantation rubber, without compliance with the chemical limits, will not be sufficient for acceptance.

54. Check Analysis.

If the Manufacturer questions the accuracy of the analytical results upon which rejections are based, the Railroad will have an analysis made by another chemist, using the procedure of the Joint Rubber Insulation Committee. If the results of such analysis show the rubber compound to be in accordance with the specifications, the Railroad will bear the expense thereof; otherwise the Manufacturer shall bear the expense. (See Section 5.)

55. Concentric Application.

The compound shall be applied concentrically about the conductor and shall fit closely thereto. If necessary, in order to achieve this result on insulated conductors of greater diameter than 0.3 of an inch, a tape may be applied over the insulation before vulcanization. Such tape, if it does not comply with Section 73, will be additional to any which may be required in the accompanying wire specifications. Where the insulation is applied in more than one layer, adjacent layers shall cohere firmly.

56. Thickness of Insulation.

Unless otherwise specified, the minimum thickness of insulation at any point shall be in accordance with Table VIII.

TABLE VIII—THICKNESS OF RUBBER INSULATION

30 Per Cent. Hevea Rubber Compound, Wall Thickness in 64th of an Inch

Size of Conductor, A. W. G. or Cir. Mils.	Working Pressure											
	a-c or d-c	3rd Rail Rys.		Volts—Alternating								
	600 or less	601 to 750	1500	2500	3500	5000	6000	7000	8000	9000	10000	11000
14–8	3	4	6	8	10	12	14	16	18	20	22	24
7–2	4	5	7	9	10	12	14	16	18	20	22	24
0000	5	6	8	10	10	12	14	16	18	20	22	24
400,000	6	7	9	10	11	12	14	16	18	20	22	24
500,000	6	8	9	10	11	12	14	16	18	20	22	24
2,000,000	7	9	10	10	12	12	14	16	18	20	22	24
2,000,000	8	10	10	10	12	14	16	18	18	20	22	24

For intermediate sizes the insulation thickness specified for the next larger size shall be used

57. Elasticity.

(a) Samples from wires of No. 8 A.W.G. or less shall be obtained by the removal of the copper wire by the elongation of the wire, or if tinned by the mercury process at the option of the Inspector.

From larger wires a sample of approximately $\frac{1}{32}$ square inch rectangular cross-section shall be cut from the insulated conductor, using a sharp knife. The sample shall be bent in every direction to magnify and reveal any surface cracks or imperfections which may exist.

(b) Two thin bench marks shall be marked on the test sample two inches apart and at right angles to the direction of pull.

The sample shall then be clamped in an approved testing machine and stretched at the rate of twenty inches per minute until the marks are six inches apart and held for one minute and then immediately released. One minute after release the marks shall not be farther apart than specified in Table IX.

Table IX—Elongation and Permanent Set of Grade A Rubber Compound

Sections	Lengthening, Stretching and Release	Length at Instant of Fracture
No. 8 and smaller, full section........................	2 3/8 inch	10 inch
Larger than No. 8, 1-32 square inch..................	2 3/8 inch	9 inch

58. Tensile Strength.

A sample prepared as described in Section 57 (a) shall be taken from every 5,000 feet or less and stretched in an approved testing machine at the rate of twenty inches per minute until it breaks.

The tensile strength shall be not less than 1,000 pounds per square inch. At the instant of fracture the distance between bench marks shall be not less than specified in Table IX.

59. Electrical Tests.

(a) Each and every length of wire or cable shall conform to the requirements of Sections 70 and 71. Electrical tests shall be made upon rubber insulated wire or cable after at least eighteen hours' immersion in water, while still immersed and before the application of any covering other than the tape used in vulcanization. In the case of multiplex cables, the high potential test shall be made and the insulation resistance shall be measured before assembling the conductors. An additional electrical test shall be made on lead covered or armored cable and shall consist of a high potential test to be made upon the cable after assembling and leading or armoring, and, if lead covered, without immersion in water. In the case of multiplex cables, this test shall be made successively between each conductor and the other conductors and sheath in multiple. The potential test shall be repeated on lead covered armored cables after armoring. (See Section 2.)

(b) The insulation resistance (megohms) at a given temperature shall be reduced to that at 15.5 deg. Cent. (60 deg. Fahr.) by multiplying by the coefficient in Table XIV corresponding to that temperature. Tests shall be made at temperatures within the range of Table XV.

Varnished Cloth Insulation

60. Description.

The insulation shall consist of a closely woven cotton cloth and viscous filler. Each surface of the cloth shall have a smooth continuous film of varnish and shall be free from wrinkles, blisters, and other imperfections. It shall be thoroughly impregnated with insulating compound, be pliable and have no tendency to crack when doubled on itself. A separator, which shall conform to Section 72, will be permitted.

61. Thickness of Insulation.

Unless otherwise specified the thickness of insulation shall be in accordance with Table X.

Table X—Thickness of Varnished Cloth Insulation in 64th-In.

Size of Conductor	D-C 0 to 500V	D-C 501 to 1500V	Single or Two-Phase up to 2500V	Belted Cables: 3-Phase Grounded Neutral Volts between Phases: 6000 to 7000, Each Cond.	6000 to 7000, Belt	11000 to 12000, Each Cond.	11000 to 12000, Belt
Cir. Mils.							
2,000,000	9	10	....	....	....	....	....
1,750,000	9	9	....	....	....	....	....
1,500,000	8	9	....	....	....	....	....
1,250,000	8	8	....	....	....	....	....
1,000,000	7	8	10	....	....	....	....
500,000	6	7	9	....	....	12	8
250,000	6	7	9	8	6	12	8
A. W. G.							
0000	5	6	9	8	6	12	8
1	5	6	9	8	6	12	8
8	4	6	9	8	6	12	8

For intermediate sizes the requirements shall be those of the next larger size.

On single conductor cables in three-phase systems the thickness of insulation on each conductor shall be the sum of those specified for each conductor and belt. For all sizes above 500,000 cir.mil. having a voltage between phases of 11,000 to 12,000 volts, the thickness shall be 28/64 inch. Double conductor cables in three-phase systems shall have the same insulation on each conductor and belt as the three conductor cables.

62. Filler.

The filler shall be a viscous moisture-repelling insulating compound having a dielectric constant approximately the same as that of the varnished cloth insulation and of such a nature as to have no deleterious effect upon the varnish. It shall prevent the tapes from unwrapping when cut, but allow the layers to slide upon each other when cable is bent.

63. Assembly.

The insulating cloth shall be applied in the form of tape wound on helically and reversed at least every two layers. The tapes shall be of such widths that they will lie smoothly and be free from wrinkles; the turns shall overlap and the joints in successive layers shall be staggered. The filler shall be applied between layers as to exclude all air and moisture, the whole forming a hard semi-flexible wall of insulation.

64. Tape.

A layer of cloth tape, which shall conform to the requirements of Section 73, shall be applied over the cloth insulation. In the case of multiple conductor cables, a tape shall be applied over each conductor and one over the belt.

65. Electrical Tests.

Each and every length of wire or cable shall conform to the requirements of Sections 70 and 71. Electrical tests shall be made upon varnished cloth insulated wire or cable after at least one hour immersion in water, and while still immersed. If the wire or cable is to be covered with dry or flameproof braid, tests shall be made before the braid is applied; if it is to be covered with weatherproof braid, the tests shall be made on the finished product. Lead covered conductors shall be tested against the sheath with sheath grounded. Multiple-conductor cables and covered cables shall be tested between each conductor and the other conductors and sheath or ground in multiple. The potential test shall be repeated on armored cables after armoring.

Impregnated Paper Insulation

66. Description.

The insulation shall consist of Manila paper applied helically and evenly to the conductor, and then thoroughly impregnated with an insulating compound. The cable shall be pliable and show no tendency to harden injuriously at 0 deg. Cent. (32 deg. Fahr.). The paper shall contain no free mineral acids or free alkalis. The compound shall be so applied as to exclude all air and moisture, and shall contain no free mineral acid, alkali or other substances which have a deleterious effect upon the paper, copper or compound.

67. Thickness of Insulation.

Unless otherwise specified, the thickness of insulation shall be in accordance with Table XI.

68. Tensile Strength.

Tensile strength tests shall be made upon paper taken from any finished cable, both from conductor and belt, if any. Test pieces ten feet in length shall be selected, looped and tension applied at the loop through a mandrel, the diameter of which is equal to the width of the paper.

A tension of 5000 pounds per square inch shall be applied for 5 minutes, and then 6500 pounds per square inch for 1 minute. If more than one out of six samples selected from each lot by the Inspector fail to meet the tests, the entire lot may be rejected.

69. Electrical Tests.

Each and every length of finished wire or cable shall conform to the requirements of Sections 70 and 71. No immersion is required before testing. The potential test shall be made between conductor and sheath with the sheath grounded. Multiple conductor cables shall be tested between each conductor, and the other conductors and sheath or ground in multiple. The potential test shall be repeated on armored cables after armoring.

TABLE XI—THICKNESS OF IMPREGNATED PAPER INSULATION—64TH INCH

Size of Conductor	D-C. up to 500 V.	D-C. 501 to 1500 V.	Single or two phase up to 2500 V.	Belted Cables. 3-Phase Grounded Neutral Volts between Phases.			
				6000—7000		11000—12000	
				Each Cond.	Belt	Each Cond.	Belt
Cir. mil.							
2 000 000	9	10	....	....	....	....	....
1 750 000	9	10	....	....	....	....	....
1 500 000	8	9	....	....	....	....	....
1 250 000	8	9	....	....	....	....	....
1 000 000	7	9	12	....	....	....	....
750 000	7	9	12	....	....	....	....
500 000	6	8	10	....	....	....	....
250 000	6	8	10	9	6	14	9
A. W. G.							
0000	5	7	10	9	6	14	9
2	4	7	10	9	6	14	9
5	4	7	10	9	6	....	....
6	4	7	10	9	6	....	....
7	4	7	10	....	....	....	....
8	4	7	10	....	....	....	....
9	4	5	....	....	....	....	....
10	4	5	....	....	....	....	....

For intermediate sizes, the requirements shall be those of the next larger size.

On single conductor cables in three-phase systems the thickness of insulation on each conductor shall be the sum of those specified for each conductor and belt. For all sizes above 500,000 cir.mil. having a voltage between phases 11,000 to 12,000 volts, the thickness shall be 28/64 inches. Double conductor cables in three-phase systems shall have the same insulation on each conductor and belt as the three conductor cables.

ELECTRICAL TESTS OF INSULATION AT FACTORY

70. High Potential Test.

The high potential test voltage specified in Table XII and Table XIII shall be applied for five minutes; shall have a frequency not exceeding 100 cycles per second and shall approximate as closely as possible to a sine-wave. The initially applied voltage shall not be greater than the working voltage, and the rate of increase shall be approximately uniform and not over 100 per cent. in ten seconds. The source of energy shall be of ample capacity.

71. Insulation Resistance.

The insulation resistance shall be measured after the high potential test and after a one minute electrification with a battery having an e.m.f. of not less than 100 and not more than 500 volts. The results corrected to the standard temperature of 15.5 deg. Cent. (60 deg. Fahr.) shall conform with the requirements of Table XIV. In the case of multiplex cables, the values in the tables shall apply to each conductor.

Separator

72. Separator.

The separator may consist of a wind or braid of soft cotton yarn, or in the case of conductors of No. 6 A.W.G. and larger, a muslin tape. With untinned conductors, the separator shall completely cover the conductors; with tinned conductors the separator shall allow the insulation sufficient contact with the conductor to prevent the conductor sliding in the insulation.

Rubber Filled Cloth Tape

73. Tape.

The tape shall consist of cotton cloth not lighter than one-quarter pound per square yard, with not less than 56 by 60 picks per inch, thoroughly filled with a rubber compound. The tape shall be applied helically overlapping not less than specified in Table XVI, which also gives the maximum width of tape allowed.

Table XII—Test Potentials for Rubber Insulation

Potentials in Kilovolts—Five Minute Test.

Size of Conductors.	Thickness of Insulation, 64th Inch.									
	2	3	4	5	6	7	8	9	10	12
Cir. mils.										
2 000 000	....	....	....	....	....	....	4.0	5.0	6.0	9.0
1 750 000	....	....	....	....	....	....	4.0	5.0	6.0	9.0
1 500 000	....	....	....	....	....	....	4.0	5.0	6.0	9.0
1 250 000	....	....	....	....	....	....	4.0	5.0	6.0	9.0
1 000 000	....	....	....	....	....	4.0	5.0	6.0	7.0	10.0
750 000	....	....	....	....	....	4.0	5.0	6.0	7.0	10.0
500 000	....	....	....	3.0	4.0	5.0	6.0	7.0	8.0	11.0
350 000	....	....	....	3.0	4.0	5.0	6.0	7.0	8.0	11.0
250 000	....	....	....	3.0	4.0	5.0	6.0	7.0	8.0	11.0
0 000	....	....	....	3.5	4.5	5.5	6.5	7.5	8.5	11.5
000	....	....	....	3.5	4.5	5.5	6.5	7.5	8.5	11.5
0	....	....	....	3.5	4.5	5.5	6.5	7.5	8.5	11.5
1	....	....	3.5	4.5	5.5	6.5	7.5	8.5	9.5	12.5
2	....	....	3.5	4.5	5.5	6.5	7.5	8.5	9.5	12.5
4	....	....	3.5	4.5	5.5	6.5	7.5	8.5	9.5	12.5
6	....	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	13.0
8	....	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	13.0
10	....	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	13.0
12	....	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	13.0
14	....	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	13.0
16	1.0	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	12.5
18	1.0	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	12.5

For greater thicknesses add 1500 volts for each $\frac{1}{64}$ inch.

Table XIII—Test Potentials for Varnished Cloth and Impregnated Paper

Potentials in Kilovolts—Five Minute Test.

For Varnished Cloth use 100 per cent. of the following potentials.
For Impregnated Paper use 75 per cent. of the following potentials.

Size of Conductors	Thickness of Insulation, 64th Inch.							
	3	4	5	6	7	8	9	10
Cir. mils.								
2 000 000	......	......	......	......	......	5.0	8.0	10.5
1 750 000	......	......	......	......	......	6.5	8.5	11.5
1 500 000	......	......	......	......	......	7.0	9.5	12.0
1 250 000	......	......	......	......	......	7.5	10.0	12.5
1 000 000	......	......	......	......	5.5	8.0	10.5	13.0
750 000	......	......	......	......	6.5	9.0	11.5	14.0
500 000	......	......	2.5	5.0	7.5	10.0	12.5	14.5
350 000	......	......	3.5	6.0	8.5	10.5	13.0	15.0
250 000	......	......	4.0	6.5	9.0	11.0	13.5	15.5
A. W. G.								
0000	......	......	4.5	7.0	9.0	11.5	13.5	15.5
000	......	......	5.0	7.5	9.5	11.5	13.5	15.5
0	......	......	5.5	8.0	10.0	12.0	13.5	15.5
1	......	4.0	6.0	8.0	10.0	12.0	13.5	15.5
2	......	4.0	6.0	8.0	10.0	12.0	13.5	15.0
4	......	4.5	6.5	8.5	10.0	11.5	13.0	14.5
6	3.0	5.0	6.5	8.5	10.0	11.5	12.5	14.0
8	3.0	5.0	7.0	8.0	9.5	11.0	11.5	13.0
10	3.0	5.0	6.5	8.0	8.5	10.0	10.5	12.0

Thickness of Insulation

Size of Conductors.	Thickness of Insulation, 64th Inch.								
	12	14	16	18	20	22	24	26	28
Cir. Mil.									
250 000	17	20	23	25	28	31	33	36	38
A. W. G.									
0000-1	16	19	22	24	27	30	32	34	36
2-4	15	17	20	23	25	28	30	32	34
5 & 6	15	17	19	21	23	26	28	30	31

For intermediate sizes the requirements shall be those of the next larger size. Where the insulation thickness is less than the minimum for which test voltages are given, no potential will be required.

Table XIV—Megohm-Miles at 15.5 Deg. Cent. (60 Deg. Fahr.)

One Minute Electrification.

Rubber, minimum shall be 100 per cent. of following.
Varnished Cloth, minimum shall be 15 per cent. of following.
Impregnated Paper, minimum shall be 12½ per cent. of following.

Size of Conductors	Thickness of Insulation, 64th Inch													
	2	3	4	5	6	7	8	9	10	12	14	16	18	20
Cir. Mls.														
2,000,000	.....	.....	.....	.....	.....	225	200	250	275	325	350	.....	.....	.....
1,750,000	.....	.....	.....	.....	200	225	275	300	375	425	425	.....	.....	.....
1,500,000	.....	.....	.....	.....	225	250	300	325	325	400	475	.....	.....	.....
1,250,000	.....	.....	.....	200	250	275	325	350	375	425	500	575	.....	.....
1,000,000	.....	.....	.....	225	275	300	350	375	400	475	575	625	.....	.....
750,000	.....	.....	.....	250	300	325	400	450	475	525	625	750	800	.....
500,000	.....	.....	250	300	375	400	475	525	575	675	750	800	950	.....
350,000	.....	.....	300	350	425	475	525	600	675	775	850	950	1150	.....
250,000	.....	.....	350	400	475	575	625	675	725	875	1000	1050	1200	1250
A. W. G.														
0000	.....	.....	375	450	550	600	650	700	800	950	1050	1150	1250	1360
000	.....	.....	400	500	600	650	750	800	850	1000	1150	1250	1350	1450
00	.....	.....	450	550	650	750	850	900	950	1050	1250	1350	1450	1600
0	.....	.....	500	600	700	800	950	1000	1050	1200	1350	1450	1600	1650
1	.....	500	600	650	750	850	1000	1050	1150	1350	1450	1600	1750	1800
2	.....	550	650	750	850	950	1050	1150	1250	1450	1600	1750	1850	2000
4	.....	650	750	850	1000	1150	1250	1400	1450	1650	1850	2000	2150	2250
6	.....	800	850	1050	1200	1350	1450	1600	1750	1950	2050	2250	2400	2550
8	.....	850	1050	1250	1450	1650	1750	2000	2050	2200	2400	2600	2750	2850
10	.....	1150	1350	1600	1800	2000	2150	2300	2400	2650	2850	3050	3200	3400
12	.....	1350	1600	1850	2050	2250	2400	2600	2750	3000	3200	3400	3600	3800
14	.....	1550	1850	2150	2350	2550	2650	2900	3050	3500	3550	3750	3850	4050
16	1400	1800	2150	2400	2650	2850	3050	3250	3400	3650	3850	4150	4250	4450
18	1600	2050	2450	2800	3000	3200	3400	3600	3750	4050	4250	4450	4750	4850

For intermediate sizes, the requirements shall be those of the next larger size. For cables having insulation over 20/64 inch in thickness, or copper cross-section greater than two million circular mils, the table may be extended by means of the formula: $\text{Megohms} = 4000 \log_{10} \frac{D}{d}$ where D is outside diameter of insulation and d is diameter of equivalent solid wire.

Table XV—Temperature Coefficients for Resistance of Rubber Compound

The insulation resistance at a given temperature shall be reduced to that at 15.5 deg. Cent. (60 deg. Fahr.) by multiplying by the coefficient corresponding to that temperature.

(Centigrade Degrees)

Temperature deg. Cent.	Coefficient	Temperature deg. Cent.	Coefficient	Temperature deg. Cent.	Coefficient	Temperature deg. Cent.	Coefficient
7	.65	16	1.02	12	.85	21	1.30
8	.69	17	1.07	13	.89	22	1.37
9	.73	18	1.12	14	.93	23	1.43
10	.77	19	1.17	15	.98	24	1.49
11	.81	20	1.23	15.5	1.00	25	1.56

(Fahrenheit Degrees)

Temperature deg Fahr.	Coefficient	Temperature deg. Fahr.	Coefficient	Temperature deg. Fahr.	Coefficient	Temperature deg. Fahr.	Coefficinet
46	.69	61	1.03	55	.88	70	1.30
47	.71	62	1.05	56	.90	71	1.33
48	.73	63	1.08	57	.92	72	1.37
49	.75	64	1.11	58	.94	73	1.40
50	.77	65	1.14	59	.97	74	1.44
51	.79	66	1.17	60	1.00	75	1.48
52	.81	67	1.20				
53	.83	68	1.23				
54	.85	69	1.26				

Table XVI—Width and Overlap of Rubber Filled Cloth Tape

Diameter over Insulation, Inches	Maximum Width of Tape, Inches	Maximum Overlap, Inches	Diameter over Insulation, Inches	Maximum Width of Tape, Inches	Maximum Overlap, Inches
2.00	5	1/2	0.62	2	3/8
1.75	4 1/2	1/2	0.50	1 3/4	3/8
1.50	4	1/2	0.38	1 1/2	1/4
1.25	3 1/2	1/2	0.31	1 1/4	1/4
1.15	3 1/4	1/2	0.25	1	1/4
1.00	3	1/2	0.19	7/8	1/8
0.88	2 3/4	3/8	0.16	3/4	1/8
0.75	2 3/8	3/8			

For intermediate sizes the requirements shall be those of the next smaller size.

Braid

74. Weatherproof Braid.

Braid, unless otherwise specified, shall be of closely woven cotton thread, at least two-ply, thoroughly impregnated with an insulating weatherproof compound and finished with a black insulating compound thoroughly slicked down. The compound shall neither be injuriously affected by nor have injurious effect upon the braid at a temperature of 90 deg. Cent. (194 deg. Fahr.). The thickness of each braid shall be not less than given in the following table:

TABLE XVII—THICKNESS OF COTTON BRAID

Diameter Under the Braid or Jute, if any, Inches	Thickness of Braid, Inches	Diameter Under the Braid or Jute, if any, Inches	Thickness of Braid, Inches
1.000 and over	0.053	0.290	0.028
0.530	0.038	0.160	0.018

For intermediate sizes, the requirements shall be those of the next smaller size.

For twin cable use mean diameter.

(This table does not apply to fancy or special braids for fixtures, weatherproof wire, or cable, etc.)

75. Tests.

A six-inch sample of wire with carefully paraffined ends shall be weighed and submerged in fresh water of a temperature of 20 deg. Cent. (68 deg. Fahr.) for a period of twenty-four hours. The increase in weight after submersion and removal of surface water shall be not more than nine per cent. of the weight exclusive of copper and insulation before submersion: The compound shall not drip at a temperature of 50 deg. Cent. (122 deg. Fahr.).

76. Circular Loom Braid.

Circular loom braids shall be of cotton and unless otherwise specified, shall be each one-sixteenth inch in thickness. The braid shall be impregnated with a black insulating compound which shall neither be injuriously affected by nor have injurious effect upon the braid at a temperature of 90 deg. (194 deg. Fahr.). The compound shall not drip at a temperature of 50 deg. Cent. (122 deg. Fahr.).

The braid shall be coated with loose mica.

DRY PAPER TAPE

77. Paper Tape.

Dry paper tape shall be of high grade Manila paper not less than five mils thick and shall be applied helically lapping at least one-third its width.

MISCELLANEOUS BRAIDS

78. Glazed Cotton Braid.

Glazed cotton braid shall be of smooth glossy hard finished black cotton and no compound shall be applied to the finished braid. Glazed braids for telephone wires shall be so applied as not to slip.

79. Hemp Braid.

Hemp braid shall be of six-lea hemp thoroughly impregnated with an insulating weatherproof compound. The compound shall neither be injuriously affected by nor have injurious effect upon the braid at a temperature of 95 deg. Cent. (203 deg. Fahr.).

80. Colored Braid.

Colored braid shall consist of cotton impregnated with fast colors and shall be glazed except where they have an outer cover as in multiple conductor cables, when they shall be unglazed. The yarns shall be approved by the Inspector before they are applied.

80-A. Flameproof Braid.

The braid shall be of closely woven cotton thread at least two-ply, thoroughly impregnated with a compound which will render it non-inflammable.

Lead Sheath

81. Composition.

The lead sheaths of cable, except telephone cables, shall consist of commercially pure lead. The sheaths of telephone cables shall be composed of an alloy of lead and antimony; the amount of antimony being approximately one per cent.

82. Thickness.

Unless otherwise specified the sheath shall have an average thickness not less than that indicated in Table XVIII and the minimum thickness shall in no place be less than 90 per cent of the required average thickness.

Table XVIII—Thickness of Sheath

Diam. of Core, Inches	Thickness of Sheath in 64th Inch		Diam. of Core, Inches	Thickness of Sheath in 64th Inch	
	For Paper Insulation	For Rubber or Varnished Cloth Insulation		For Paper Insulation	For Rubber or Varnished Cloth Insulation
2.70 and over	10	9	0.70	7	6
2.00	9	8	0.30	6	5
1.25	8	7	Less than 0.30	5	4

For intermediate sizes the requirements shall be those of the next smaller size.

For twin cable, use the mean diameter.

Galvanized Steel Wire Armor

83. General.

The purpose of these specifications is to describe the armoring of insulated wire and cable with galvanized steel wire.

84. Preparation for Armor.

(*a*) *Cloth Taped or Braided Cables:* The cable shall be run through a hot asphalt compound, served with a helical layer of jute yarn, run through hot asphalt compound, then served with a second layer of jute yarn, run through hot asphalt compound and then laid with galvanized wire.

(*b*) *Lead Sheathed Cables:* The leaded cable shall be run through a hot asphalt compound, served with a layer of jute yarn, run through hot asphalt again, and then laid with galvanized wire.

85. Thickness of Jute Bedding.

The jute bedding under the armor, measured in the finished cable, shall be not less than 3/32nds of an inch on taped or braided cables and not less than 2/32nds of an inch on lead sheathed cables.

86. Armor Wire.

The armor shall consist of galvanized mild steel wire of uniform diameter, free from all cracks, splits or other flaws. Splices in the armor wire shall be smooth.

87. Application of Armor.

The armor shall be applied closely without appreciable space between adjacent wires. The lay shall be from eight to twelve times the pitch diameter.

88. Covering Over Armor.

The armored cable shall be run through hot asphalt compound, served with a layer of the best three-ply 14 lb. hard twisted jute yarn spun on with a close short lay, run through hot asphalt compound, then served with a second layer of the best three-ply, 14 lb. jute yarn, run through hot asphalt compound, and finally run through some material to prevent sticking.

89. Direction of Lay.

Successive layers of jute, or jute and armor, shall be laid in opposite directions. In the case of multiple conductor cable armored without lead, the direction of lay of the armor shall be opposite to that of the outside layer of conductors.

90. Size of Wire.

Unless otherwise specified, the armor wire shall be of the size specified in Table XIX. The same number of the Birmingham wire gage will be acceptable.

TABLE XIX—SIZE OF STEEL ARMOR WIRE

Diameter of Cable under Jute Bedding, Inches	Minimum Size of Wire, Steel Wire Gage	Diam. of Wire, In.	Diameter of Cable under Jute Bedding, Inches	Minimum Size of Wire Steel Wire Gage	Diam. of Wire, In.
1.30 and over......	4	0.225	0.63...............	10	0.135
1.25...............	6	0.192	0.44...............	12	0.105
0.88...............	8	0.162	Less than 0.44.....	14	0.080

For intermediate diameters, the requirements shall be those of the next smaller diameter.

91. Samples for Test.

Samples for each of the following tests shall be taken at random from ten per cent. of the coils, the number of samples being never less than two. If more than 20 per cent. of the samples fail to pass the tests, the entire lot will be rejected.

92. Tensile Strength and Elongation.

The wire shall have a tensile strength of not less than 50,000 pounds per square inch and an elongation of not less than ten per cent. in eight inches. The instructions for making tests, given in Section 49, shall be followed.

93. Galvanizing.

The galvanizing shall conform in every respect to the requirements of Sections 97 to 102.

94. Flexibility.

The armor wire shall be capable of being bent around a spindle ten times the diameter of the wire and straightened without developing cracks in the galvanizing, visible to the naked eye.

STEEL TAPE ARMOR

95. Application of Armor.

The cable shall be run through hot asphalt compound, served with a layer of jute yarn spun on with a close short lay, run through hot asphalt compound, armored with a steel tape; armored with a second steel tape; run through hot asphalt compound, served with a layer of 3-ply, 14 pound jute yarn with a close short lay, run through hot asphalt compound and finished by running through some material to prevent sticking. Both steel tapes shall be laid in the same direction and the outer shall be centered over the spaces between turns of the inner. If the cable is rubber insulated, it shall be covered with tape, braid or other suitable protection before passing through the asphalt compound. Each layer of jute shall be applied in the reverse direction to the adjacent layer. The space between adjacent turns of steel tape shall not exceed one-tenth the width of the steel tape.

96. Armor Tape.

The galvanized steel tape and the jute, under the armor, after armoring, shall conform to the following table:

TABLE XX—SIZE OF STEEL TAPE AND JUTE FOR ARMORING CABLES

Cable Diameter Before Armoring, Inches	Max. Width Steel Tape, Inches	Min. Thickness, each Tape, Inches	Minimum Jute Bedding, under Armor, Measured in Finished Cable, Inches
Over 2.00	2	0.05	2/32
2.00	1¾	0.04	2/32
1.70	1½	0.04	2/32
1.40	1¼	0.03	2/32
1.00	1	0.03	2/32
0.75	¾	0.02	2/32
0.45 or less	½	0.02	2/32

For intermediate diameters the requirements shall be those of the next larger diameter.

GALVANIZING

97. General.

These specifications shall apply to galvanized iron or steel unless otherwise specified. Seven samples shall be taken from each lot for the purpose of the following test:

98. Coating.

The galvanizing shall consist of a continuous coating of commercially pure zinc of substantially uniform thickness, and so applied that it adheres firmly to the metal. The finished product shall be smooth.

99. Cleaning.

The samples shall be cleaned before testing, first with carbona, benzine or turpentine, and cotton waste (not with a brush), and then thoroughly rinsed in clean water and wiped dry with clean cotton waste.

100. Test.

The samples shall be immersed for one minute in a solution of copper sulphate of specific gravity 1.186 at 18.3 deg. Cent. (65 deg. Fahr.), rinsed in clean water and wiped dry. This operation shall be repeated until the samples have been immersed four times. After these immersions no sample shall show any bright deposit of copper. The samples shall be approximately straight and the ends protected with paraffin. The solution shall be saturated with copper sulphate to which an excess of chemically pure cupric oxide has been added, and shall be maintained at 15.5-20 deg. Cent. (60-68 deg. Fahr.) during the test.

101. Quantity of Solution.

Wire samples shall be tested in a glass jar of at least two inches inside diameter. The jar without the wire samples shall be filled with standard solution to a depth of at least four inches.

The solution shall not be used for more than one series of four immersions.

Not more than seven wires shall be simultaneously immersed, and not more than one sample of galvanized material other than wire shall be immersed in the specified quantity of solution.

The samples shall not be grouped or twisted together, but shall be well separated so as to permit the action of the solution to be uniform upon all immersed portions of the samples.

102. Results of Test.

In case of failure of only one sample in a group of seven samples immersed together, or if there is a reasonable doubt as to the copper deposit, two check tests shall be made on these seven samples. If there is more than one failure in the original test or if either check test shows any failures, the lot may be rejected.

Cable Reels

106. General.

Cable shall be delivered on reels which shall conform with the following requirements:

107. Form of Reel.

Each reel shall consist of a wooden drum with wooden discs or heads securely fastened thereto.

108. Bushing.

If the shipping weight exceeds 300 pounds, each disc or head of the reel shall be provided with a cast iron bushing or an iron plate, in the center of which shall be a hole 2½ inches in diameter. The bushing or plate shall be secured to the head by means of bolts through the head.

109. Size and Weight.

The reels shall be of suitable size and weight for the service in which they are used. Both the drum and the head diameters shall be selected with this in view.

110. Covering and Lagging.

Insulated cable shall be thoroughly covered with burlap before lagging is applied.

When used for insulated cable, the reels shall be suitably lagged; when used for bare cable, the lagging of the reel shall be replaced by a burlap covering securely bound to the cable.

111. Marking.

A tag containing the following information shall be fastened to the coil inside the lagging with a duplicate securely fastened to the outside of the reel: (a) Name of Manufacturer; (b) size and number of conductors; (c) character of insulation; (d) gross pounds; (e) number of feet; (f) Railroads requisition and order number.

Each reel shall be given a number for identification.

112. Chocking.

Reels shall be properly chocked in the car so that there shall be no movement of reels during transit.

Note—The Committee has given consideration to alternate methods of securing the desired quality of rubber insulation, which will be reported upon at a later date.

Approved for the Committee,
Edwin B. Katte, *Chairman.*

RAILROAD SPECIFICATIONS FOR UNDERGROUND CONDUIT CONSTRUCTION FOR POWER CABLES

General

1. Scope.

These specifications describe the materials to be used and the processes to be employed in the construction of underground conduit lines for power cables for railroad purposes.

2. Materials. Drawings.

The conduit line and the materials used in its construction shall conform in every respect to the specifications. The accompanying drawings approved by the Engineer in charge shall form an essential part of these specifications.

3. Location of Conduit.

(a) Conduit lines shall be located so as to be subject to the least amount of disturbance and to interfere the least possible with prior installation.

(b) Preferably conduits shall be installed in a straight line between adjacent splicing chambers. If curves are unavoidable, they shall be of the greatest radius practicable. Curves of less than two hundred and fifty (250) feet radius shall not be constructed unles approved by the Engineer in charge.

(c) Conduit lines paralleling a railroad shall be located as far as practicable from the tracks. Where located within six (6) feet, measured horizontally from the nearest rail, the elevation of the top of the conduit line shall be at least four (4) feet below the base of rail. Where this is impracticable special protection shall be provided subject to the approval of the Engineer in charge. Where located six (6) feet or more from a track rail the top of the conduit line shall have at least two feet six inches (2′ 6″) of earth protection.

(d) Where conduit lines cross beneath the railroad tracks the top of the conduit protection shall be not less than four (4) feet below the base of rail unless special protection is provided which shall be approved by the Engineer in charge.

Ducts or Conduits

4. General.

The ducts or conduits shall be made of vitrified clay or impregnated wood fiber. They shall be straight and true and of uniform cross-section throughout and free from defects except as hereinafter permitted. The dimensions of the ducts or conduits shall conform to the dimensions shown on approved drawings within the limits hereinafter specified.

VITRIFIED CLAY DUCTS

5. Vitrified Clay Ducts.

(a) The shape of the duct shall be as shown on the approved drawing. The ducts shall be straight and true. The ends of each duct shall be perpendicular to its sides, and they shall be practically smooth and free from projection. The interior of the duct shall be beveled at each end.

(b) Ducts shall be made of finely divided clay free from stones or pebbles. The clay shall be thoroughly mixed, compacted, burned and vitrified. Ducts shall be glazed on all surfaces with a good salt glaze.

6. Defects.

(a) CRACKS: Ducts shall not contain cracks which will appreciably weaken them. The presence of cracks shall be determined by tapping the ducts with a steel hammer or its approved equivalent, and any duct which fails to give a clear metallic ring under this test shall be rejected. Ducts having injurious air or fire cracks shall be rejected. Ducts having cracks in their surfaces which exceed one-sixteenth ($\frac{1}{16}$) of an inch in width or which extend injuriously into their surfaces shall be rejected.

(b) CHIPPED ENDS: Ducts having chipped ends may be accepted providing the fracture does not extend further into the duct than the beveling.

(c) PROJECTIONS: The interior surfaces of ducts shall be free from rough or sharp broken blisters or other projections and from smooth rounded unbroken blisters which project more than one-sixteenth ($\frac{1}{16}$) of an inch above the surface. Blisters or other projections on the outer surface of ducts shall not project more than three-sixteenths ($\frac{3}{16}$) of an inch above the surface. Smooth salt drip which does not project more than one-eighth ($\frac{1}{8}$) of an inch above the inner surface is not objectionable.

(d) RECESSES: Recesses in the walls of ducts caused by broken blisters or other defects shall not decrease the thickness of the walls by more than three-sixteenths ($\frac{3}{16}$) of an inch. When on the inner surface, the edges of the recess shall be smooth.

7. Combing.

The outer surfaces of ducts shall be combed with two (2) sets of three (3) combings, each running lengthwise on the duct and placed adjacent to the corners.

8. Dimensions.

(a) LENGTH: The unit length of standard clay ducts shall be eighteen (18) inches. Short lengths shall be approximately six (6), nine (9) and twelve (12) inches long.

(b) INSIDE DIMENSIONS: The minimum inside dimension of ducts shall be not less than that specified and the maximum not more than one-quarter ($\frac{1}{4}$) inch in excess thereof.

(c) WALL THICKNESS: The thickness of the walls of ducts shall be not more than three-quarters (3/4) of an inch or less than nine-sixteenths (9/16) of an inch at the thinnest part of the section exclusive of the combing.

9. Tests.

(a) Ducts offered for inspection shall be factory run from which no ducts of superior quality have been removed.

(b) The ducts shall permit a mandrel eighteen (18) inches long and one-eighth (1/8) inch less than the specified inside dimension of the duct to pass freely through them.

(c) A section of finished duct weighing from three to four pounds broken so as to have all edges unglazed after being thoroughly dried and then immersed for twenty-four (24) hours in a sufficient quantity of water to just cover them and having a temperature of from sixty (60) to eighty (80) degrees Fahr. shall show an absorption of water of not more than five (5) per cent of its weight.

(d) The water in which the broken pieces of ducts have been immersed shall not test either acid or alkaline with litmus paper after the completion of the immersion test.

FIBER CONDUIT

10. Fiber Conduit.

Fiber conduit shall be made of finely divided wood pulp or fiber thoroughly impregnated with bituminous insulating compound. The compound shall not flow when the conduit has been heated to 212 deg. Fahr. for one hour, nor shall there be any separation into layers. The conduit shall not be affected by acids, alkalies or moisture and shall be free from all substances which might corrode or injure the sheath or rubber compound of a cable.

11. Walls.

The walls shall be hard and smooth and free from dents or obstructions, or excess of compound.

12. Dimensions.

The unit length of standard fiber conduit shall be five feet.

The inside and outside circumferences of any section of conduit including the joints shall not vary more than one-sixteenth (1/16) inch from a true circle at any temperature not exceeding 150 deg. Fahr.

The thickness of the conduit walls shall not be more than one-thirty-second (1/32) inch less or one-sixteenth (1/16) inch greater at any point than that given in Table I.

TABLE I—NOMINAL THICKNESS OF FIBER CONDUIT WALLS

Nominal Inside Diameter	*Socket Joint*	*Drive Joint*	*Screw Joint*
1½ in.	¼ in.	¼ in.	5/16 in.
2 in.	¼ in.	¼ in.	3/8 in.
2½ in.	¼ in.	¼ in.	3/8 in.
3 in.	¼ in.	¼ in.	7/16 in.
3½ in.	¼ in.	¼ in.	7/16 in.
4 in.	¼ in.	¼ in.	1/2 in.

13. Test for Section.

Each piece of conduit shall permit the passage of a mandrel thirty-six (36) inches long and of a cross-section one-eighth (⅛) inch less than the nominal inside diameter of the conduit.

14. Socket Joints.

Socket joints shall have a mortise on one end and a tenon on the other end of each piece of conduit. The mortise and tenon shall be machine cut to produce a snug fit not less than three-eighths (⅜) inch long, slightly tapered and free from projecting surfaces, which would prevent the joint from being properly assembled. The thickness of the conduit wall left after the mortise and tenon have been turned shall be not less than one-thirty-second (1/32) inch less than one-half the nominal thickness of the wall.

15. Drive Joints.

Drive joints shall have smooth machine cut tapers on each end of each piece of conduit. The taper shall be four degrees to the axis of the conduit. For each joint there shall be furnished a sleeve of the same material as specified for the conduit, machine cut to an internal taper at each end, the taper being the same as that specified for the conduit. The minimum thickness of the sleeve shall be not less than one-half the nominal thickness of the conduit. The tapers on the conduit and the sleeve shall be so cut that when the joint is made up the ends of the conduit shall not touch or be separated more than one-half (½) inch.

The dimensions of the sleeves shall be within the following limits:

TABLE II—SLEEVE DIMENSIONS—DRIVE JOINTS

Nominal Inside Diameter of Conduit	*Outside Diameter of Sleeve*		*Length of Sleeve*
	Not More Than	*Not Less Than*	*Not Less Than*
1½ in.	2⅜ in.	2 3/16 in.	2 7/16 in.
2 in.	2⅞ in.	2 11/16 in.	3 7/16 in.
2½ in.	3⅜ in.	3 3/16 in.	3 7/16 in.
3 in.	3⅞ in.	3 11/16 in.	3 7/16 in.
3½ in.	4⅜ in.	4 3/16 in.	3 7/16 in.
4 in.	4⅞ in.	4 11/16 in.	3 7/16 in.

16. Screw Joints.

Screw joints shall have a machine cut thread on each end of each length of conduit. For each joint there shall be furnished a sleeve of the same material as specified for the conduit, having machine cut thread to give an easy fit on the thread of the conduit. The minimum thickness of the sleeve shall be not less than three-quarters of nominal thickness of the conduit. The threads shall be cut and the ends of the conduit shall be faced so that the ends of the conduit will butt with a firm water-tight joint when the joint is screwed up firmly by hand, using a suitable bituminous compound. The threads shall be four to the inch.

TABIE III—SLEEVE DIMENSIONS—SCREW JOINTS

Nominal Inside Diameter of Conduit	*Outside Diameter of Sleeve*		*Length of Sleeve*
	Not More Than	*Not Less Than*	*Not Less Than*
1½ in.	2¾ in.	2½ in.	$2\frac{5}{16}$ in.
2 in.	3½ in.	3¼ in.	$2\frac{15}{16}$ in.
2½ in.	4 in.	3¾ in.	$3\frac{7}{16}$ in.
3 in.	5⅝ in.	$4\frac{7}{16}$ in.	$3\frac{7}{16}$ in.
3½ in.	$5\frac{5}{16}$ in.	$4\frac{15}{16}$ in.	$3\frac{15}{16}$ in.
4 in.	5⅞ in.	$5\frac{13}{16}$ in.	$3\frac{15}{16}$ in.

17. Fittings and Bends.

Fittings and bends shall be made of the same material specified for fiber conduit and all requirements as to quality, material, dimensions, tests and joints shall apply thereto.

Bends shall have left-handed threads and sleeve for bends shall have one end threaded left-handed. All other threads shall be right-handed.

18. Short Pieces.

In each shipment there shall be included not less than five (5) nor more than fifteen (15) per cent of pieces of conduit, less than the standard length of five (5) feet but no conduit shall be furnished less than two and one-half (2½) feet in length.

19. Tests

(a) A sample of conduit at seventy (70) degs. Fahr. resting on supports twenty-six (26) inches apart shall not exceed the deflection and shall not break under the load as shown in Table IV, when the load is centrally suspended between the supports.

(b) A six (6) inch sample of conduit at seventy (70) degs. Fahr. shall not be crushed when placed between two (2) flat surfaces under the pressure of a weight shown in the following table:

TABLE IV—DEFLECTION AND COMPRESSION TESTS

Inside Diameter	*Thickness of Wall*	*Deflec-tion*	*Deflection Test*	*Compression Test*
1½ in.	¼ in.	⅝ in.	200 lbs.	475 lbs.
2 in.	¼ in.	¾ in.	300 lbs.	506 lbs.
2½ in.	¼ in.	¾ in.	450 lbs.	500 lbs.
3 in.	¼ in.	¾ in.	550 lbs.	347 lbs.
3½ in.	¼ in.	⅝ in.	800 lbs.	317 lbs.
4 in.	¼ in.	⅝ in.	900 lbs.	310 lbs.

(c) A six (6) inch sample of conduit shall be thoroughly dried at a temperature of one-hundred-ten (110) degs. Fahr. for four (4) hours, then weighed, and after immersion for forty-eight (48) hours in pure water at seventy (70) degs. Fahr. shall show less than four (4) per cent. increase in weight due to absorption of water.

General—Vitrified Clay Ducts and Fiber Conduits

20. Inspection.

The Railroad may inspect the duct or conduit at any time during the process of manufacture and shall be furnished free of cost the necessary tools and appliances for making such tests as are necessary to determine if the requirements of these specifications have been met.

21. Packing and Marking.

Ducts when shipped in cars shall be carefully stacked, packed and braced.

Where shipped in less than carload lots they shall have the name of the Manufacturer, railroad order number and the shipping address plainly marked on a tag securely fastened to ten (10) per cent. of the pieces in the shipment.

Conduit Line Construction

22. Trenching.

(a) Where necessary the trench shall be opened at points along the line of the proposed conduit line so that the nature and location of obstructions may be approximated and the grade line determined.

(b) The trench shall be excavated six (6) inches wider than the width of the section of the conduit line and deep enough to provide at least the earth protection specified in Section 3 (c).

(c) The trench shall be so graded that it will have a fall of at least three (3) inches in one hundred (100) feet towards the lower splicing chamber. The bottom of the trench shall closely follow the grade and be free from depressions, humps or other irregularities.

About ten feet back from the splicing chamber the grade shall be changed to permit the separation of the duct as described in Section 24 (d).

(d) After grading has been completed the trench shall be kept as reasonably free from water by draining, pumping or bailing as may be necessary in the judgment of the Engineer in charge.

(e) In making excavations parallel to the tracks of the Railroad the excavated material shall be piled on one side of the trench and trimmed back two (2) feet to provide necessary working clearance. Where the trench is adjacent to high speed tracks the side nearest the tracks shall be thoroughly braced to prevent the slipping of the roadbed. No bracing shall extend above the top of the rail or be attached in any way to the rails or ties.

23. Conduit Foundation.

The conduit foundation shall have a minimum thickness of four (4) inches for the full width of the trench, except where ledge rock is encountered, in which case the concrete foundation may be omitted and the bottom of the trench levelled with cement mortar. The concrete foundation shall be allowed to attain its initial set before ducts are laid thereon. The concrete shall conform to the Standard Specifications of the Railroad.

24. Laying Clay Ducts.

(a) A layer of mortar of necessary thickness to insure an even bearing shall be placed on the concrete foundation before placing the lower tier of ducts. The ducts shall be laid so as to break joints at least three (3) inches in the same tier and in each succeeding tier the joints shall be broken, the same amount with relation to the tier below.

(b) Ducts shall be carefully butted. Each joint shall be wrapped with a strip of burlap, cheesecloth or other wrapper of quality approved by the Engineer in charge, not less than six (6) inches wide saturated with neat Portland cement mortar and laid equally over the abutting ducts. The ends of the strip shall lap not less than six (6) inches on top. These wraps shall be double on curves and also where concrete encasing is placed simultaneously with the laying of the ducts.

(c) The joints shall be plastered with one-half (½) inch layer of mortar. A layer of mortar of necessary thickness shall be placed underneath each succeeding tier of ducts as laid.

(d) Commencing about ten feet back from the splicing chamber the ducts shall be gradually separated both vertically and horizontally so that there will be a separation of four (4) inches where they enter the splicing chamber. Only eighteen (18) inch or twelve (12) inch ducts shall be used at the entrance to splicing chambers. Short lengths necessary for this adjustment shall be used further out in the section. Where the ducts are cut to special lengths the cut shall be dressed with a chisel and rasped until the hole is slightly bell mouthed and has smooth edges to conform closely to the original design.

(e) Wherever the work is suspended leaving incompleted tiers the free ends of the ducts shall be closed with tapered wood or other approved plugs which shall conform accurately to the shape of the opening and be of such size at the large end that they cannot be forced entirely within the opening. Where the conduit lines pass over quicksand or other unstable ground, the concrete foundation shall be specially reinforced or supported.

25. Concrete Protection.

The duct line shall be encased with concrete which shall be not less than three (3) inches thick on the sides and four (4) inches over the top. The concrete shall conform to the specifications in Section 38. The concrete shall be allowed to attain its initial set and preferably its final set before the trench is filled in.

LAYING FIBER CONDUITS

26. Laying Fiber Conduits.

(a) A layer of mortar of necessary thickness to ensure an even bearing shall be placed on the concrete foundation before placing the lower tier of conduits. One tier shall be laid at a time with all joints staggered at least six (6) inches as between adjacent conduits and tiers of conduits. Spacers shall be used between conduits so as to maintain a separation of at least one (1) inch, both vertically and horizontally. These shall be removed as the pouring of the concrete nears them.

(b) After the first tier of conduit is laid one (1) inch of concrete shall be placed thereon extending three (3) inches beyond the side of the conduit line. Succeeding tiers of conduit shall be laid in a similar manner with one (1) inch of concrete laid over each tier except the upper tier. After the upper tier has been placed a four (4) inch layer of concrete shall be poured on top of the last layer of conduit.

(c) The concrete shall be carefully placed so as not to disturb the conduits or to injure the joints in any way when tamping is being done.

(d) Where either the socket, sleeve or screw joint type of conduit is used the joints shall be treated with a joint paste or compound. The paste or compound shall not act injuriously on the conduit or on the sheaths or rubber insulation of cables. Extreme care shall be taken to exclude the paste or compound from the interior of the conduits.

27. Joining Different Ducts.

Where a change from one style or size of duct to another is necessary it shall be made at a splicing chamber.

28. Back Filling.

Back filling shall be done in layers and each layer shall be thoroughly tamped without flushing. Where openings have been made through paving, sidewalls or platforms they shall be brought to a grade three (3) or four (4) inches above the existing grade until after the replacements have been made.

29. Clearing.

Materials, boulders and rubbish incidental to the construction shall be removed as the work will permit and at its completion the site shall be left clean and unobstructed.

30. Cleaning and Rodding.

After the conduit line has been completed and the concrete enclosing it well set the ducts shall be cleaned and rodded by using a steel plunger, a steel wire flue brush and wood mandrel in the order named. All mortar or other foreign substance shall be removed from the conduit line, leaving clean smooth surfaces inside the ducts. If obstructions are found in rodding the ducts which cannot be removed by cleaners so as to give a clean smooth opening one-eighth (1/8) inch less than the nominal size of the duct for the entire length between adjacent splicing chambers, the conduit lines shall be opened up and the obstruction removed and the ducts replaced.

Splicing Chambers

31. General.

(a) Splicing chambers shall be located where indicated on the plans and shall be of the type shown on the accompanying drawings. The modifications necessary to suit local conditions shall be subject to the approval of the Engineer in charge.

(b) Splicing chambers shall preferably be made of concrete. Where concrete splicing chambers are not practicable, hard burned brick laid with Portland cement mortar joints shall be used.

(c) The splicing chambers shall generally be spaced from four hundred (400) to five hundred (500) feet apart, depending on the size and weight of cable to be installed.

(d) Splicing chambers shall be so located as to provide safe and ready access and in general shall be built so that no part of the cover of a manhole is less than three (3) feet measured horizontally from the nearest rail. Splicing chambers shall, where possible, be located in dips or depressions in the conduit line so that drainage will be naturally toward them. The lower tier of ducts shall enter the splicing chambers at not less than eight (8) inches above the floor and the upper tier not less than eight (8) inches below the roof.

(e) Pulling in irons shall be located as shown on the drawings. The manhole shall be circular in form and not less than thirty inches in diameter. It shall, where practicable, be placed in the center of the splicing chamber roof.

32. Dimensions of Splicing Chambers.

The dimensions of splicing chambers shall be determined by the number of ducts entering them, the character and importance of the installation and local conditions.

The dimensions of typical splicing chambers are shown in the following table:

DIMENSIONS OF SPLICING CHAMBERS

Table V—Two-Way Splicing Chambers

No. of Ducts	*(A)*	*(B)*	*(C)*
9 or less	8′-0″	5′-0″	6′-6″
10 to 16	9′-0″	6′-0″	7′-0″
	Three-Way Splicing Chambers		
9 or less	8′-0″	8′-0″	6′-6″
10 to 16	9′-0″	10′-0″	7′-0″
	Four-Way Splicing Chambers		
9 or less	7′-0″	10′-0″	6′-6″
10 to 16	8′-0″	11′-0″	7′-0″

33. Excavation for Splicing Chambers.

Where outside forms are not used, the excavation shall be made to conform with the outside dimensions of the splicing chambers.

Where outside forms are used or the splicing chamber is to be constructed of brick, excavation shall be at least eight (8) inches greater than the outside dimensions.

34. Walls.

(a) Walls shall be of a thickness necessary for local conditions and will be shown on plans.

(b) Where brick construction is used, every third course shall be headers. Brick bats shall not be used. At horizontal joints, the mortar shall not exceed one-half inch in thickness and at vertical joints three-eighths inch in thickness.

(c) The thickness of concrete and brick walls may be increased or decreased from the dimensions shown on the plans to fit local conditions, with the approval of the Engineer in charge.

(d) Where splicing chamber walls are within eight feet of the nearest rail of railroad tracks, the walls shall be designed so as to take care of the additional loads imposed upon them.

35. Floors.

The floors shall preferably be of concrete and placed at the same time that the walls are built. If the manhole is of brick construction, the floor shall be either of concrete four inches thick, or of grouted brick.

36. Cable Hangers.

Provision shall be made for supporting the cables in the splicing chambers. A method is described below and illustrated on Plate No. 8.

(a) Racks: Each rack shall be made of not less than one-quarter (¼) inch angle iron punched or drilled and galvanized or sherardized. The racks shall be fastened to the splicing chamber wall by galvanized or sherardized bolts which are to be set in the side wall.

(b) Hangers: Each rack shall be provided with a number of single or double cast iron cable hangers, of design shown on drawings, as the Engineer in charge may direct. Each hanger shall be made of good quality tough gray iron made by the cupola process and shall be true to dimensions, smooth, clean and free from blow holes and other injurious imperfections. Each hanger shall be fastened to the rack with a bolt. Each hanger shall be given one coat of an approved moisture resisting paint before and after installation or otherwise protected from corrosion as may be directed by the Engineer in charge.

(c) Insulators: Cable hangers shall be provided with semi-porcelain insulators, glazed on all surfaces and shall be smooth and free from cracks, flaws, chipped surfaces or other injurious imperfections.

37. Manhole Covers and Frames.

Frames and covers shall be of tough gray iron, free from injurious cold-shuts, shrinkage strains, blow holes or other imperfections, and shall be true to dimensions and workmanlike in finish. The frames and covers shall conform with the size and type indicated on the drawings.

38. Drains.

A back pressure valve and trap with perforated inlet and guard, subject to approval of the Engineer in charge, shall be furnished and placed as designated or as indicated on the drawing, and the same shall be properly connected by means of a pipe with the main sewer, or with gutter drains or ditches at the nearest practicable point.

39. Anchor Bolts.

Anchor bolts in walls of splicing chambers and the pulling in irons shall conform to dimensions called for on the plans, and shall be of material similar to that covered by specifications for bridge iron.

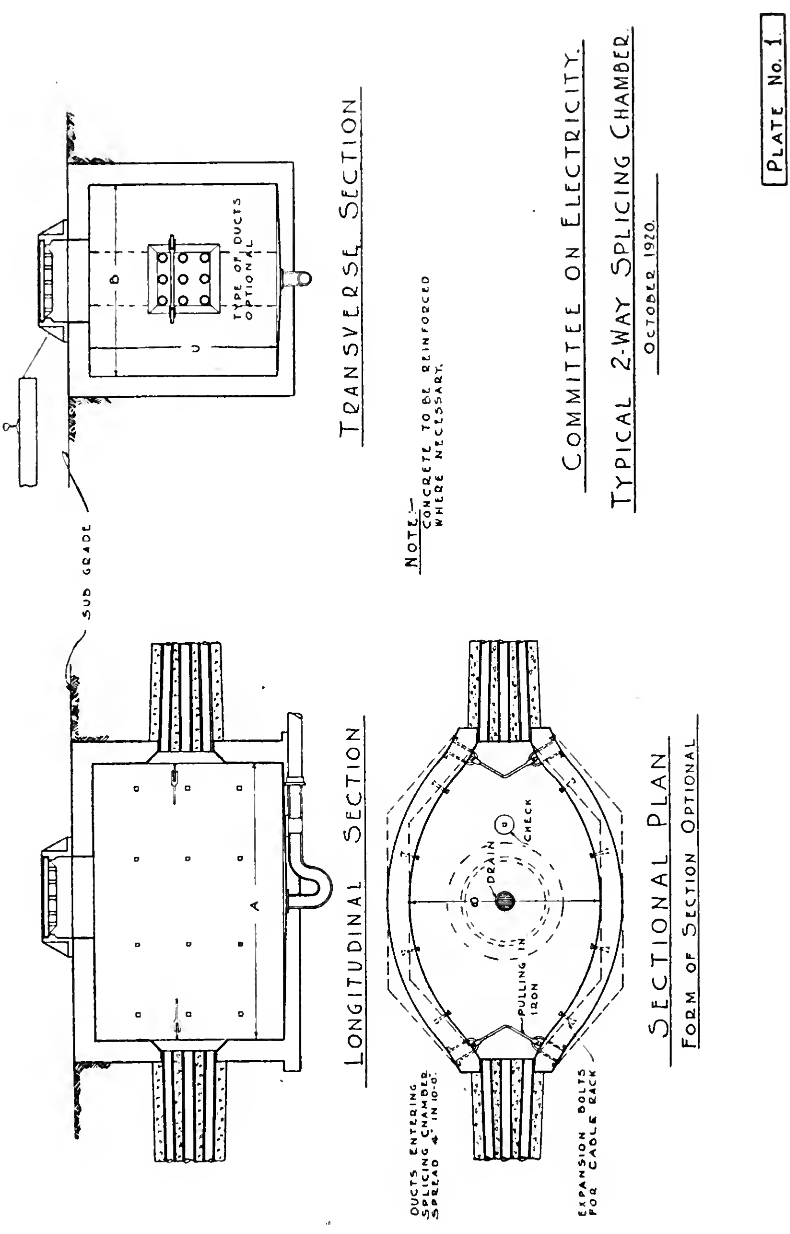
40. Reinforcing Bars.

Reinforcing bars to be used in the construction of the roof of splicing chambers and for reinforcing walls, when necessary, shall conform with the standard specifications for reinforcing bars.

41. Structural Steel.

Structural steel when indicated as necessary on the drawings, shall conform to Railroad standard specifications for this class of material.

Approved for the Committee,
Edwin B. Katte, *Chairman.*


TRANSVERSE SECTION
TYPE OF DUCTS OPTIONAL
B
C
SUB GRADE
LONGITUDINAL SECTION
A
NOTE:- CONCRETE TO BE REINFORCED WHERE NECESSARY.
SECTIONAL PLAN
FORM OF SECTION OPTIONAL
DRAIN
CHECK
PULLING IRON
DUCTS ENTERING SPLICING CHAMBER SPREAD 4" IN 10-0"
EXPANSION BOLTS FOR CABLE RACK
COMMITTEE ON ELECTRICITY.
TYPICAL 2-WAY SPLICING CHAMBER
OCTOBER 1920.
PLATE No. 1

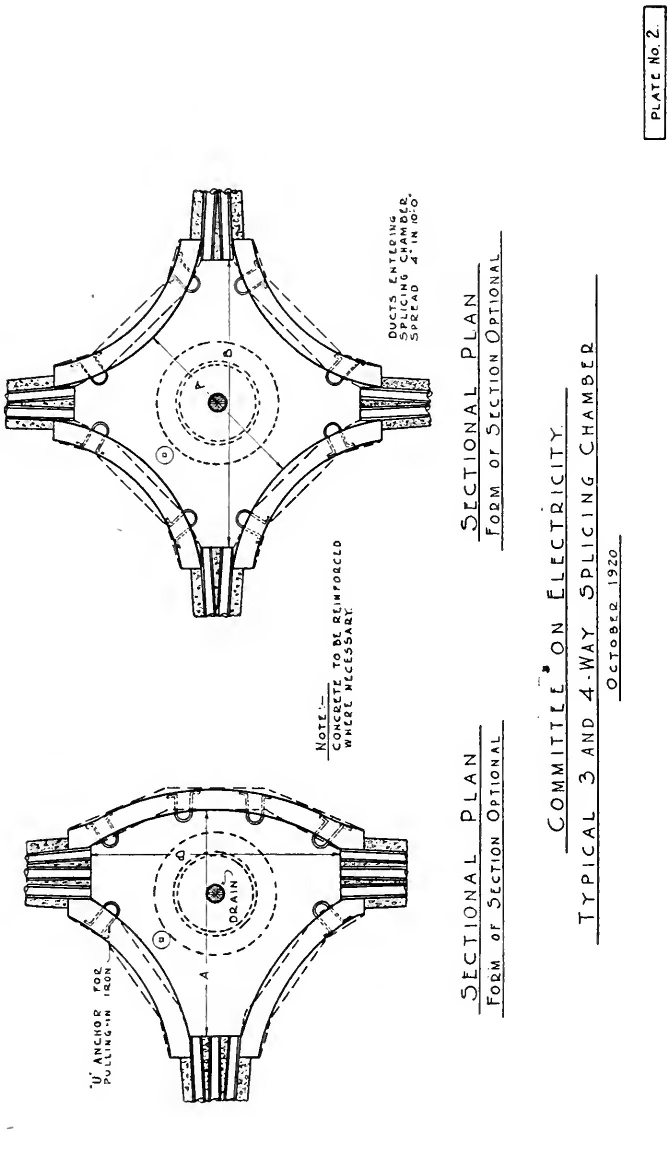


PLATE No. 2.
'U' ANCHOR FOR PULLING-IN IRON
DRAIN
A
B
NOTE:— CONCRETE TO BE REINFORCED WHERE NECESSARY.
DUCTS ENTERING SPLICING CHAMBER, SPREAD 4" IN 10'-0"
SECTIONAL PLAN
FORM OF SECTION OPTIONAL
SECTIONAL PLAN
FORM OF SECTION OPTIONAL
COMMITTEE ON ELECTRICITY.
TYPICAL 3 AND 4-WAY SPLICING CHAMBER
OCTOBER 1920

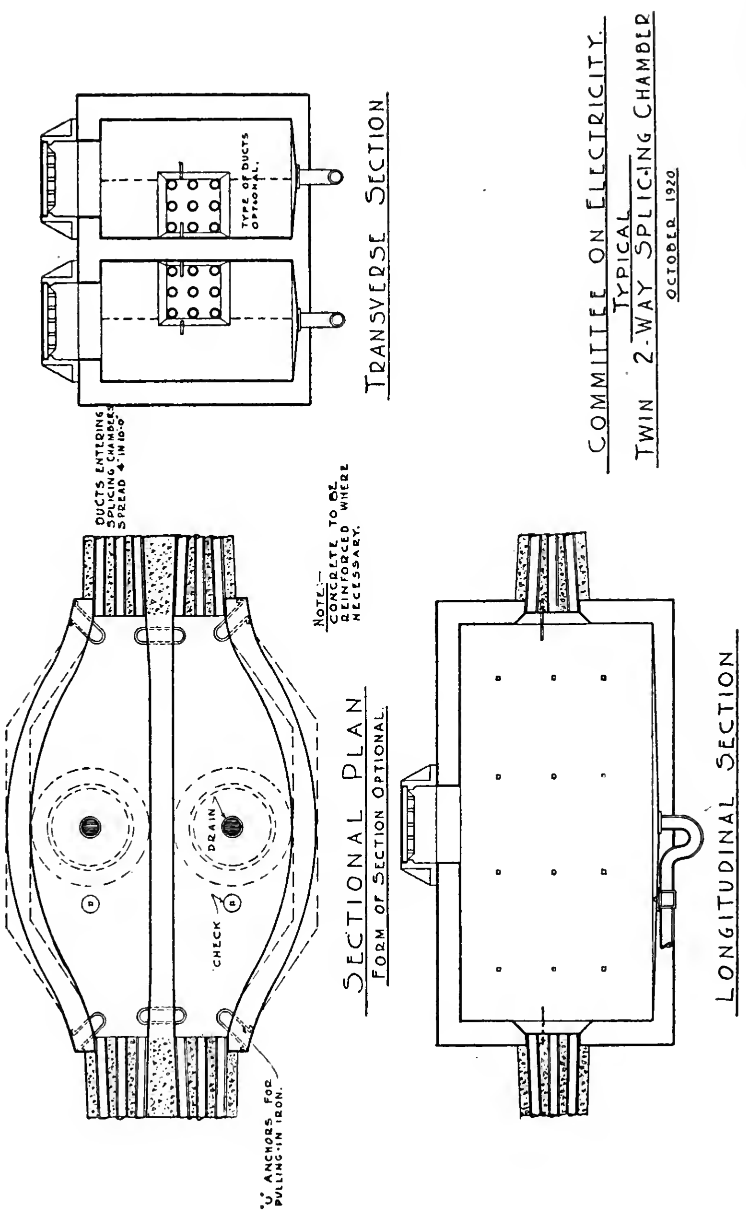

TRANSVERSE SECTION
TYPE OF DUCTS OPTIONAL.
DUCTS ENTERING SPLICING CHAMBERS SPREAD 4" IN 10'-0"
NOTE:— CONCRETE TO BE REINFORCED WHERE NECESSARY.
SECTIONAL PLAN
FORM OF SECTION OPTIONAL.
DRAIN
CHECK
"U" ANCHORS FOR PULLING-IN IRON.
LONGITUDINAL SECTION
COMMITTEE ON ELECTRICITY.
TYPICAL
TWIN 2-WAY SPLICING CHAMBER
OCTOBER 1920

PLATE No. 3.

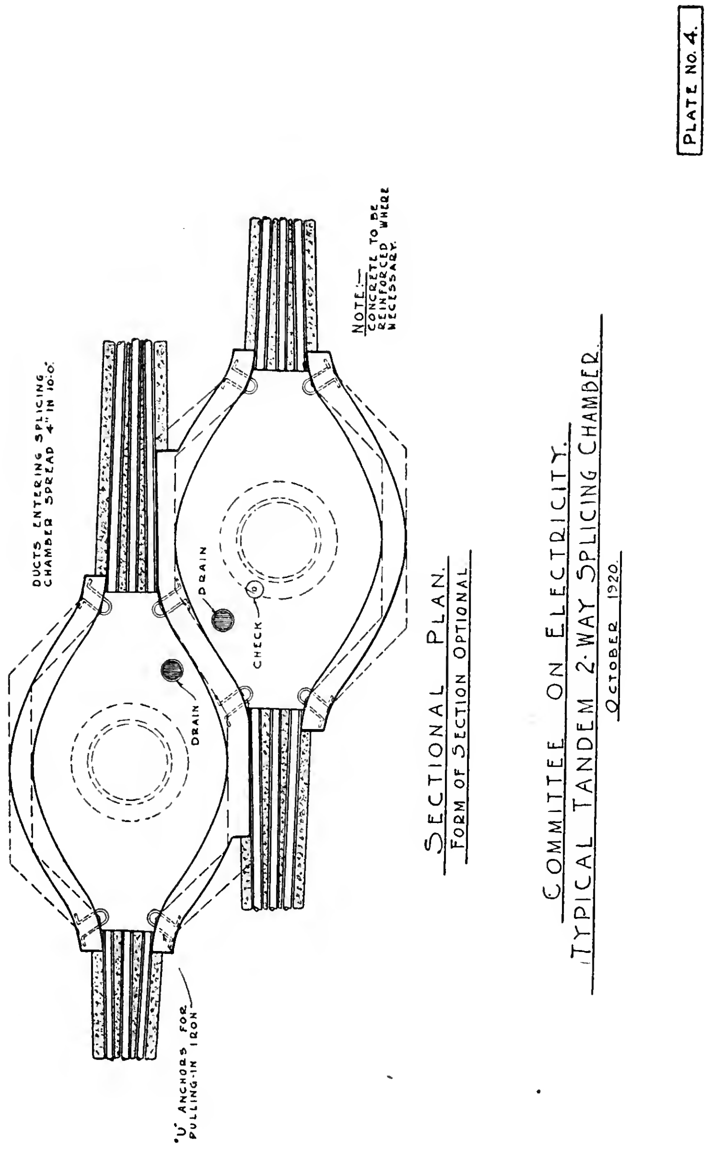


PLATE NO. 4.
"U" ANCHORS FOR PULLING-IN IRON
DUCTS ENTERING SPLICING CHAMBER SPREAD 4" IN 10-0".
NOTE:— CONCRETE TO BE REINFORCED WHERE NECESSARY.
DRAIN
DRAIN
CHECK
SECTIONAL PLAN.
FORM OF SECTION OPTIONAL
COMMITTEE ON ELECTRICITY.
TYPICAL TANDEM 2-WAY SPLICING CHAMBER.
OCTOBER 1920.

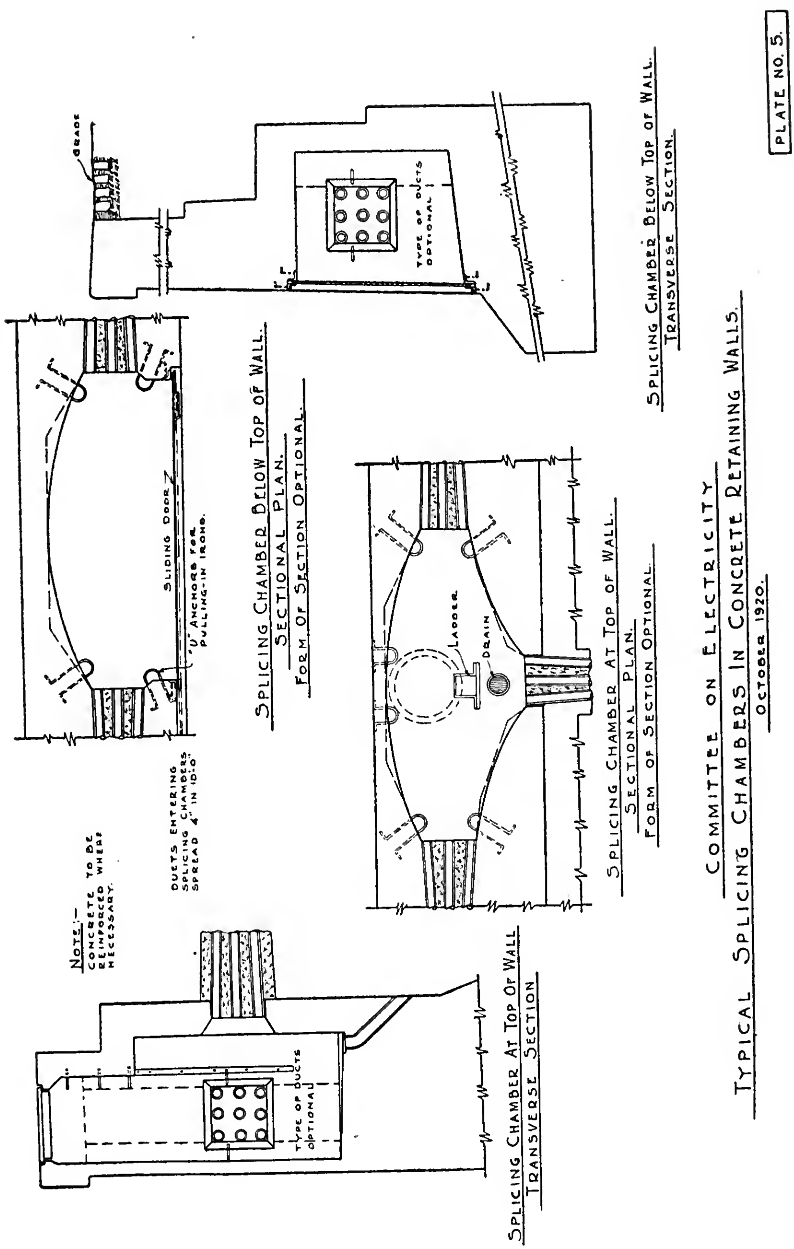


PLATE NO. 5.
GRADE
TYPE OF DUCTS OPTIONAL
SPLICING CHAMBER BELOW TOP OF WALL.
TRANSVERSE SECTION.
SLIDING DOOR
"U" ANCHORS FOR PULLING-IN IRONS.
SPLICING CHAMBER BELOW TOP OF WALL.
SECTIONAL PLAN.
FORM OF SECTION OPTIONAL.
LADDER
DRAIN
SPLICING CHAMBER AT TOP OF WALL.
SECTIONAL PLAN.
FORM OF SECTION OPTIONAL.
DUCTS ENTERING SPLICING CHAMBERS SPREAD 4" IN 10'-0"
NOTE:- CONCRETE TO BE REINFORCED WHERE NECESSARY.
TYPE OF DUCTS OPTIONAL
SPLICING CHAMBER AT TOP OF WALL
TRANSVERSE SECTION
COMMITTEE ON ELECTRICITY
TYPICAL SPLICING CHAMBERS IN CONCRETE RETAINING WALLS.
OCTOBER 1920.

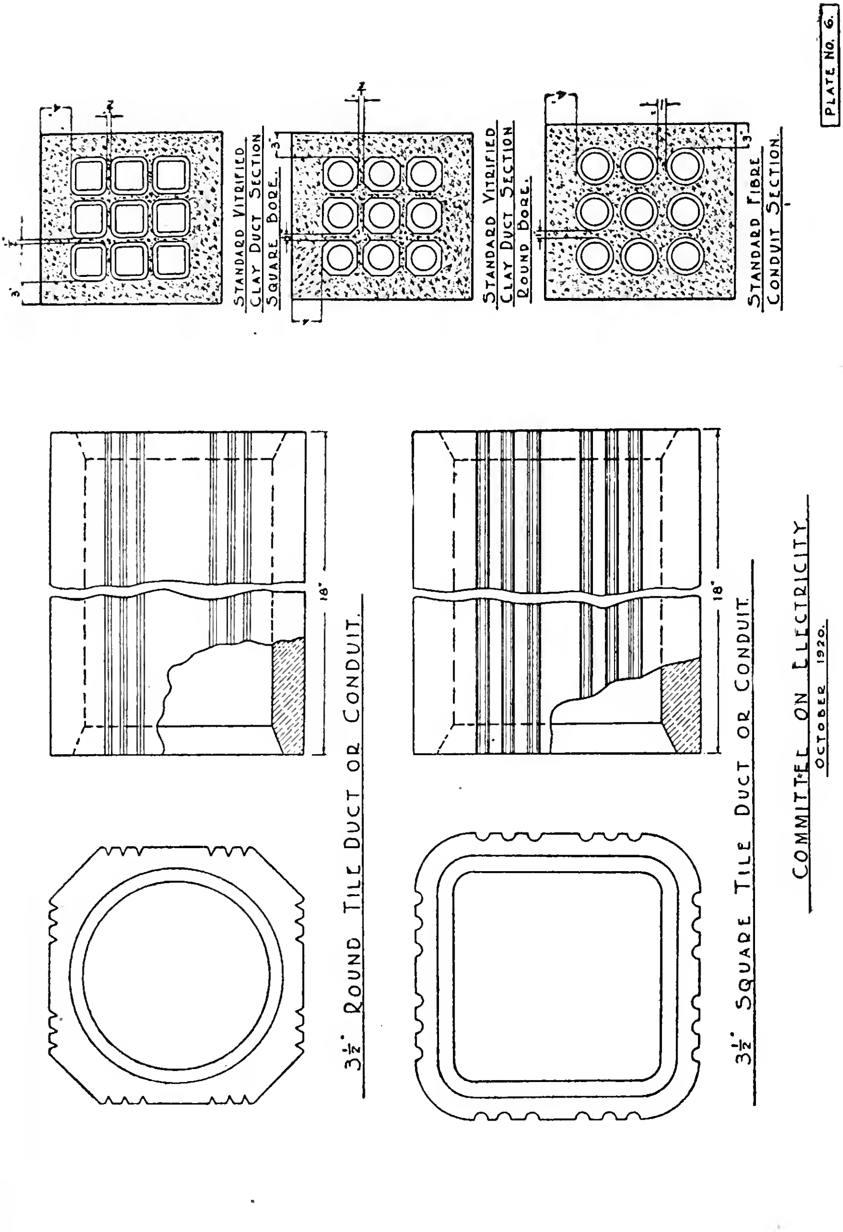
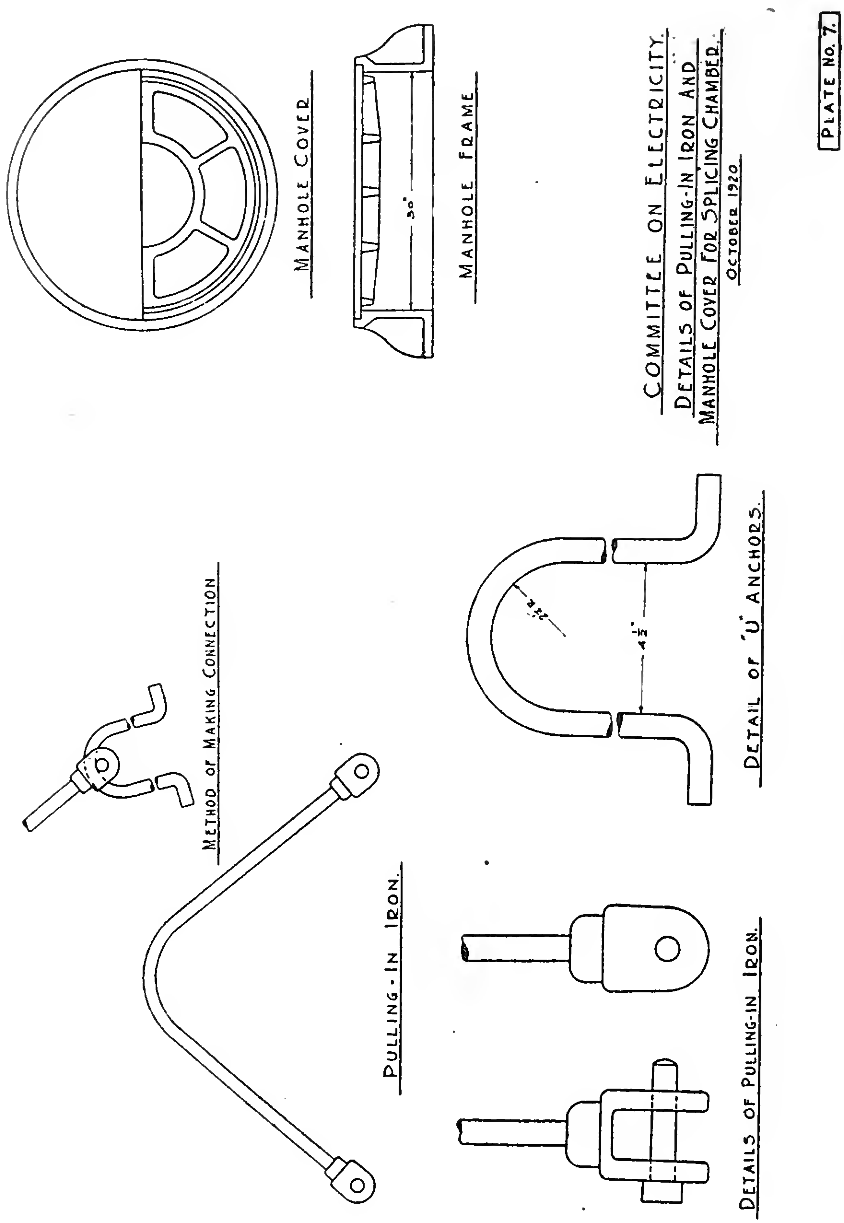


PLATE NO. 6.
STANDARD VITRIFIED CLAY DUCT SECTION SQUARE BORE.
STANDARD VITRIFIED CLAY DUCT SECTION ROUND BORE.
STANDARD FIBRE CONDUIT SECTION.
3"
18"
3½" ROUND TILE DUCT OR CONDUIT.
3½" SQUARE TILE DUCT OR CONDUIT.
COMMITTEE ON ELECTRICITY
OCTOBER 1920.


Manhole Cover
Manhole Frame
30"
Committee on Electricity.
Details of Pulling-In Iron And
Manhole Cover For Splicing Chamber.
October 1920
Plate No. 7.
Method of Making Connection
Pulling-In Iron.
Detail of 'U' Anchors.
4½"
Details of Pulling-In Iron.

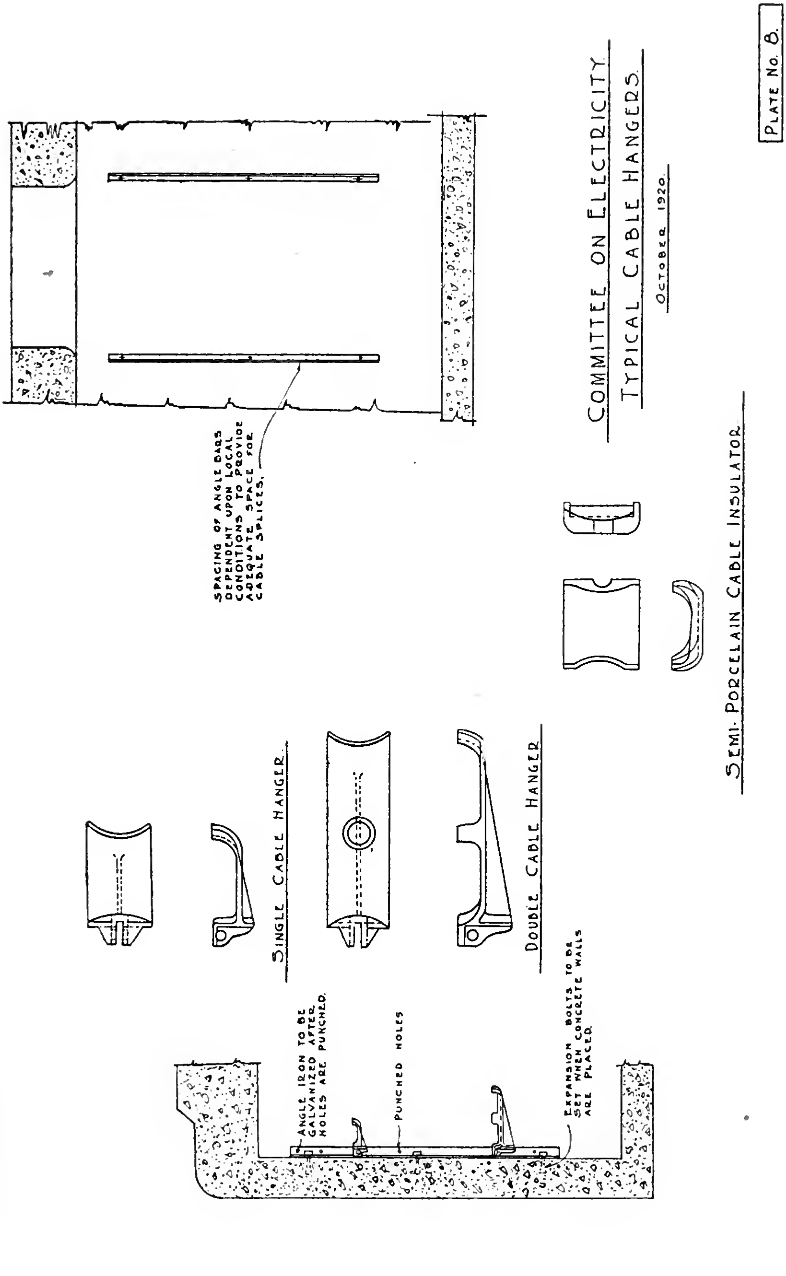


PLATE No. 8.
COMMITTEE ON ELECTRICITY
TYPICAL CABLE HANGERS
OCTOBER 1920
SPACING OF ANGLE BARS DEPENDENT UPON LOCAL CONDITIONS TO PROVIDE ADEQUATE SPACE FOR CABLE SPLICES.
SEMI-PORCELAIN CABLE INSULATOR
SINGLE CABLE HANGER
DOUBLE CABLE HANGER
ANGLE IRON TO BE GALVANIZED AFTER HOLES ARE PUNCHED.
PUNCHED HOLES
EXPANSION BOLTS TO BE SET WHEN CONCRETE WALLS ARE PLACED.

REPORT OF COMMITTEE IV—ON RAIL

G. J. Ray, *Chairman;*
E. E. Adams,
A. S. Baldwin,
W. C. Barnes,
W. C. Cushing,
G. M. Davidson,
Dr. P. H. Dudley,
J. M. R. Fairbairn,
L. C. Fritch,
J. H. Gibboney,
A. W. Gibbs,
C. R. Harding,
H. B. MacFarland, *Vice-Chairman;*
John D. Isaacs,
H. D. Knecht,
Howard G. Kelley,
R. Montfort,
A. W. Newton
J. R. Onderdonk,
F. S. Stevens,
F. M. Waring,
M. H. Wickhorst,
J. B. Young,

Committee.

To the American Railway Engineering Association:

Your Committee on Rail respectfully submits its report to the Twenty-second Annual Convention.

The subjects assigned the Committee for 1920 by the Board of Direction for investigation and report were as follows:

1. Make thorough examination of the subject-matter in the Manual, and submit definite recommendations for changes.
2. Report on rail failures, present statistics and conclusions as to causes, and submit suggestions for improvements in rail steel.
3. Continue special investigation of rail steel.
4. Recommend sections for rails over 140 lb. per yard.
5. Report on details of manufacture and mill practice as they affect rail quality.
6. Recommend designs of rail joints covering important dimensions affecting interchange of joint bars.
7. Report on material for joint bars and methods of treatment.
8. Recommend designs for track bolts covering important dimensions affecting interchange of bolts.
9. Report on rational relation between intensity of. pressure due to wheel loads and resistance of rail steel to crushing and deformation.
10. Report on effect of age on the physical properties of rail steel.
11. Report on developments in methods of inspection.

Meetings were held in 1920 as follows: Chicago, March 17th, with ten present; New York, May 19th, with fifteen present; New York, September 14th, with twenty-two present; jointly with the Rail Manufacturers' Committee at New York, September 14th, with seventeen representing the Rail Committee and nine representing the Manufacturers, or a total of twenty-six; Chicago, November 16th, with twenty-one present.

(1) Revision of Manual

The Committee has given considerable attention to the rail record forms in the Manual, and in Appendix A presents forms recommended for inclusion in the Manual to replace the present forms.

(2) Rail Failure Statistics

The rail failure statistics for the period ending October 31st, 1918, classified by railroads are shown in Vol. 21, p. 1125. This is the first time the statistics have been presented thus classified and they constitute in effect a supplement to the rail failure statistics for 1918 classified by mills presented in the usual form with last year's report. The statistics for the period ending October 31st, 1919, were published in Bulletin 229 for September, 1920. The failures are classified both by the mills that made the rails and by the railroads that use them, and other new features are included in the report. The average failures per hundred track miles for all the rails reported on are given below.

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	.....
1916	1.6	11.8	29.2	47.7	.....	.....
1917	5.3	21.6	38.9	.....	.....	.....
1918	1.6	8.9	....	.....	.....	.....
1919	2.0	....	....	.....	.....	.....

It will be noted that the 1908 to 1914 rollings show successively decreased numbers of failures compared on a basis of five years' service. Judged by the performance on a four-year basis, the record of the 1915 rails will show a little increase. The more recent or "war-time" rollings of 1916 and especially those of 1917 are starting out badly and promise to give high failure records, due mostly to the product of certain mills.

(3) Investigations

During the year special reports have been presented by the Rail Committee as follows:

No. 89. Rail Failure Statistics for 1918 Classified by Railroads, by M. H. Wickhorst.

No. 90. The Relation of Shattered Steel in Fissured Rails to the Mill End of the Rail, by M. H. Wickhorst. (Appendix B.)

No. 91. Rail Failure Statistics for 1919, by M. H. Wickhorst.

No. 92. Residual Ductility Tests in the Bearing Surface from Failed Rails in Service, by Dr. P. H. Dudley. (Appendix C.)

Report No. 90 is a continuation of the research work to discover the cause of interior rail shattering so a remedy can be provided. Previous reports by the Rail Committee have announced the discovery of a shattered condition in the interior of the heads of rails that had failed from transverse fissures; that is, the interior steel contained numerous small cracks, some of which developed in service and some of these in turn finally breaking the rail. It has already been shown that in the body of the rail the shattering remains about one-half inch away from the exterior surface and this investigation shows that the shattered interior also terminates about one-half inch short of the end of the rail as hot-sawed at the mill. This indicates that the shattering was not in the hot rail bar as rolled but developed in the cooling of the rail; that is, the small cracks are probably shrinkage checks.

Dr. Dudley's paper describes the results of drop tests of sixty-five rails which had failed in service. They were cut into short lengths and tested in the drop test with the head in tension, to determine their ductility. Most of the rails were lacking in ductility but some showed good ductility. Failures of the coalescent type occurred mostly in the A rails, while failures of the intergranular type were more numerous in the B and C rails.

(4) Rail Sections

The Committee has been giving attention to the designing of a section for 150 lb. rail, and although not ready to submit a design to the Association, reports progress on the subject.

(5) Mill Practice

The American Railway Association increased its appropriation for Rail Committee work and the Committee recently employed Mr. John B. Emerson as Assistant Engineer of Tests, for the purpose largely of making a critical study of the influence of mill practice on the properties of the rails as made at the various mills.

Subjects (6) to (10) Inclusive

The Committee has no reports to make on these subjects this year.

(11) Methods of Inspection

The Committee sent out a questionnaire on the subject of methods used in the inspection of steel rails. The replies are being tabulated and studied, and the Committee expects to submit recommendations later.

CONCLUSION

Your Committee submits the following resolution for adoption by the Association:

That the rail record forms submitted with this report (Appendix A) be adopted by the Association and included in the Manual to replace the present forms.

Subjects for Future Work

Your Committee recommends the subjects 1 to 11 be assigned to it for 1921, except that subject 10 be dropped and replaced by the subject, "Report on the most desirable length for rails."

The Committee on Rail,
G. J. Ray, Chairman.

Appendix A

RAIL RECORD FORMS

A. W. Newton, *Chairman;*
W. C. Cushing,
J. M. R. Fairbairn,
C. R. Harding,
M. H. Wickhorst,
Sub-Committee.

After giving careful consideration to a revision of the Rail Record forms as they appear in the 1915 Manual and concluding that it would be desirable to make a thorough revision of these blanks, as a result of its labors the Sub-Committee presents in the following pages revised forms and recommends that they be substituted for those in the Manual.

The forms have been re-grouped and re-numbered. Below is given the grouping with the form number and title:

Group 1—Inspection and Shipment:

401-A, Mill Inspection.
401-B, Certificate of Inspection.
401-C, Report of Shipment.
401-D, Tabulation of Results of Mill Inspections of Rail.
401-E, Yearly Summary of Mill Inspections of Rail.

Group 2—Rail Failures:

402-A, Track Foreman's Report of Rail Failure.
402-B, Monthly Summary of Rail Failures.
402-C, Yearly Summary of Rail Failures.
402-D, Statement of Rails in Main Tracks.

Group 3—Rail Wear:

403-A, Diagram of Location of Rails.
403-B, Diagram of Lines of Wear.
403-C, Record of Wear.

Explanation of Forms

As will be noted above, the Rail Record forms are divided into three groups as follows:

401—Mill Inspection and Shipment.
402—Rail Failures.
403—Rail Wear.

Group 1

401-A, Report of Chemical and Physical Tests of Rails.

This form gives the Inspector's reports of chemical, physical and other tests of rails on which acceptance or rejection is based.

401-B, Certificate of Inspection of Rails.

This form gives a statement of the amount of rails accepted and rejected of each class, tonnages, etc.

401-C, Report of Shipment of Rails.

This form gives the details of the rails loaded into each car for shipment. When properly checked by the receiving officer, it furnishes the basis for the payment of the invoice.

401-D, Tabulation of Results of Mill Inspections of Rail.

This form is a tabulation of the results of the mill inspections of rails covering in general the results for several days' rolling, or rollings distributed over several weeks. The form may be varied to suit the specifications to which the rails are rolled.

401-E, Summary of Mill Inspection of Rails.

This form is for an annual report by each railway to the American Railway Association covering the main results of the mill inspection of rails.

Group 2

402-A, Report of Rail Failures in Main Track.

This form is intended for use by the Track Foreman to report each rail failure as it occurs in the track. It is the basic report from which monthly and annual summaries are made.

402-B, Rail Failures for the Month.

This form is a monthly summary of the rail failures on a division.

402-C, Rail Failures for the Year.

This form is an annual summary of the rail failures and is used by each railway to make an annual report to the American Railway Association.

402-D, Statement of Steel Rails in Main Tracks.

This form is a statement showing the rails existing in the tracks at the end of the year.

Group 3

403-A, Location Diagram.

This is a form on which may be drawn a diagram showing the location of the rails in test.

403-B, Diagram Showing Lines of Wear.

This form contains sections of the rails being tested and on which the progressive wear may be shown. The diagram should be of the section of the rail under test.

403-C, Statement of Comparative Wear of Test Rail.

This form is a tabulation of the results of tests of wear.

Form 401A

REPORT OF CHEMICAL AND PHYSICAL TESTS OF RAILS

Rolled By.................... At.................... For North & South Railroad Report No.....
Height Of Drop........Ft. Span Of Supports........Ft. Section And Weight Per Yard Of Rail........ Date Of Rolling................
Specifications Used.. Maximum Shrinkage Allowed On 33 Ft. Rails................ Inchs
Size Of Ingots....By....Inchs; Nominal Discard From Ingot........Percent From Top....Percent From Bottom; Nominal No. Of Rails Per Ingot...

Heat No.	No. Of Ingots	No. Of Rails	Chemical Analysis														Ingot No. In Heat	Head Up Or Base Up	Drop Test Blow No.	Perm Set Inchs	Elongation In Inchs						Total Elongation	Remarks Showing Disposition Of Rails After Testing
			C		Mn		P		S		Si.										1st	2nd	3rd	4th	5th	6th		
			L	R	L	R	L	R	L	R	L	R	L	R	L	R												
Spec'ns																												
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																												
32																												

Date Of Report..........192.. 'L' Means Ladle Test; R. Means Rail Analysis Signed.................................... Inspector

Form No 401B

CERTIFICATE OF INSPECTION OF RAILS

Rolled By________________At____________ For North & South Railroad Report No____

Section And Lbs Per Yd____________ Dates Of Rolling______________

Mr________________________,

The Following Steel Rails Have Been Inspected And Accepted According To Contract. The Rails Are Certified To Be Within The Specifications Of The ____

And Approved As Per Details Given Below. All Rails Have Been Inspected And Approved In Accordance With Specifications Now In Effect. Number Of Rails Rolled____________ Number Of Heats Rolled__________ Number Of Heats Rejected________ Number Of Rails Placed In Stock; No.1________No.2_______ Other____

	Rails Accepted		Total		Rails Rejected On Account Of		Rails	Tons
1	As No.1 From This Rolling			14	Top Rail Test Piece (Or Pieces)	Breaking		
2	" No.2 " " "			15	" " " " " " "	Failing in Ductility		
3	As Other From This Rolling			16	" " " " " " "	Showing Interior Defects		
4	As No.1 From Stock	(See Report No.___)		17	Second " " " " "	Breaking		
5	" No.2 " "	(See Report No.___)		18	" " " " " " "	Failing in Ductility		
6	As Other From Stock	(See Report No.___)		19	" " " " " " "	Showing Interior Defects		
7	Total Accepted And Shipped			20	Third " " " " "	Breaking		
8	As No.1 Rails Stocked From This Rolling			21	" " " " " " "	Failing in Ductility		
9	" No.2 " " " " "			22	" " " " " " "	Showing Interior Defects		
10	" Other " " " " "			23	Surface Defects	Other Reasons		
11	Rails Restraighted			24	Total Rejected			
12	Rails Cut; For Flaws	For Other Reasons						
13	Rails Made No 2; For Flaws	For Other Reasons						

Number Of Rails Of Each Length

Length	33	32	31	30	29	28	27	26	25	24			Total
No.1													
No 2													
Other													

	Calculated Weight			Shipper's Scale Weight		
	Total Pounds	Tons	Lbs	Total Pounds	Tons	Lbs
No. 1						
No. 2						
Other						

Railroad Order No.	Amount Of Orders			Accepted Under This Certificate						Balance Due				
				No 1		No. 2		Other		No. 1		No. 2		
	Tons No.1	Tons No.	Tons Other	Tons	Lbs	Tons	Lbs	Tons	Lbs	Tons	Lbs	Tons	Lbs	

Remarks

Date Of Report________192__ Signed________________________Inspector

FORM 401C
REPORT NO. ....

REPORT OF SHIPMENT OF RAILS

ROLLED BY.......................AT.......................FOR. North & South Railroad

SECTION AND LBS. PER YD. ....R. R. ORDER NUMBER......................

CONSIGNED TO...

QUALITY NUMBER.....................

	LOADED ON CARS		NO. OF RAILS OF EACH LENGTH													SHIPPERS WEIGHTS POUNDS
	INITIAL	NO.	33	32	31	30	29	28	27	26	25	24			TOTAL RAILS	
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																
		TOTAL														

TOTAL WEIGHT OF SHIPMENT.......................TONS...................................POUNDS

	TOTAL TONS OF ORDER	TOTAL SHIPMENTS		BALANCE DUE	
		TONS	LBS.	TONS	LBS.
NO. 1 RAIL					
NO. 2 RAIL					
TOTAL					

REMARKS:

DATE OF REPORT.................192.....

SIGNED...INSPECTOR

FORM 40TE

SUMMARY OF MILL INSPECTIONS OF RAIL

Rolled For North & South Railroad During Year Ending Dec.31, 192...

MILL	RAILROAD	KIND OF STEEL	SPECIFICATIONS USED	POUNDS PER YARD	SECTION	SPECIFIED CARBON		AV TOP DISCARD PER CENT	ACCEPTED-TONS				AV ELONG. OF ACCEPTED RAILS PER CENT	REJECTED							TOTAL TONS ROLLED	PER CENT REJECTED OF TOTAL ROLLED	PER CENT NO.2 OF TOTAL TONS ROLLED	REMARKS
														TONS				PER CENT OF TOTAL TONS						
						MIN	MAX		NO.1	NO.2	OTHER RAILS	TOTAL		A RAILS	B RAILS	OTHER RAILS	TOTAL	A RAILS	B RAILS	OTHER RAILS				

REMARKS:

INSTRUCTIONS

1 ATTACH TO THIS REPORT A COPY OF THE RAIL SPECIFICATIONS USED
2 FILL IN THIS SHEET SO BLUEPRINTS CAN BE MADE OF IT. USE INDIA INK, OR IF TYPEWRITTEN, FACE THE UNDER SIDE OF THIS SHEET WITH BLACK CARBON PAPER
5 FILL IN EACH LINE WITHOUT USING DITTO MARKS FOR SORTING AND TABULATING. THE PRINTS ARE TO BE CUT ALONG THE HORIZONTAL LINES, AND EACH STRIP SHOULD HAVE ITS INFORMATION COMPLETE.
4 UNDER "KIND OF STEEL" SHOW WHETHER OPEN-HEARTH, BESSEMER, ELECTRIC, ALLOY, SPECIAL TREATMENT, OR OTHERWISE
5 UNDER "AVERAGE TOP DISCARD" SHOW THE AVERAGE PER CENT. OF DISCARD FROM THE TOP OF THE INGOT, INCLUDING CROPPINGS FROM BOTH THE BLOOM AND THE RAIL-BAR
6 THE "AVERAGE ELONGATION OF ACCEPTED RAILS" REFERS TO THE EXHAUSTED DUCTILITY OF RAILS TESTED TO DESTRUCTION IN THE DROP TEST AND WHICH IN ANY GIVEN PIECE IS THE MAXIMUM PER CENT. OF STRETCH IN ANY ONE INCH OF THE USUAL SIX SPACES OF ONE INCH EACH.
7 IN EXPRESSING TONS, USE WHOLE NUMBERS. IN EXPRESSING PER CENTS, USE WHOLE NUMBERS AND TENTHS.
6 IN CASE OF DOUBT AS TO THE INTERPRETATION OF ANY OF THE ITEMS ON THIS FORM, WRITE TO ENGINEER OF TESTS, RAIL COMMITTEE, AMERICAN RAILROAD ASSOCIATION, SECTION II, ENGINEERING, ROOM 1426, 431 SOUTH DEARBORN STREET, CHICAGO, ILLINOIS

(A)

Tabulation of Results of Mill Inspections of Rail

Line No.	Inspector's Report Number	Name of Company and Mill Where Rolled	Rail			No. of Tons Ordered	No of Tons Ordered							No of Tons Rejected –		No of Tons Rolled and Submitted to Inspector.	No. of Rails Accepted			
			Weight	Section	Kind of Metal		No 1		No. 2		Other		Total Tons	Number	% of Total Rolled		No. 1 Rails	No 2 Rails	Other Rails	Other Rails
							Tons	% of Total	Tons	% of Total	Tons	% of Total								
1																				
2																				
3																				
4																				
5																				
43																				
44																				
45																				
46																				
47																				
48																				

Form 401D

Rolled from ....192.... to ....192....

Number Of Rails Rejected																Permanent Set Under First Blow Inches				Exhausted Elongation Percent In Maximum Inches				Average Analysis Of Heats Accepted														Average Discard From Ingots		Average No. Of Ingots In Heat	Normal No. Of Rails Per Ingot	Size Of Ingots	No. Of Heats Rolled
Total Number	% Of Total Rolled	Top Rails				Second Rail				Third Rail				Surface Imperfection										C		P		Mn		Si		S											
		Failing In Elongation		Showing Interior Defect		Failing In Elongation		Showing Interior Defect		Failing In Elongation		Showing Interior Defect				No. Of Pieces Tested	Max.	Min.	Average	No. Of Pieces	Highest	Lowest	Average	L	R	L	R	L	R	L	R	L	R	L	R	L	R	% Top	% Bottom				
		No.	% Of Total Reject	No.	% Of Total Reject	No.	% Of Total Reject	No	% Of Total Reject	No.	% Of Total Reject	No.	% Of Total Reject	No.	% Of Total Reject																												

"L" Means Ladle Test; "R" Means Rail Test.

FORM 402A

North & South Railroad

REPORT OF RAIL FAILURE IN MAIN TRACK

DIVISION.................................SECTION.................................DATE OF REPORT..............192.....

1	WEIGHT, PER YARD....................	19	WAS RAIL MUCH OR LITTLE WORN....................
2	RAIL SECTION....................	20	BY WHOM DISCOVERED....................
3	MANUFACTURER....................	21	DATE AND TIME FOUND....................
4	DATE ROLLED....................	22	WAS RAIL REMOVED....................
5	HEAT NUMBER STAMPED ON RAIL....................	23	DATE REMOVED....................
6	RAIL LETTER.............. 7 INGOT NUMBER..........	24	EXACT GAGE OF TRACK AT BREAK....................
8	KIND OF STEEL....................	25	WAS BREAK OVER OR BETWEEN TIES....................
9	MONTH AND YEAR LAID....................	26	DISTANCE BETWEEN EDGES OF TIES AT BREAK..........
10	LOCATION..............FEET..........OF MILE POST..........	27	KIND OF TIES....................
11	WHICH TRACK..............12 WHICH RAIL....................	28	CONDITION OF TIES AT BREAK....................
13	ON CURVE OR STRAIGHT LINE....................	29	KIND OF TIE PLATES....................
14	DEGREE OF CURVE....................	30	KIND OF BALLAST....................
15	HIGH OR LOW RAIL....................	31	WAS ROADBED FROZEN....................
16	ELEVATION OF OUTER RAIL....................	32	KIND OF JOINT..............33 NUMBER OF HOLES..........
17	KIND OF FAILURE (SEE CLASSIFICATION)....................	34	NUMBER OF BOLTS LOOSE....................
18	DISTANCE FROM END OF RAIL....................	35	DISTANCE END OF RAIL TO EDGE OF TIE....................

36 CONDITION OF WEATHER..

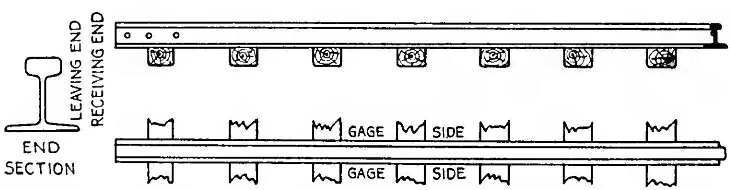
37 DESCRIBE BREAK..

....

38 WAS ACCIDENT OR DETENTION CAUSED BY BREAK IF SO DESCRIBE..

....

39 DRAW LINES ON THE DIAGRAM BELOW TO SHOW NATURE OF BREAK IF BREAK WAS NEAREST RECEIVING END DRAW LINE THROUGH WORDS "LEAVING END" INDICATE GAGE SIDE BY DRAWING LINE THROUGH WORDS "GAGE SIDE" ON OPPOSITE SIDE.



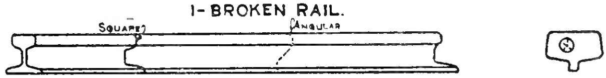
SIGNED..FOREMAN

Back Of Form 402 A

CLASSIFICATION OF RAIL FAILURES

Mark With (X) One Or More Of The Diagrams Showing The Nature Of The Failure. The Foreman Should Fill Out This Report And Forward The Same Day The Break Is Discovered, Or In The Case Of A Damaged Or Defective Rail, The Day It Is Taken Out Of The Track

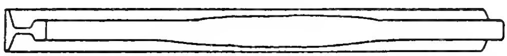
1- BROKEN RAIL.



(A) Transverse Fissure: This Term Covers A Fracture Progressing Outwardly From A Central Nucleus With This Type Of Fracture, There Is Always A Smooth (Bright Or Dark Oval) Spot In The Interior Of The Head.

(B) Ordinary Breaks: This Term Covers A Square Or Angular Break In Which There Is No Evidence Of A Transverse Fissure

2-FLOWED HEAD



This Term Means A Rolling Out Of The Metal On Top Of The Head Toward The Sides Without There Being Any Indication Of A Breaking Down Of The Head Structure; That Is The Under Side Of The Head Is Not Distorted

3-CRUSHED HEAD

This Term Is Used To Indicate A Flattening Of The Head And Is Usually Accompanied By A Breaking Down Of The Head

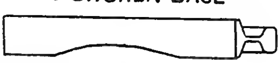
4-SPLIT HEAD

This Term Includes Rails Split Through Or Near The Center Line Of The Head, Or Rails With Pieces Split Out Of The Side Of The Head. When This Term Is Used It Should Be Further Defined By Stating Whether It Is Or Is Not Accompanied By A Seamed Or Hollowed Head.

5-CRACKED WEB

This Term Refers To A Longitudinal Crack In The Side Of The Web.

6-BROKEN BASE



This Term Covers All Breaks In The Base Of The Rail And Should Be Described And Illustrated On The Sketchs On The Front Page

7-DAMAGED

Under Head Will Be Included All Rails Broken Or Injured By Wrecks, Broken Wheels Or Similar Causes

FORM 402B

North & South Railroad

RAIL FAILURES FOR THE MONTH OF..........192....ON....................DIVISION

LINE NUMBER	REPORT NUMBER	DESCRIPTION OF RAIL: WT. PER YARD	TYPE OF SECTION	MARKS ON RAIL: MANUFACTURER	ROLLED MO.	ROLLED YEAR	KIND OF STEEL	HEAT NO.	INGOT NO.	RAIL LETTER	LENGTHS	LOCATION OF RAIL: MILE POST NO.	MILE POST FEET	WHICH TRACK	CURVE OR TANGENT	DEGREE OF CURVE	DATE LAID MO.	DATE LAID YEAR	DAY OF MONTH FOUND	TIME IN SERVICE YEAR	TIME IN SERVICE MO.	NATURE OF FAILURE: TRANS. FISSURE	BROKEN, ORDINARY	FLOWED HEAD	CRUSHED HEAD	SPLIT HEAD	CRACKED WEB	BROKEN BASE	DAMAGED	IN JOINT	OUT OF JOINT
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																															
																					TOTAL FAILURES →										
																						GRAND TOTALS OF FAILURES FOR MONTH									

DATE OF STATEMENT............192....

Form 402-C

Rail Failures for the Year Ending October 31, 19

______________________________ Railroad

Kind of Steel	Mill	Year Rolled	Pounds Per Yard	Section	Railroad	Tons New Rail Laid	Equivalent Track Miles	Specified Carbon		Period	Number of Failures																									Failures per 100 Track Miles of New Rail Laid
								Min.	Max.		Head					Web					Base					Broken					Total					
											A	B	L	U	Total	A	B	L	U	Total	A	B	L	U	Total	A	B	L	U	Total	A	B	L	U	Total	
										This Year																										
										Total to Date																										
										This Year																										
										Total to Date																										
										This Year																										
										Total to Date																										

INSTRUCTIONS FOR FILLING IN FORM 402-C

1. Statistics are desired for rails weighing 70 lb. per yard and over. Omit rail rolled previous to 1908. Omit information for lots of less than 1000 tons.

2. Fill in the information concerning rail lots in which there were no failures, as well as for rail lots in which there were failures.

3. Rails broken or injured by wrecks, broken wheels or similar causes are not to be included in this report.

4. Express the tonnage of rails in whole numbers. Express the mileage in whole numbers and hundredths. Express the failures per 100 track miles in whole numbers and tenths.

5. Under "Kind of Steel" show whether the rails were bessemer, open-hearth or special steel.

6. Under "Number of Failures" the letter "A" denotes the top rail of the ingot; "B" denotes the second rail, "L" denotes the lower rails or those below the "B" rail; "U" denotes that the ingot position of the rail is unknown.

7. To convert tons into track miles, the number of tons may be divided by the figures given below, which show the tons (2240 lb.) of rail per mile of single track for different weights per yard of rail.

70-lb.	110.00 tons	100-lb.	157.14 tons
72-lb.	113.14 tons	101-lb.	158.71 tons
75-lb.	117.86 tons	105-lb.	165.00 tons
80-lb.	125.71 tons	110-lb.	172.86 tons
85-lb.	133.57 tons	120-lb.	188.57 tons
90-lb.	141.43 tons	125-lb.	196.43 tons
91-lb.	143.00 tons		

8. Each line for the different rail lots should be completely filled in without the use of ditto marks. Use india ink or black typewriter ribbon and black carbon. Blueprints can thus be made and each strip formed by cutting along the horizontal lines will contain complete information for the lot it covers.

9. Opposite the lines "This Year" only the failures for the year ending October 31st, should be shown, and opposite the lines "Total to Date," all failures from date laid to October 31st.

10. In case of doubt as to the interpretation of this form or any of its items, write to Engineer of Tests, Rail Committee, American Railway Association, Division IV, Engineering, 431 South Dearborn Street, Chicago, Ill.

11. This form, when filled out, should be returned to J. E. Fairbanks, General Secretary, American Railway Association, 431 South Dearborn Street, Chicago, Ill.

FORM 402D

North & South Railroad

STATEMENT OF RAILS IN MAIN TRACKS OF .... DIVISION

.... MAIN TRACK DECEMBER 31, 19......

	LOCATION													TRACK FEET		
	MILE POST FROM		MILE POST TO			NEAREST STATION				ROLLED						
	M.P.	†FT.	M.P.	†FT.	MILES	FROM	TO	YEAR LAID	MILL	MONTH	YEAR	WEIGHT PER YARD	TYPE OF SECTION	LAID PREVIOUS TO 19	NEW STEEL LAID 19	REMARKS
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																

.... FT. ...... LB RAIL = ... TRACK MILES

.... " ...... " " = ... " "

.... " ...... " " = ... " "

.... " ...... " " = ... " "

FORM 403A

A= .... SHOWN IN RED B= .... SHOWN IN YELLOW

SUMMARY

MONTH AND YEAR ⟶												
KIND OF RAIL ⟶	A	B	A	B	A	B	A	B	A	B	A	B
TOTAL SQ IN. ABRADED. AVER SQ IN. ABRADED PER SEC AREA ABRADED IN PERCENTAGE OF ORIGINAL AREA OF HEAD. TOTAL TONNAGE TO DATE.												

North & South Railroad

.... DIVISION

LOCATION DIAGRAM

OF

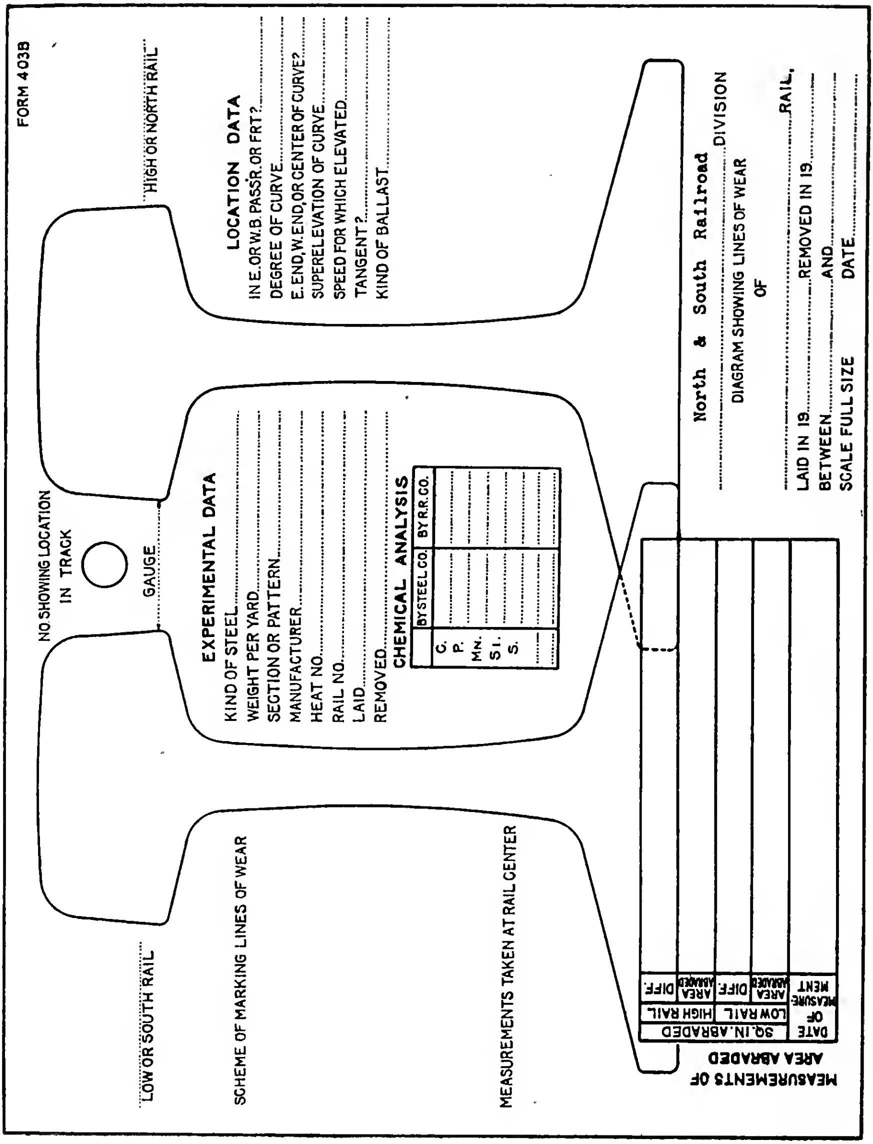
.... RAILS .... TONS

LAID .... REMOVED ....

BETWEEN .... AND ....

DATE ....

"TONNAGE" = TOTAL TONS (INCLUDING LOCOMOTIVES AND CABOOSE CARS) OVER EXPERIMENT FROM DATE LAID TO DATE OF REPORT, EXPRESSED IN UNITS OF 10,000 TONS.


FORM 403B
"HIGH OR NORTH RAIL"
LOCATION DATA
IN E. OR W.B. PASS'R. OR FRT?
DEGREE OF CURVE
E. END, W. END, OR CENTER OF CURVE?
SUPERELEVATION OF CURVE
SPEED FOR WHICH ELEVATED
TANGENT?
KIND OF BALLAST
North & South Railroad
DIVISION
DIAGRAM SHOWING LINES OF WEAR
OF
RAIL,
LAID IN 19
REMOVED IN 19
BETWEEN
AND
SCALE FULL SIZE
DATE
NO. SHOWING LOCATION
IN TRACK
GAUGE
EXPERIMENTAL DATA
KIND OF STEEL
WEIGHT PER YARD
SECTION OR PATTERN
MANUFACTURER
HEAT NO.
RAIL NO.
LAID
REMOVED
CHEMICAL ANALYSIS
BY STEEL CO.
BY R.R. CO.
C.
P.
MN.
SI.
S.
"LOW OR SOUTH RAIL"
SCHEME OF MARKING LINES OF WEAR
MEASUREMENTS TAKEN AT RAIL CENTER
MEASUREMENTS OF AREA ABRADED
DATE OF MEASUREMENT
SQ. IN. ABRADED
LOW RAIL
AREA ABRADED
DIFF.
HIGH RAIL
AREA ABRADED
DIFF.

FORM 403C

North & South Railroad

STATEMENT OF COMPARATIVE WEAR OF TEST RAIL

.................................192.....

TEST NO.	LOCATION	TAN. OR DEGREE OF CURVE	MFR.	WT. PER YARD	TYPE OF SECTION	KIND OF STEEL	NO. OF TONS LAID	CHEMICAL COMPOSITION AVE. OF ALL HEATS							PHYSICAL PROPERTIES AVE. OF ALL RAILS TESTED				BRINELL HARDNESS NO.	DATE LAID	DATE REMOVED IF NOT STILL IN TRACK	DATE OF LAST MEASUREMENT	LGTH. OF SERVICE AT TIME OF LAST MEAS. IN YRS.	*TONNAGE OVER RAILS	PER CENT OF AREA OF HEAD ABRADED AVE.	AREA ABRADED IN SQ. IN. AVERAGE OF ALL SECTIONS TAKEN		
								CAR.	PHOS.	MAN.	SIL.	SUL.	NI.	CHR.	TENSILE STRENGTH LBS. PER SQ. IN.	ELASTIC LIMIT LBS. PER SQ. IN.	ELONGATION % OF ORIG. LENGTH	REDUCTION OF AREA % OF ORIG. SEC.								TOTAL	PER YEAR OF SERVICE	PER 10 MILLION TONS
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																												

*"TONNAGE"= TOTAL TONS (INCLUDES LOCOMOTIVES AND CABOOSE CARS) OVER EXPERIMENT FROM DATE LAID TO DATE REMOVED, EXPRESSED IN UNITS OF 10,000 TONS

Appendix B

THE RELATION OF SHATTERED STEEL IN FISSURED RAILS TO THE MILL END OF THE RAIL

By M. H. Wickhorst
Engineer of Tests, Rail Committee

Rails that have failed in track due to interior transverse fissures contain "shattered" steel in the interior of the rail head, as disclosed by deep etching with strong hydrochloric acid of sections of the rail head, particularly horizontal longitudinal sections through the middle of the head. Deep etching with strong acid was first used in this connection by the Altoona Laboratory (1) and has proved to be very valuable in adding to our knowledge of the subject of fissured rails which is so actively in process of development.

Rawdon has definitely shown that the defects disclosed by the deep etching are pre-existent cracks (2), that is, they are present previous to the etching, the acid serving to open them up.

The present work is a contribution to throw a little light on the question of the origin of the cracks. Etchings have shown the cracks to be deeply imbedded in the rail head, they occurring not less than about one-half inch from an external surface. This suggested that the cracks are shrinkage cracks formed during or after the cooling after the rail bar has been fully formed. If so, then the end of the rail produced in the sawing of the hot bar also should be free from the cracks for about one-half inch or so from the end as hot sawed. This report describes some tests to determine whether the "shattered" condition of the interior of the rail head of fissured rails extends to the end of the rail or remains clear of it. If it does not extend fully to the end, it indicates that the shattering was not in the hot bar as formed.

Through the kindness of Mr. H. B. MacFarland, Engineer of Tests of the Atchison, Topeka & Santa Fe Railway System, about twenty-five fissured rails were examined at the Topeka Laboratory. As part of the

---

(1) Report of F. M. Waring to J. T. Wallis, Sept. 25, 1918, on Investigation of Transverse Fissures in Failed Rails. See Proceedings Am. Ry. Eng. Assn., Vol. 20, 1919, pp. 614-617. See also paper by F. M. Waring and K. E. Hofammann, Deep Etching of Rails and Forgings, Am. Soc. for Testing Materials, Proceedings, 1919, Part 2, p. 183.

(2) Henry S. Rawdon. The nature of the Defects Revealed by the Deep Etching of Transversely Fissured Rails. Am. Ry. Eng. Assn. Bulletin 225, March, 1920, pp. 239-249. Also Proceedings, 1920.
H. S. Rawdon and Samuel Epstein. Metallographic Features Revealed by the Deep Etching of Steel. Bureau of Standards, Technologic Paper 156.

Report 90, July, 1920.

investigation of the rails, longitudinal sections through the interior of the head, six inches long, prepared as shown in Fig. 1, were cut from each end of the rail and from near its middle. Most of the samples showed a defective condition in the interior of the head and about half the rails showed a condition of badly shattered steel, displaying numerous etching cracks. The method of etching was to immerse the slab, repre-

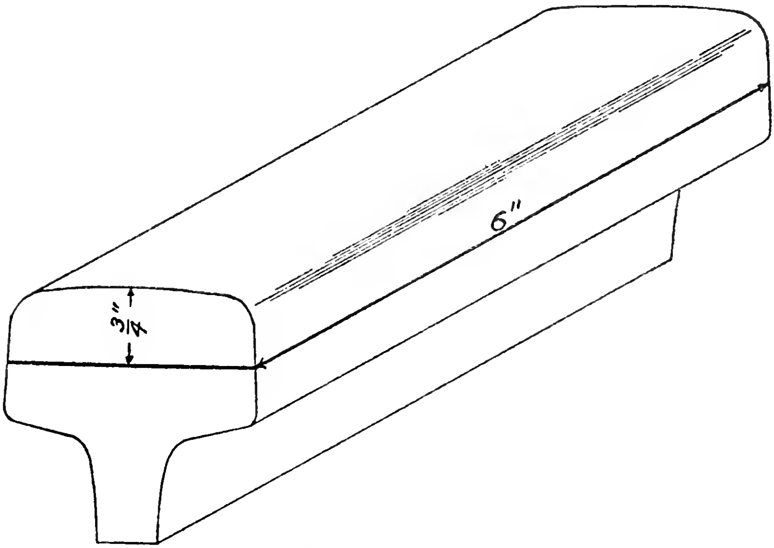


Fig. 1—Specimen Used for Deep Etching.

senting the upper half of the head, in hot commercial hydrochloric acid in a large porcelain dish for about 30 minutes.

The samples which showed numerous etching cracks were suitable for observations as to whether the zone of shattered steel terminates before reaching the end of the rail and measurements were therefore made on these rails, of the distance from the end of the rail to the nearest crack displayed in the etched section. The numbers of the rails on which the measurements were made and the mill and service data concerning the rails are compiled in Table 1. The results of the measurements showing the distance of the end of the rail to the nearest crack in the shattered metal are given in Table 2. It will be noted that the shattered steel terminates from .33 to .62 inch from the end of the rail, with an average distance of .49 inch in the 19 rail ends measured (3). At any other place on the etched surface, including the end of the slab cut six inches from the mill end of the rail, a line drawn at right angles across the surface from side to side would be apt to cut through a crack or come close to it.

Table 1. - Data Concerning Rails.

Rail No.	Mill	Rail Section	Heat No.	Rail Letter	Date Made	Date Laid	Location Laid	Date Removed	Age in Service	Position	Chemistry C	P	S	M	Si
9010-2	Bethlehem	85 B	23043	E	4-1908	1909	Sou.Div.Gulf Lns.	1915	6 yr.		-	-	-	-	-
9031	Bethlehem	85 B	16175	D	1-1908	3-1909	Middle Division.	1-1-1917	7 yr.10 mo.		-	-	-	-	-
9069-5	Gary	9021	43247		12-1909	1910	Panhandle Div.	2-2-1913	3 yr.		-	-	-	-	-
9086	Gary	9021	46192	E	8-1909	11-1909	Sou.Div.Gulf Lns.	2-24-1918	8 yr.3 mo.	O M	0.58 0.57	.020 .025	.033 .034	.69 .68	.160 .163
9095	Bethlehem	85 B	17165	F	1-1908	3-1909	Middle Division.	6-1919	10 yr.3 mo.		-	-	-	-	-
9098-1	Gary	9021	42153		12-1909	3-1910	Panhandle Div.	8-1919	9 yr.5 mo.	O M	0.56 0.56	.012 .011	.031 .031	.54 .54	.116 .122
9098-2	Gary	9021	42153	E	12-1909	3-1910	Panhandle Div.	11-1919	9 yr.8 mo.	O M	0.58 0.58	.011 .010	.031 .030	.54 .53	.109 .113
9115	Gary	9021	52119	B	11-1910	1910	Illinois Div.	11-1919	9 yr.		-	-	-	-	-
9124-1	Bethlehem	85 B	3--77	F	4-1908	9-1909	Illinois Div.	3-1920	10 yr.6 mo.	O M	0.60 0.60	.048 .045	.041 .038	.81 .80	.076 .076
9124-2	Bethlehem	85 B	22038	F	1-1908	1908	Western Division.	1-1920	12 yr.	O M	0.53 0.65	.030 .038	.034 .041	.62 .62	.077 .084
9125	Gary	9021	64060	G	2-1913	1913	Illinois Div.	3-1920	7 yr.	O M	0.59 0.69	.042 .036	.027 .025	.74 .76	.171 .176
9126-2	Colorado	903	1713	C	4-1914	6-1914	Eastern Division.	2-1920	5 yr. 8 mo.	O M	0.64 0.65	.031 .031	.030 .028	.58 .55	.028 .047
9131	Gary	9021	44057	B	5-1910	11-1910	Middle Division.	1920	10 yr.		-	-	-	-	-

O-position means "outside", the sample being taken from an upper corner of the head. M-position means "middle", the sample being taken from the interior of the head near the web.

Six illustrations are given in Figs. 2 to 7, inclusive, which show best the shattered steel as displayed in the etched surfaces. In these may be seen how the shattered zone terminates before reaching the end of the rail. This fact and the angular nature of the small cracks indicate that the shattering was not present in the hot bar as it left the finishing rolls, but developed in the cooling; that is, the cracks seem to be shrinkage checks. On the other hand, it has been suggested that the freedom of the end of the rail from cracks, is due to the densifying effects of the hot saw, and not to the relief of the end from strains.

(3) Since this work was done, Howard has presented a paper to the Am. Soc. for Testing Materials, "On the Shattered Zones in Certain Steel Rails," in which he also states that the shattered zones have been found to terminate before reaching the hot sawed ends of the rails.

TABLE 2.—DISTANCE OF SHATTERED STEEL FROM END OF RAIL.

Rail Number	*——End of Rail to Nearest Crack——* *A End*	*B End*
9010-2	.62 in.	.49 in.
9031	.38	(Note)
9069-6	.46	.51
9086	.51	..
9095	.59	.49
9098-1	..	.33
9098-2	.51	.49
9115	.41	.49
9124-1	..	.56
9124-2	.48	..
9125	.52	.51
9126-2	.46	.48

Minimum, .33 inch; maximum, .62 inch; average, .49 inch. In this table, the letters A and B are used simply to distinguish the two ends and have no other significance.

Note.—The B end of rail 9031 had some longitudinal streaks which extended close to the end of the rail and it was uncertain just how close the shattered zone proper was to the end.

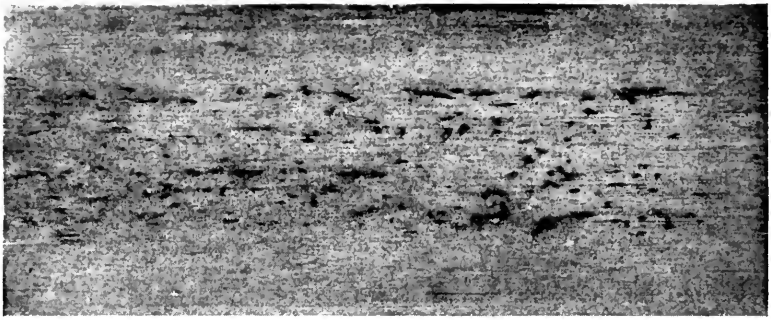


Fig. 2—Etched Horizontal Section at End of Rail 9010-2.

Fig. 3—Etched Horizontal Section at End of Rail 9086.

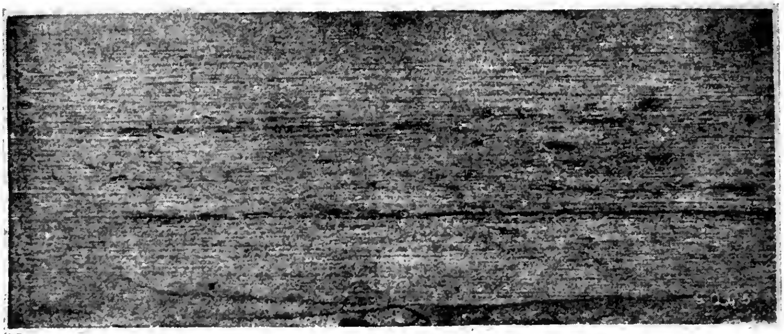


Fig. 4—Etched Horizontal Section at End of Rail 9095.

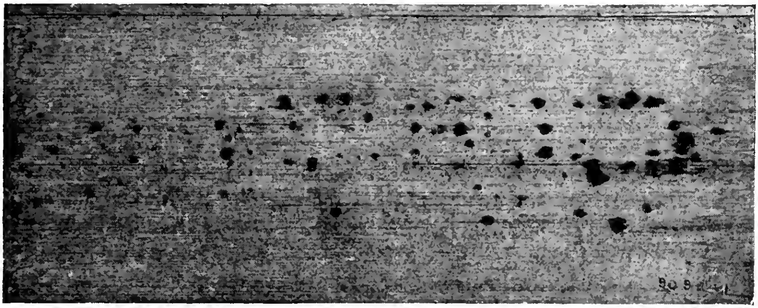


Fig. 5—Etched Horizontal Section at End of Rail 9098-1.

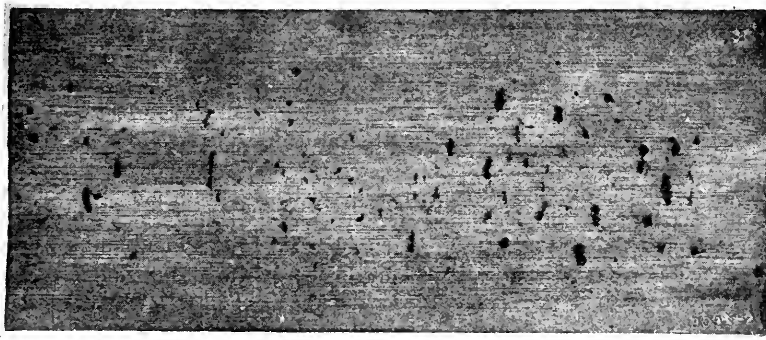


Fig. 6—Etched Horizontal Section at End of Rail 9098-2.

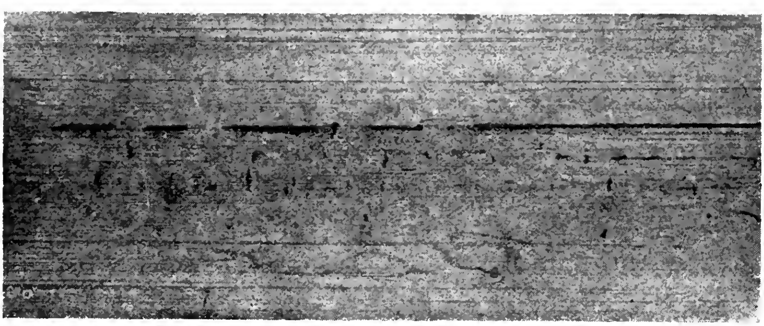


Fig. 7—Etched Horizontal Section at End of Rail 9124-2.

Appendix C

RESIDUAL DUCTILITY TESTS IN THE BEARING SURFACE FROM FAILED RAILS OF SERVICE

By Dr. P. H. Dudley

For several years the New York Central Lines have conducted numerous drop tests on rails removed from service after having developed interior transverse fissures. These tests were conducted principally at Beacon, N. Y., under an improvised drop testing machine with a solid anvil, and so constructed that the full residual ductility could not be developed under successive blows on the test pieces.

It was therefore arranged with one of the manufacturers for tests to be conducted at their plant during July, 1920, under the standard drop testing machine, so that each individual piece could be tested to destruction, and the full residual ductility developed. For this purpose a general order was issued on the main line of the New York Central Railroad—East of Buffalo—to collect together any rails on hand which had been removed from the tracks due to the development of interior transverse fissures in service. These rails were gathered from widely scattered locations, and represent failures in melts rolled in different years, as well as different months of the same year.

All rails, with the exception of three from one melt, had originally met the chemical and physical test requirements of the New York Central Lines' specifications for basic open hearth steel, which call for a carbon range of 0.62 to 0.75 for rails 100 and 105 pounds per yard, and elongation requirements of 5 per cent. in two consecutive inches, or 6 per cent. in one inch for test butts from the second, middle and last full ingot poured. One test butt per melt, in rotation, has the full ductility exhausted by successive blows, to check with the full ductility to be obtained, due to the chemical composition.

All rails in this series of tests were rolled direct from the ingot without reheating the blooms, and were either 100 or 105 pounds per yard weight.

The rails were shipped to the mill, then cut into pieces averaging about 5 feet in length, so that from five to six tests were obtained from each rail. Three hundred and five pieces were obtained from the 65 rails shipped to the mill. Each test was made to destruction; the ductility after each blow and deflection were measured, and finally the type of fracture was noted, as well as any irregularities.

The tests were all made with the head in tension, supports 3-foot centers, and the 2,000-pound tup falling through a height of 15 feet. This differs from the standard drop tests on butts from new rails of these weights, which stipulates a 20-foot drop, and either with the base or head in tension. The object in testing all pieces of the old rails with head in

Report No. 92.

tension was to determine the amount of residual ductility in the cold rolled bearing surface, and also to classify the type of head fracture as each piece was broken under successive drops.

Fissures of either the Intergranular or Coalescent type had developed in at least a portion of each rail during its service in the track, and was the cause of the removal. The complete history of each rail is known, including its chemical composition, physical properties, date laid, length of service, location in track, ballast, degree of curvature, if any, and class of traffic over the rail. This information, together with the data obtained in the recent drop tests on the old rails, constitutes sufficient information to make a complete analysis for study. This analysis is partially shown in the following Tables No. 1 to 7, inclusive, together with brief comments and discussion.

Illustrations are also shown in Figures No. 1 to 4, inclusive, of the various types of failures classified from observation of the fractures developed originally in the track, or under the drop test of the pieces of old rails after removal from service.

Figure 1 illustrates the most predominant type of interior transverse fissure, which is classified as the "INTERGRANULAR" type.

Figure 2 shows the second type of interior transverse fissure, and classified as the "COALESCENT" type, which originates at an imprint of the gag in the interior metal of the head, generally about 5/8 of an inch under the running surface of the head, and parallel to it, and then rounds off into the transverse section.

Figure 3 represents a "CORE" of brittle metal as the starting point of fracture of the rail section. These cores closely correspond in physical properties to the metal at the nucleus of the Intergranular type of interior transverse fissure, as both show decided brittleness and lack of ductility.

Figure 4 illustrates the classification of the "PLAIN" fracture, which is free from defects of the type shown in either Figures 1, 2 or 3. In classifying Plain fracture, a note was made of any irregularities found, such as segregation, pipes, if any, gray spots, slag, etc.

Fig. 1—Interior Transverse Fissures, Intergranular Type, Nucleus Over Outside of Web. One-Half Size, 6-inch 100-lb. Rail.

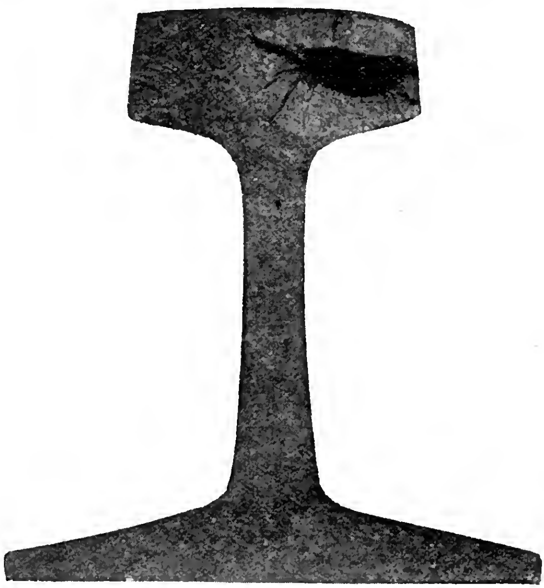


Fig. 2—Interior Transverse Fissure, Coalescent Type. Horizontal Split in Head, from Imprint of Gag. Gage Side. "A" Rail. One-Half Size, 6-inch 100-lb. Rail.

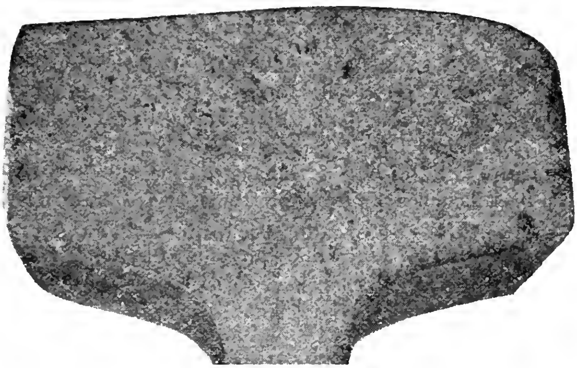


FIG. 3—CORE NEAR CENTER OF HEAD, FULL SIZE, NON-DUCTILE METAL.

FIG. 4—6-IN. 100-LB. RAIL HEAD, FULL SIZE. FRACTURE OF DUCTILE METAL. DROP 30,000 FOOT-POUNDS.

It would not be feasible to show the results of every test in detail, therefore only a few typical drop test data are herewith submitted. Tables 1, 2 and 3 are actual drop test data of a complete rail in each case. The original results obtained on the new rail test butts in the exhausted ductility test, together with the ladle analysis, are shown for each rail.

TABLE 1—ILLUSTRATING BRITTLE RAIL FOR ITS ENTIRE LENGTH.

Section 100-lb. Melt No. 1940. Rail "B". Rolled January 23, 1911.
Ladle Analysis.
Carbon, 0.641. Manganese, 0.79. Phosphorus, 0.025. Sulphur, 0.046.
Original Drop Test, New Rail, Head Up.
Blows to Fracture, 3. Def., 2.6". Exhausted Duc., 13-18-13-13-8-5 = 0.70.
Drop Test Data on Failed Rail from Service, Head Down.

Test No.	Blow.	Per. Set.	Elongation Per Inch 1 in.	2 in.	3 in.	4 in.	5 in.	6 in.	To- tal.	Remarks.
571—1	1	Broke	...	...	...	...	...	...	....	Core.
571—2	1	Broke	...	...	...	...	...	...	....	Core.
571—3	1	Broke	...	...	...	...	...	...	....	Intergr. Fiss.
571—4	1	Broke	...	...	...	...	...	...	....	Intergr. Fiss.
571—5	1	Broke	...	...	...	...	...	...	....	Intergr. Fiss.

Table 1 contains the drop test results on a typical BRITTLE rail for its entire length. Pieces from rails of this type invariably fail on the first blow, and generally reveal additional fissures, partly or fully developed, or cores.

TABLE 2—ILLUSTRATING RAIL OF SECOND TYPE WITH BOTH BRITTLE AND DUCTILE METAL.

Section 100-lb. Melt No. 4004. Rail "A". Rolled January 24, 1911.
Ladle Analysis.
Carbon, 0.736. Manganese, 0.89. Phosphorus, 0.029. Sulphur, 0.037.
Original Drop Test on New Rail, Head Up.
Blows to Fracture, 3. Def., 2.2". Exhausted Ductility, 7-10-14-15-12-9 = 0.67.
Drop Test Data on Failed Rail from Service, Head Down.

Test No.	Blow.	Per. Set.	Elongation Per Inch 1 in.	2 in.	3 in.	4 in.	5 in.	6 in.	To- tal.	Remarks.
568—1	1	Broke	...	...	...	...	...	...	....	Intergr. Fiss.
568—2	1	Broke	...	...	...	...	...	...	....	Large Core.
568—3	1	0.94	03	03	05	05	03	03	6.22	
	2	1.61	05	06	08	08	06	05	6.38	
	3	2.29	05	07	10	12	09	07	6.50	
	4	Broke	06	09	12	*14	12	10	6.63	Plain Fracture
568—4	1	0.92	03	03	03	05	04	02	6.20	
	2	1.66	05	05	08	08	06	05	6.37	
	3	Broke	05	07	08	*09	07	05	6.41	Plain Fracture
568—5	1	0.90	03	03	04	04	04	04	6.22	
	2	Twisted	05	05	06	05	04	03	6.28	Plain Fracture

Table 2 is a tabulation of drop test data on another complete rail and shows that while one end or a portion of the rail was decidedly brittle, the balance of the rail was ductile, and in some tests a residual ductility was obtained almost the equivalent of that obtained from the test butt of the new rail at the time it was manufactured. In other words, after a number of years' service in main line track, the ductility of the section had only been slightly reduced by the cold rolling of the wheel loads. The phenomena of both ductile and brittle metal being found in the same rail length is of great significance.

TABLE 3—ILLUSTRATING THE DUCTILE TYPE OF RAIL.

Section, 105 lb. Melt No. 16361. Rail "A". Rolled September 13, 1913.
Ladle Analysis.
Carbon, 0.645. Manganese, 0.75. Phosphorus, 0.023. Sulphur, 0.047.
Original Drop Test on New Rail, Head Up.
Blows to Fracture, 4. Def., 3.80". Exhausted Duct., 9-13-20-22-20-17 = 7.01.
Drop Test Data on Failed Rail from Service, Head Down.

Test No.	Blow.	Per. Set.	Elongation Per Inch 1 in.	2 in.	3 in.	4 in.	5 in.	6 in.	Total.	Remarks.
572—3	1	1.05	03	04	04	05	04	03	6.23	
	2	1.79	07	07	07	06	05	03	6.35	
	3	2.56	09	09	12	12	10	07	6.59	
	4	3.24	09	09	12	13	13	10	6.66	
	5	Broke	10	10	13	13	13	*11	6.70	Fracture O. K,
572—4	1	1.05	04	05	05	05	03	03	6.25	
	2	1.80	04	05	06	08	08	10	6.41	
	3	2.62	05	05	07	12	13	15	6.57	
	4	Broke	05	05	08	12	13	*16	6.59	Seg. in web.
572—2	1	1.11	05	05	06	06	04	03	6.29	
	2	1.94	05	05	08	09	08	06	6.41	
	3	Twist	07	08	12	12	10	08	6.57	Fracture O. K.
572—5	1	1.10	04	04	04	06	05	04	6.27	
	2	1.97	05	08	10	08	06	04	6.41	
	3	2.28	10	12	15	13	08	05	6.63	
	4	Broke	12	14	*16	14	10	07	6.73	Seg. in web.
572—1	1	1.10	04	04	05	05	04	03	6.25	
	2	2.00	08	10	10	08	07	04	6.47	
	3	Broke	11	12	*15	13	08	05	6.64	Seg. in web.
572—6	1	1.15	04	04	05	05	04	04	6.26	
	2	2.04	06	07	10	09	07	05	6.44	
	3	Broke	07	08	*11	12	13	12	6.63	Fracture O. K.

Table 3 are the results of tests on one rail which was ductile for its entire length, except for the isolated portion of the rail length which contained the original interior transverse fissure, developed in service. This type is somewhat similar to the type illustrated in Table 2, except for the fact that neither fissures, nor lack of ductility, is found in any of the remaining portions of the head under the drop test.

Figure 5 shows sketches of the manner in which the rails fracture under the drop test, and illustrate the three types mentioned in the above tables. The tables and the sketches are from corresponding rails. Similar sketches were made of the fracture of each rail in detail.

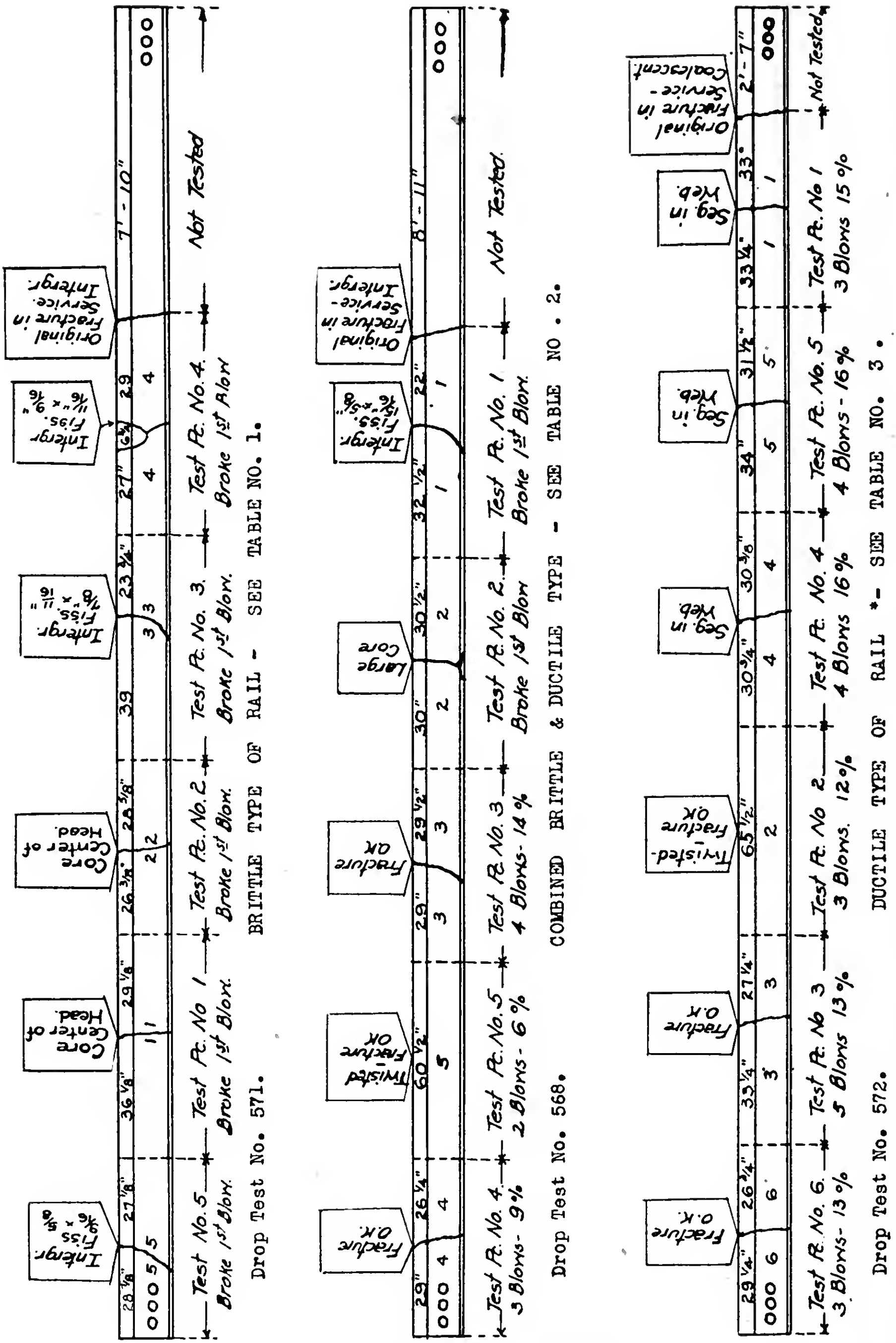


FIG. 5—DIAGRAM OF DROP TESTS.

The rails from each ingot were bunched on the hot beds, at the plants of manufacture, and the pertinent questions then are:

1. Why should an occasional rail cool with nearly its entire length of head brittle?

2. Why should an occasional rail cool with its ductility in a portion of its length of head, due to the chemical composition, and another portion of its head cool brittle?

3. Do the strains of the movements of the metal in the heads after recalescence and at the blue heat make an occasional rail or a portion brittle?

4. Do the jars of the movements of the rails on the hot beds to be transferred to the Finishing Department at a blue heat make a portion of the metal of the heads brittle?

TABLE 4—ANALYSIS OF DROP TEST SPECIMENS REMOVED FROM SERVICE.

Position in Ingot	Rail Failed from Coalescent Type	Rail Failed from Intergranular Type
A	20 rails	8 rails
B	3 "	12 "
C	0 "	7 "
D	1 "	3 "
Unknown	0 "	2 "
Totals........	24 rails	32 rails

Table 4 is a classification of failures originally developed in service, with reference to the position of the rail in the ingot. It will be noted that of the 24 rails which developed Coalescent type interior transverse fissures in service, 20 were from the "A" position. This corresponds with the general experience with fissures of this type, as more than 80 per cent. occur in "A" rails, and in nearly all cases show either decided segregation, inclusions or impurities.

The majority of the Intergranular type of fissure are generally found in the "B" and "C" positions, in metal of good chemical uniformity. There is, however, in nearly every case investigated for fissures of this type decided interior brittleness in the vicinity of the nucleus. In other words, the unsoundness in fissures of this type is PHYSICAL, rather than CHEMICAL.

TABLE 5.

Length of Service	Rail Failed from Coalescent Type	Rail Failed from Intergranular Type
1 year	....	....
2 "	1 rail	....
3 "	1 "	2 rails
4 "	1 "	1 "
5 "	2 "	4 "
6 "	11 "	10 "
7 "	6 "	8 "
8 "	2 "	7 "
Totals........	24 rails	32 rails

Table 5 is a classification of failures according to length of service rendered before failure. It is interesting to note that 21 of the 24 Coalescent type, and 29 of the 32 Intergranular type had given 5 to 8 years of service before ultimate failure. This is typical of the development of fissures in open hearth rails, as the majority render about 6 years' service before complete fracture occurs. This applies to the heavy main line traffic, on well ballasted track, and for high speeds of train movement.

TABLE 6—RESULTS OF DROP TESTS ON FISSURE RAILS REMOVED FROM SERVICE.

Weight of Drop, 2,000 lbs. Height of Drop, 15 ft. Supports, 3 ft. centers.

	No. Pieces	
No. pieces breaking on the first blow	137	
" " showing 3% Ductility (Exhausted)	4	
" " " 4% " "	4	
" " " One (5)% " "	2	
	——	= 147 = 48% of total
" " " Two (5)% " "	14	
" " " 6% " "	19	
" " " 7% " "	18	
" " " 8% " "	23	
" " " 9% " "	18	
" " " 10% " "	14	
" " " 11% " "	8	
" " " 12% " "	15	
" " " 13% " "	10	
" " " 14% " "	6	
" " " 15% " "	9	
" " " 16% " "	2	
" " " 17% " "	0	
" " " 18% " "	1	
" " " 19% " "	1	
	——	= 158 = 52% of total
Total number pieces tested	305	305 = 100%

Table 6 is a classification of the failure of the individual test pieces, according to the amount of residual ductility obtained. Of the 305 pieces tested, 137 broke on the first blow without displaying ductility. One hundred and fifty-eight, or 52 per cent. of the total tested, developed at least five per cent. in two consecutive inches; the residual ductility on the various test pieces ranging all the way from 5 to 19 per cent.; the latter amount being obtained in one inch of one test piece. This is a remarkable showing in view of the service records of these rails under severe traffic, speed and weather conditions, and substantiates the fact that the broad head of the 100 and 105 pound rail sections provides ample area to carry the wheel loads of present-day traffic, without impairment of its initial ductility, when the rails are made from sound, homogeneous metal, both physically and chemically.

It has been shown by our previous experiments on tangent track that the average intensity of pressure per square inch on the broad heads of the 6-inch 100 and 105 pound rails, which are similar in all details, are not high under the heavy locomotives on the rail heads.

We conducted one series of tests on worn 6-inch 100-pound rails in service 8 to 10 years, and found that the average static intensity of pressure per square inch for all wheels of a Pacific type locomotive, including tender, was 82,150 pounds.

In a second series of tests on 6-inch 105-pound rails in service about eight months, a similar locomotive of the same type as used in the first test showed on average static intensity of pressure per square inch of 57,425 pounds.

The locomotive showing the lowest average intensity had run 40,539 miles, and the wheel treads were worn slightly concave. The locomotive showing the highest average intensity was just out of the shop, and, therefore, the relationship between contour of wheel tread and rail head was not as favorable as when the wheel treads are worn slightly hollow. The locomotives on the New York Central usually run from one hundred to one hundred and twenty-five thousand miles before the treads of the driving tires are returned.

The areas of contact obtained on the rail heads of the stiff 6-inch 100 and 105 pound sections show that the major axis may be transverse to the running surface of the rail head, and yet the areas of contact are as large as those formerly obtained on the light 4½-inch 65-pound rails.

Referring further to Table 6, it will be noted that 137 test pieces failed under the first blow of the tup, of which number fifty-seven disclosed cores, or fissures of either the coalescent or intergranular type. Over half of the remaining eighty pieces were portions of high and low rails from curves. These contained the accumulated deformation and abrasive effect from the impingement of thousands of wheels, of which a great many were cast iron wheels with the M. C. B. contour. The chamfer of the cast iron wheels on the low rails does more than simply abrade the bearing surface. The action seems to exhaust the ductility in a faster ratio than the ordinary rolling abrasion. The metal in the low rails wears hollow, and in portions of the bearing surface the metal is frayed and ragged. It could hardly be expected under the 30,000 foot-pounds of the drop that this frayed metal would show as much ductility as on rails where only rolling abrasion has occurred.

TABLE 7—ANALYSIS OF DROP TESTS ON FISSURE RAILS.

Length of Service	Broke on 1st Blow.	EXHAUSTED DUCTILITY * PERCENT. 3	4	One 5	Two 5's.	6	7	8	9	10	11	12	13	14	15	16	18	19	TOTALS.
DISCLOSED UNDER DROP TEST - COALESCENT TYPE.																			
2 years	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
5 "	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
6 "	2	-	-	-	-	-	--	-	-	-	-	-	-	-	-	-	-	-	2
7 "	---	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	--
8 "	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
DISCLOSED UNDER DROP TEST - INTERGRANULAR TYPE.																			
5 years	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6
6 "	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
7 "	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
8 "	9	-	-	-	-	-	-	-	-	-	--	-	-	-	-	-	-	-	9
DISCLOSED CORES IN HEAD UNDER DROP TEST.																			
3 years	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
4 "	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
5 "	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
6 "	5	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	7
7 "	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
8 "	7	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
PLAIN FRACTURES.																			
2 years	---	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1
3 "	1	-	-	-	-	1	1	2	1	3	1	2	-	-	2	-	-	-	14
4 "	2	-	-	-	-	-	-	1	2	1	-	1	-	-	-	-	-	-	7
5 "	7	-	2	-	-	2	1	4	1	1	-	-	-	-	-	-	-	-	18
6 "	25	1	-	1	2	6	6	7	9	3	5	8	6	4	5	3	1	1	93
7 "	18	1	1	2	4	4	5	6	1	4	1	2	1	-	1	-	-	-	51
8 "	6	-	-	1	1	1	-	-	2	-	-	-	-	1	-	-	-	-	12

NOTE : * Numerals in each column are actual number of pieces.
Example:- The figure 2 in the first column in the first table means that two pieces of rail broke on the first blow, and disclosed fissures of the coalescent type.

Table 7 contains a summary of drop test results on 56 rails of the series, showing the length of service, residual ductility developed, as well as the number of pieces failing on the first blow of the tup, and the type of defect according to the classifications of Figures 1 to 4. It is apparent from a survey of the table that test pieces containing hidden interior fissures are devoid of ductility, and fail on the first blow. Four test pieces containing cores developed a small amount of ductility before fracture, and the balance of test pieces with defects of this type displayed brittleness, and failed under one drop.

The portion of the table showing plain fractures, reveals that 59 test pieces failed on the first blow with no indications of cores or fissures. Of the remaining 137 plain fractures which displayed residual ductility of from 3 to 19 per cent. in one or more inches, there were 58 test pieces which developed 10 per cent. or a greater amount in one inch. It is an interesting fact to find so many pieces from a number of rails still containing this large amount of residual ductility.

There are differences in the number of rails or test pieces analyzed in the Tables Nos. 4 to 7, inclusive, due to the fact that a portion of the information relating to some of the rails had not been furnished. This however, does not affect these analyses in any way, except to a minor extent. Additional tables have been compiled, but are not included in this report.

It was exceedingly important to find the high residual ductility in such a large number of the test pieces from these rails after 5 years, or more, of service. The statement has often been made and inferred that the ductility is practically nil in all rail heads after relatively lighter traffic conditions and shorter lengths of service than was obtained on this lot of rails. This supposition will need revision from a study of the tests included in this report, for the evidence presented shows that a large amount of ductility still remains in many of the pieces of the old rails, with the full ductility due to the chemical composition, after a number of years' service.

Rails rolled for the New York Central Railroad—East—and received from the mills during the period 1910 to 1920 in basic open hearth steel amount to 1,098,400, while interior transverse fissures developed in this number of rails at the rate of 0.062 per cent. for the entire period, which is a very low rate. The rails included are the 6 inch 100 pound, 6 inch 105 pound, and the 5⅛ inch 80 pound sections in all types of service—main line, secondary track, and on subsidiary lines. This information is added to show the difficulties involved in detecting and locating the small percentage of failures in the very large tonnage of rails rolled and installed.

The material included in this report is sufficiently comprehensive to add considerable to our knowledge of the Ductility in Old Open Hearth Rails removed from service, and points out the necessity for the accumulation of information of a similar nature on rails in service on other Lines, having different rail sections and service or traffic conditions.

The most important problem in the research work on interior transverse fissures is to determine the causes inducing the irregular ductility and brittleness disclosed in these tests, which at present seems attributable to cooling conditions of the rails during manufacture, either on the hot bed, or in rolling, or during handling of the cooling rails from the hot beds. Elimination of brittleness which has been shown to exist in a portion of some rails would go far toward reducing the number of failures due to interior transverse fissures in service.

REPORT OF COMMITTEE XXII—ON ECONOMICS OF RAILWAY LABOR

C. E. Johnston, *Chairman;*
C. H. Stein, *Vice-Chairman;*
W. J. Backes,
C. B. Hoyt,
A. F. Blaess,
T. T. Irving,
B. M. Cheney,
R. E. Keough,
C. C. Cook,
E. R. Lewis,
W. R. Dawson,
C. A. Paquette,
John Evans,
W. H. Penfield,
R. H. Ford,
J. R. Sexton,
L. C. Hartley,
W. J. Towne,
W. R. Hillary,
Committee.

To the American Railway Engineering Association:

The following subjects were assigned to the Committee on Economics of Railway Labor:

1. Report on plans and methods for obtaining labor for railways.
2. Study and report upon methods for training and educating employees in Engineering and Maintenance work.
3. Study and report on standard methods for performing maintenance of way work with the view of establishing units of measure of work performed.

Committee Meetings

Meetings of the Committee were held in Chicago, June 8th, July 16th, August 27th, October 18th and November 30th, 1920. The names of the members in attendance have been given in the Minutes of the meetings which have been printed in the Bulletin.

(1) Report on Plans and Methods for Obtaining Labor for Railways

A carefully prepared questionnaire was sent to 65 representative roads in Eastern, Western and Southern territory and to representative roads in Canada, in order to develop the existing practices throughout the country. Replies were received from about 85 per cent and, in addition, several letters from railway officers, whom the Committee interrogated on this subject.

This questionnaire developed that very little is being done by the railways in the way of specializing for the selection of their maintenance of way labor. The returns when carefully analyzed also show that for maintenance of way labor, at least, the railways have not availed themselves of the lessons which the experiences resulting from the war merely developed and intensified, and that no positive action has been taken to overcome the economic conditions which tend to create serious labor shortages at different seasons of the year.

Except for such labor as can be obtained locally, on approximately two-thirds of the roads throughout the country, the great army of excess workers required during the working season are, as a rule, recruited through Labor Agents, the majority of whom charge the men for securing the temporary job. There is no uniform practice as to the officer charged with responsibility for such matters, the tendency, however, seems to be to leave it, in a general way, under the Engineer Maintenance of Way, where same exists. Where the services of these Labor Agents are utilized, it is almost the universal custom for the railways to obtain labor from various agencies, there being little tendency to accomplish this through a single source of supply.

As a general rule, railways do not pay bonuses or compensation to agencies for maintaining a stated supply of workers on their lines, but there are cases where this method has been followed, especially in times of labor stringency, the agency being responsible for maintaining the supply and being paid accordingly. Very little, if any, written limitations or rules are placed upon Labor Agents concerning the manner and method that they shall observe in securing labor, although some States and the larger cities have regulations pertaining to same, which, however, are not very rigidly enforced.

Very few railways pay the agencies for securing their labor, it being customary for the Labor Agent to require the laborers to reimburse him for his efforts. This has resulted in a great many abuses which are alike prejudicial to the interests of the worker and the railways, and your Committee has been impressed with the need of uniform regulations with respect to such matters.

During the war, the U. S. Employment Service was created, and for a time the indications pointed to some unified system, but for various reasons it ceased to be an effective factor as a labor gathering medium.

Many roads report that they use State and Municipal Agencies to a more or less extent but, as a rule, the majority of the roads rely on their own unorganized efforts, or a few utilize the services of free labor gathering agencies, either wholly or partially supported by themselves, but the majority depend upon the fee agencies, who, as previously stated, are supported by fees obtained from workers.

The majority of the roads do not contract maintenance work, although there is a tendency in this direction on some of the more important items requiring extra gangs, or where special skill is required.

Prior to the war, it was the practice for many roads to maintain labor agencies in the large labor centers, like Chicago, St. Louis, Kansas City, Omaha, etc. These were abolished during the war, but since the armistice was signed pre-war conditions have been restored and there has been a marked tendency to increase agencies either wholly or partially supported by individual roads entering the larger labor centers. There has also been a marked increase of fee agencies patronized by the railways.

No cases are reported where more than one road has combined for this purpose. There does not appear to be any uniformity of practice as to whom labor gathering agencies shall report, although the tendency is towards the Maintenance of Way Department.

The reports indicate that in reality practically no limitation is placed on free transportation for transporting labor that cannot be obtained locally, and apparently no means has been found for protecting against the abuses resulting from the flagrant misuse of transportation furnished for the purpose of transporting this labor. In times of shortages, where labor cannot be supplied locally or obtained by labor contractors from territory tributary to the carriers, it is customary for most roads to pay fare for laborers recruited in off-line districts over other lines in order to bring them to their own road.

It is not the practice of the roads to invoke statutory requirements against the misuse of transportation, as no method has yet been found whereby this may be effectively used. This problem presents many difficult and baffling angles, and various remedies have been suggested, but they have failed by reason of an entire absence of coördinated effort among the roads.

No effective means has so far been developed to protect against the worker who, having accepted free transportation, fails to accept service. When such worker leaves the service after a few days' (or hours') service, as is frequently the case, few roads make any attempt to retain part of his earnings as partial compensation for such free transportation.

The investigations of this Committee, previously reported, have shown that the length of service for the casual worker is of exceedingly short duration, and the facility with which these transient workers may move from place to place is almost entirely responsible for this condition. The questionnaire, however, develops that the majority of the roads appear not to feel that the abolition of free transportation for these casual workers would operate to stabilize labor. The replies reaching the Committee indicate a general recognition of this widespread abuse in connection with the transportation of laborers, but few practical suggestions have so far reached the Committee for its remedy. The popular one seems to be that some arrangement should be worked out by each road whereby laborers will be piloted from the source of employment to the particular job for which they are engaged.

Where the services of boarding contractors are utilized to feed extra or floating labor, it is customary to afford free, reduced or limited transportation for their camp and food supplies, on approximately half of the roads reporting, the others assessing charges in some form or other thereon.

There is no accepted practice among roads concerning the wisdom of permitting their own employees to board extra or floating labor, when by doing so free or limited transportation for camp and food supplies are given.

During the war, Regional Director R. H. Aishton, in Circular No. 63, made some progress in unifying this and similar practices and some of the roads have still adhered to same, but it is not universal.

(A)

The replies indicate a decided effort is being made to furnish houses for regular Section Foremen at nominal rental, and some feeble efforts are being made to furnish better quarters than heretofore for common labor, but it is not general.

The conditions in the Eastern section do not, as a rule, require this for its excess labor, whereas in the West it is necessary in some form on account of the long stretches of open country and the comparatively long distances between the towns. The majority of the roads furnish bunk houses for their laborers for which no rental is charged, but as a rule they consist of old car bodies. Some tendency for improvement in this direction is reported.

It is the general practice for the railways to supply housing with wood or steel bunks for their floating, or semi-permanent labor, but the bedding, kitchen and other utensils are supplied by the boarding contractors, or the laborers themselves.

It is also the general practice to supply cooks for track gangs, but no uniformity exists as to the number in proportion to the men employed. This applies to Bridge and Building Department and miscellaneous employees as well.

The majority of the roads reporting apparently contract with companies or individuals for feeding their common labor that is seasonally employed, the balance evidently believing that better results are secured where this is not done.

There is almost an entire absence of trained supervision over food, sanitation or camp supplies for the workers. Where such supervision exists it is usually of a sporadic character and confined to local officers engaged in other duties. One large Eastern road, however, has assigned the feeding of its laborers to its dining car department and through it secures the benefit of the same sanitation and supervision of its food and camp equipment that is afforded to its patrons.

There is a marked difference between the practices of Eastern and Western roads in the matter of engaging and caring for labor. The general tendency of the Eastern lines is to so arrange their maintenance work that it shall be done with regular forces and minimize, as far as possible, the use of extra gangs, whereas, as a general rule, the Western roads depend on the extra gangs and casual labor to supplement the work of the sections, principally for relaying rail, ballasting and similar heavy work.

There appears to be an almost universal appreciation by the roads of the serious effect that intermittent labor has on their organization and efficiency in maintaining the railways of the country. There is also a general feeling on the part of a majority of the roads that this can only be corrected, or at least minimized, by working out a more scientific method of arranging the maintenance of way program whereby large armies of workers will not be made idle during a very considerable part of the year. The annual man-hours remain about the same, but due to the fact that it is not scientifically arranged, a great many excess workers remain frequently on furlough, creating an economic condition that is hurtful to all concerned.

There is a universal feeling that before very much can be done by railways to stabilize labor, housing and living conditions must be more in conformity with the current practice of industrial and similar concerns, who seem very much in advance of the railways in this particular. Better sanitation, proper facilities for bathing and improved structures for housing the employee would appear to be the medium that will react powerfully to stabilize railway track labor. A better distribution of the forces so arranged as to give consideration to the comfort of the foremen and their families are a greater asset than is popularly supposed for increasing the efficiency, contentment and loyalty of the worker.

Changed working conditions have now served to intensify the importance of securing greater efficiency and a better selection of workers than ever before in the history of our railways. Section 15-A, of the Transportation Act, expressly stipulates that in determining the allowable return, expenditures for maintenance of way and structures and equipment must be so managed "as to secure honest, efficient and economic results." Manifestly if methods are employed which are wasteful or extravagant and as a result the principal item of railway maintenance (labor) is affected, the net return may also be affected. It would seem that it is well within the province of this Association to study the effect of poor methods in housing, transporting and otherwise caring for railway labor to the end that nothing of this kind may ever occur. Comparison of practices of industrial, public utility and commercial concerns as compared with railway practices should be of great assistance in this connection as indicating the trend of modern ways and methods concerning the human investment and permit a greater return than heretofore.

(2) Study and Report upon Methods for Training and Educating Employees in Engineering and Maintenance Work

Your Committee has not completed its study of the subject-matter, consequently are not in a position to make conclusive recommendations.

In our study thus far there appears no limit to the field involved, and it will require much more investigation and thought by the Committee to arrive at any really worth-while conclusions.

As information, your Committee prepared and submitted to representative lines during the year a questionnaire to develop the present situation and practices, and at the date of this report (November 30, 1920), 60 railway companies, having a minimum length of not less than 150 miles of main track and with a total main track mileage of approximately 152,000 miles, have reported. A tabulation of these returns expressed in percentage is as follows:

(a) Organization

Of the roads reporting (60) 75 per cent have a Divisional and 25 per cent Departmental organization.

(b) Education and Training

Notwithstanding the large percentage divisional organization, approximately 72 per cent of the lines charge an Engineer or the Engineering Department with the direct responsibility of maintenance of way. We also find approximately 65 per cent of the lines give preference to Engineers, or men having Engineering training, in selecting Division officers in charge of maintenance of way. Fifty per cent of the total of Roadmasters and Track Supervisors employed by the roads reporting have had Engineering training. Our reference to Roadmasters and Track Supervisors are those having charge of an average of 111 main track miles and 75 sidetrack miles. The average age of Roadmasters and Track Supervisors being approximately 45 years.

Our investigations to date show approximately 99 per cent of track foremen selected from common labor; the percentage of common labor being about as follows:

Native White	40 per cent
Negro	17 per cent
Mexican	10 per cent
Other Foreign	33 per cent
	100 per cent

NOTE.—The Mexican labor reported is employed on but 26 of the total of 60 lines.

The average length of track section in charge of section foreman includes:

6.7 miles main tracks
3.1 miles side track

Section motor cars are in use on approximately 69 per cent of the mileage reported.

Your Committee will continue vigorously to assemble more complete data with respect to the present situation and practices, but it appears obvious that there is at this time a lack of appreciation on the part of General Officers of railways of the tremendous inefficiency and resulting waste of loss due to the absence of concerted organized effort to educate and properly train employees in maintenance of way work.

Replies received also indicate a lack of coördination among the railways that must be secured before any real start can be made towards efficiency and stability.

Our investigation to date (September, 1920) indicates an estimated relative efficiency of only 67 per cent as compared with the results obtained during the pre-war period or, say, 1912 to 1916, these averages based upon replies from 52 of the 60 principal railways of the country reporting.

Progress Report

(1) The Committee feels that good progress has been made on this subject during the year. It has assembled much data that will be very helpful in the further study of this important subject.

(2) The Committee has assembled and is assembling much information helpful in its consideration of this subject. We do not underestimate its importance and the necessity of thoroughly developing every phase of this extensive field.

(3) The Committee has devoted all time possible during the year to the study of subjects (1) and (2), and feel that solution of the problems in these subjects must antedate and be used as factors in the conclusions to be drawn on subject (3).

CONCLUSION

The Committee has reached no conclusion on the subjects assigned.

Recommendations for Future Work

The Committee strongly recommends reassignment of only these three subjects for the ensuing year.

In its study, investigation and discussion thus far sufficient facts have been developed to indicate the trend of present practice on the railways with respect to maintenance of way labor. Our analysis of the practices in vogue causes us to suggest to the membership that the railways take immediate and individual action to improve their labor situation and put forth organized effort to increase labor efficiency.

Your Committee fully appreciates the magnitude of the subjects assigned and hopes, in due time, to arrive at helpful conclusions. It must, to a large extent, be guided by the information and suggestions furnished by the membership who cannot but appreciate also the necessity of real constructive work along these lines.

Respectfully submitted,

THE COMMITTEE ON ECONOMICS OF RAILWAY LABOR,

C. E. JOHNSTON, *Chairman.*

REPORT OF SPECIAL COMMITTEE ON STANDARDIZATION

E. A. Frink, *Chairman;*
F. L. C. Bond,
A. Crumpton,
A. F. Dorley,
W. T. Dorrance,
W. J. Eck,
J. M. R. Fairbairn,
W. H. Hoyt,
Edwin B. Katte,
F. R. Layng,
J. R. W. Ambrose, *Vice-Chairman;*
B. H. Mann,
G. J. Ray,
H. L. Ripley,
O. E. Selby,
H. M. Stout,
C. M. Taylor,
W. P. Wiltsee,
J. J. Yates,
Committee.

To the American Railway Engineering Association:

Instructions to the Committee for this year's work were as follows:

1. Review at once, plans and specifications heretofore adopted and suggest to the Committee on Outline of Work a list of recommendations which interest more than one committee or of which further study ought to be made in the interest of improving such plans and specifications with a view of having the Committee on Outline of Work issue specific instructions to the several committees to undertake certain of this work during the coming year. The purpose of this being the development of minimum specifications for as many items of standard railway materials as possible, not only in the interest of economy and better materials, but to insure the fullest measure of competition.
2. Endeavor to secure the more general use by railways of the specifications, standards and recommendations of the Association, as a means of saving time and money.
3. Submit as suggested work for each committee for the 1921 outline of work definite recommendations for minimum specifications for specified items of standard railway materials.

Committee Meetings

Two meetings were held on June 16th and December 7th, both in New York, reports of which have been published in the Bulletin.

Progress Report

In accordance with instructions 1 and 3, a list of recommendations has been prepared for the Committee on Outline of Work and is attached as Appendix A.

In accordance with instructions 2, chairmen of the committees were asked to make active inquiries into the use of recommendations of their committee and to promote general use of A. R. E. A. recommended practices.

Conclusions

The Committee has no conclusion to present.

Recommendations for Future Work

In last year's report, your Committee recommended a concerted effort to cover the desirable field of railroad standardization and that it be directed to proceed with the development of its work along the lines indicated by the instructions approved by the Committee on Outline of Work for 1919.

Standardization—considered solely in relation to railroad requirements—from its very nature, as well as its wide scope and diversified application, has been in the past and must continue to be the result of growth. But your Committee believes that its natural growth can and should be advantageously accelerated by judicious assistance.

Much has been done in standardizing twist drills, wood screws, machine screws, rails, steel angles and beams, certain types of hardware, like butts, strap and tee hinges, nails, spikes, machine and carriage bolts, signal fittings, wire—the list is too long to quote here. Due to the efforts of the R. S. A. (Signal Section, A. R. A.), many signal fittings now are interchangeable, both in part and as a whole, which otherwise would still be made to individual pattern by each manufacturer, thus requiring the railroads to multiply repair stock and divide repair orders. The Mechanical Division of the A. R. A. has made some progress.

Material benefits will accrue to the railroads from standardizing track spikes, track bolts, track jacks, track and ballast tools of all kinds, rail drilling, switch lamps, etc., and this Association should lead in the work. This can be done by detailed handling of each article until the final design, acceptable to both producers and consumers, is reported to this Association. Our experience would lead us to believe that a purchasers' market would expedite results. Therefore, your Committee recommends that the following instructions be given it for next year's work:

1. Review at once, plans and specifications heretofore adopted and suggest to the Committee on Outline of Work a list of recommendations which interest more than one committee or of which further study ought to be made in the interest of improving such plans and specifications with a view to having the Committee on Outline of Work issue specific instructions to the several committees to undertake this work. The purpose of this to be the development of the least number of specifications for as many items of standard railway materials as possible, not only in the interest of economy and better materials, but to insure the fullest measure of competition.

2. Endeavor to secure the more general use by railways of the specifications, standards and recommendations of the Association, as a means of saving time and money.

3. Submit as suggested work for each committee for the 1921 outline of work definite recommendations for specifications for specified items of standard railway materials.

Your Committee also recommends that all standards adopted by the A. R. E. A. be known and designated as R.E. standards. In case of the adoption of standards originated by other bodies, due credit should be given to the originators.

Respectfully submitted,

The Committee on Standardization,

E. A. Frink, *Chairman.*

Appendix A

Committee	*Article*	*Consult with Committee on*
II—Ballast	Ballast tools	Track
IV—Rail	Rail sections	
	Rail drilling	
	Bolts	Track
V—Track	Track tools, except ballast	
	Tie plates	Ties, Ballast, Rail
	Frogs	
	Switches	Signals
	Switch stands	
	Spikes	
	Screw spikes	
	Guard rails	
	Rail braces	Signals
	Derails	Signals
VI—Buildings	Glass sizes	
	Hydrants, fire	Water Service
	Hoze, nozzles, etc.	
	Baggage trucks, hand	
	Scales, freight house and baggage	
	Fire extinguishers	
VIII—Masonry	Portland cement	
	Cement testing	
	Metal reinforcement	
IX—Signs, Fences and Crossings	Highway crossing signs	
X—Signals	R. S. A. standards	
	Switch lamps	Track
	Bridge lamps	Iron and Steel
	Highway crossing signs	Signs
XIII—Water Service	Wood tank details	
	Tank fittings	
	Water columns	
	Tank gages	
	Float valves	
XVII—Wood Preservation	No. 1 Creosote	
	No. 2 Creosote	
	No. 3 Creosote	
	Coal tar—Creosote solution	
XVIII—Electricity	Incandescent lamps	Signals
	Insulators	
	Insulated wires and cables	Signals
	Tile and other conduits	
	Friction, rubber and other tapes	Signals
	Knife and snap switches	

REPORT OF COMMITTEE XX—UNIFORM GENERAL CONTRACT FORMS

W. D. FAUCETTE, *Chairman;*
C. F. ALLEN,
A. O. CUNNINGHAM,
G. L. DAVENPORT,
CLARK DILLENBECK,
G. E. GIFFORD,
J. C. IRWIN,
E. H. LEE,
O. K. MORGAN,
C. A. WILSON, *Vice-Chairman;*
C. B. NIEHAUS,
H. A. PALMER,
C. J. PARKER,
J. W. PFAU,
A. C. SHIELDS,
E. L. TAYLOR,
FRANK TAYLOR,

Committee.

To the American Railway Engineering Association:

The following subjects were assigned Committee XX—Uniform General Contract Forms, for study and report:

1. Make thorough examination of the subject-matter in the Manual and submit definite recommendations for changes.

2. Report on forms of agreement embodying rules governing the construction of undercrossing of railways with electrical conductors, conduits, pipe lines and drains, conferring with Committee on Roadway and Electricity.

3. Make final report, if practicable, on form of lease agreement for industrial site.

Committee Meetings

Meetings of this Committee were held in New York on June 29th and November 9th, 1920. List of those present has been given in the minutes of the meetings which have been furnished the Secretary of the Association, and which have been referred to in the Bulletin.

(1) Revision of the Manual

In Appendix A, covering Revision of the Manual, certain changes have been recommended for adoption by the Association. This work was in charge of a Sub-Committee, the Chairman of which was Mr. Clark Dillenbeck, the members of the Sub-Committee being: Clark Dillenbeck, J. C. Irwin, C. B. Niehaus, E. L. Taylor, Frank Taylor.

(2) Report on Forms of Agreement

This subject was assigned to a Sub-Committee, of which Mr. J. C. Irwin was Chairman, with the following members: J. C. Irwin, C. A. Wilson, E. H. Lee, E. L. Taylor, H. A. Palmer, C. F. Allen.

This Sub-Committee has given considerable study to proposed form of agreement but it was the final conclusion of the Sub-Committee and of the General Committee, that this form should be submitted to the Association as a progress report, and it is, therefore, shown in Appendix B. It is the wish of this Committee to receive any criticisms or suggestions in connection with this form, and the Committee desires that this subject be reassigned to this Committee as part of next year's work. Attention is drawn that it was thought best to change the title of the form which is set forth in Appendix B.

(3) Lease Agreement for Industrial Site

The Committee makes its final report on the form of Lease Agreement for Industrial Site as set forth in Appendix C and recommends to the Association the adoption of this form of agreement.

This assignment has been on the Committee's list of work for several years and has been considered very carefully by the Committee during the present year. The various paragraphs have been thoroughly discussed and exchange of views in meeting and by correspondence resulted in the adoption at the last Committee meeting of this final report.

Your Committee realizes that in standardizing a form of lease agreement for industrial site that it is hardly possible such an agreement can be adopted without some modification to meet conditions that will arise, but your Committee believes that this agreement embodies the fundamental principles governing the preparation of such a lease agreement and offers it to the Association as a result of its work. Conditions will arise in different parts of the country where modifications, and no doubt the insertion of additional paragraphs, will be necessary. However, your Committee feels that paragraphs herein contained can be adapted and that the railroads will find in this report a guide in the preparation and standardization of a form of lease agreement for industrial site.

Your Committee believes that in view of the length of time it has considered this form of agreement nothing would be gained by carrying it over another year. It was the hope of the Committee to receive detailed criticism from the American Railway Development Association before the completion of this report, but the President of the American Railway Development Association did not feel justified in giving an expression on the form of lease before the matter was brought before his membership and as it was necessary that the work of your Committee for this year be closed, no expression from the American Railway Development Association was obtained, much to our regret.

In the preparation of a form of agreement of this character, the Committee fully realizes that the diversified territory in Canada and in the United States through which this form of agreement will be distributed, if printed in the Manual, will probably call for changes in some of the paragraphs in order that it may become a workable agreement in the hands of any particular road, but as before stated, the Committee feels that it has embodied herein those essential paragraphs which should not be overlooked in the preparation of such an industrial site lease agreement.

CONCLUSIONS

(1) The Committee recommends that the changes in the Manual, set forth in Appendix A, be approved and that the revised matter be substituted for the present recommendations existing in the Manual or Supplements.

(2) The Committee recommends that the form of license for wires, pipes, conduits and drains on railroad property set forth in Appendix B be received as information, and be assigned as part of the Committee's work for the coming year.

(3) The Committee recommends that the final report on Form of Lease Agreement for Industrial Site, Appendix C, be adopted and printed in the Manual.

Recommendations for Future Work

Your Committee recommends that the following list be considered in making future assignments:

(1) Make thorough examination of the subject-matter in the Manual, and submit definite recommendations for changes.

(2) That the license for wires, pipes, conduits and drains on railroad property, which was submitted this year as information, be reassigned this Committee for further study.

(3) Form of Agreement for private road crossing.

(4) Form of Agreement for the purchase of electricity.

(5) Form of Agreement for the sale of electricity.

(6) Form of Agreement to cover joint use of passenger station.

(7) Form of Agreement to cover joint use of a freight station.

(8) Form of Agreement for trackage rights.

(9) Form of Agreement for private crossing at grade.

(10) Cost-Plus Contracts and recommend a form for such as may desire to use this form of contract. (Although the Committee mentions this subject, and while we do not recommend or favor this manner of doing work, it is only our purpose that if such a type of contract under any condition be used, it may be the wish of the Association to have this Committee give some study to such form of contract.)

(11) Study of all specifications in the Manual in connection with which Form of Construction Contract would be used, with the view of changing or eliminating any conflicting verbiage from one or the other which might raise questions as to the meaning or intent of the agreement as a whole.

Work of Committee XX

At the request of the Chairman of the Standardization Committee, your Chairman sent a questionnaire to 61 Chief Engineers of railroads, and at this writing replies from 40 have been received.

It is very gratifying to observe the amount of interest manifested in these replies, but on account of the large amount of matter which would be contained in printing the full answers your Chairman undertook to condense the substance of these replies in the form of a table which is attached as Appendix D.

In reading this report we attract your attention to the answers to the fourth question, which were very encouraging to your Committee.

From replies received from many of the railroads it was noted that considerable thought was given in answering the questionnaire and in many instances agreements were sent for examination and comments were made in regard to the practice on the different railroads.

It is the thought of your Committee that the publication of this canvass as an Appendix to this report would be of interest to the Association. This is submitted only as information.

The Committee records, with pleasure, the satisfactory attendance at the Committee meetings held and the interest manifested by its members.

Respectfully submitted,

THE COMMITTEE ON UNIFORM GENERAL CONTRACT FORMS,

W. D. FAUCETTE, *Chairman.*

Appendix A

REVISION OF THE MANUAL

CLARK DILLENBECK, *Chairman*, Sub-Committee.

This matter was given careful consideration by your Sub-Committee and report prepared. This report was carefully considered in detail at the meeting of the General Committee on November 9th, and we submit the following revised report as approved at that meeting:

"CONSTRUCTION CONTRACT FORM," pages 653 to 665 of the Manual:

Change Heading page 653.

Present Heading	*Proposed Heading*
CONSTRUCTION CONTRACT FORM	FORM OF CONSTRUCTION CONTRACT
FORM OF PROPOSAL, page 655.	

It is recommended that this be placed to precede "(A) AGREEMENT," now on page 653.

Section 30, page 661. Change heading and first paragraph.

Present Heading	*Proposed Heading*
PROPERTY AND RIGHT OF ENTRY.	LAND OF COMPANY, USE OF BY CONTRACTOR.
Present Form.	*Proposed Form*
30. The Company shall provide the lands upon which the work under this contract is to be done, except that the Contractor shall provide land required for erection of temporary construction facilities and storage of his material, together with right of access to the same.	30. The Company shall provide the land upon which the work under this contract is to be done, and will, so far as it can conveniently do so, permit the Contractor to use so much of its land as is required for the erection of temporary construction facilities and storage of materials, together with the right of access to same, but beyond this the Contractor shall provide, at his cost and expense, any additional land required.

Section 32, page 662. Change last line of last sentence.

Present Form	*Proposed Form*
32. But if the work, or any part thereof, shall be stopped by the notice in writing aforesaid, and if the Company does not give notice in writing to the Contractor to resume work at a date within ....of the date fixed in the	32. But if the work, or any part thereof, shall be stopped by the notice in writing aforesaid, and if the Company does not give notice in writing to the Contractor to resume work at a date within ....of the date fixed in the

Present Form	Proposed Form
written notice to suspend, then the Contractor may abandon that portion of the work so suspended and he will be entitled to the estimates and payments for such work so abandoned, as provided in Section 38 of this contract.	written notice to suspend, then the Contractor may abandon that portion of the work so suspended and he will be entitled to the estimates and payments for work done, on such portion so abandoned, as provided in Section 38 of this Contract.

Section 34 (a), page 663. Omit the words "thirty days" from second and third lines.

Present Form	*Proposed Form*
34. (a) The Company shall have the right at any time, for reasons which appear good to it, to annul this contract upon giving thirty days' notice in writing to the Contractor, in which event the Contractor shall be entitled to the full amount of the estimate for the work done by him under the terms and conditions of this contract up to the time of such annulment, including the retained percentage.	34. (a) The Company shall have the right at any time, for reasons which appear good to it, to annul this contract upon giving notice in writing to the Contractor, in which event the Contractor shall be entitled to the full amount of the estimate for the work done by him under the terms and conditions of this contract up to the time of such annulment, including the retained percentage.

Page 666, Bond. Change Heading.

Present Heading	*Proposed Heading*
Bond	Form of Bond

Bulletin 189, pages 71 and 72, Revision to Agreement Form in Manual. No change is recommended.

Bulletin 207, Industrial Track Agreement, pages 103 to 107. Change heading.

Present Heading	*Proposed Heading*
Industrial Track Agreement	Form of Industry Track Agreement.

The Committee realizes that changes are necessary in the form and regret that definite recommendations must be postponed to a later date.

Pages 109 to 115, Agreement for Interlocking Plant. Change heading.

Present Heading	*Proposed Heading*
Agreement for Interlocking Plant.	Form of Agreement for Interlocking Plant.

Omit the whole of Section 9, Wage Rates, page 113.

Present Form	
9. The wages of employees connected with maintenance, renewal and operation of said interlocking piant shall be the same as the standard wages paid by the ....Company for similar service to its other employes in the same territory.	9. (Omit this paragraph.)

Bulletin 217, AGREEMENT FOR GRADE CROSSINGS, pages 41 to 47. Change heading.

Present Heading	*Proposed Heading*
AGREEMENT FOR GRADE CROSSINGS.	FORM OF AGREEMENT FOR CROSSING OF RAILROADS AT GRADE.

Omit the first note.

Present Form

(Note.—During Federal Control terminology should conform to requirements of Federal Administration.)

Change the words "grade crossing" to "railroad crossing at grade" in second note under "Whereas" second line, and in Section 3, page 42, under "Construction," second line.

Recommendations

Your Committee recommends that the above changes in the Manual be approved and that when the Manual is reprinted the changes be incorporated therein.

Appendix B

LICENSE FOR WIRES, PIPES, CONDUITS AND DRAINS ON RAILROAD PROPERTY

(Tentative Form)

THIS AGREEMENT, made this..........day of............19.., by and between the.. hereinafter called the Company, and.................................. ....having a principal office or place or business in .... hereinafter called the Licensee,

WITNESSETH, THAT:

Whereas, the Licensee desires to construct, maintain and use...... .... upon the property of the Company, situated in........................ ...., and more definitely shown on the plan hereto attached, designated as.. ....and dated..............., and made a part hereof:

It is mutually agreed as follows:

1. The Company grants permission to the Licensee to construct, maintain, and use.. upon the property of the Company, in accordance with said plan and the specifications forming a part hereof, and subject to the requirements of the Company.

2. In consideration of this license, the Licensee shall pay to the Company, in advance, the sum of................per................ beginning..............................

3. Every cost and expense of construction, maintenance, use and removal resulting from this license shall be paid by the Licensee. The Company may perform without notice any work which it considers necessary to the safe operation of the railroad. The Licensee shall do no work under this license, which may interfere with the operation of the railroad without the written permission of the Company.

4. Use of the property of the Company however long continued shall not affect any estate or easement in the Licensee or any rights other than license.

5. The Licensee shall indemnify, protect, and save harmless, the Company from and against all claims, suits, costs, charges, and damages, made upon or incurred by the Company in connection with this license.

6. This agreement may be terminated by either party by ....notice to the other party, or without notice on disuse by the Licensee for................

7. Any notice given by the Company to the Licensee shall be deemed to be properly served if the notice be delivered to the Licensee, or if left with any responsible agent of the Licensee, or if deposited in the postoffice, post paid, addressed to the Licensee at................... last known place of business.

8. Upon termination hereof the Licensee shall forthwith remove all his constructions from the property of the Company, satisfactory to the Company. In case of the Licensee's failure so to do, the Company may at its option either retain such constructions or remove them at the cost of the Licensee.

9. This agreement shall not be assigned or in any manner transferred, without the written consent of the.............................. of the Company.

10. Until terminated as hereinbefore 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 on the day and year first above written.

....

COMPANY.

WITNESS........................ ....

WITNESS........................ By..............................

Appendix C

FORM OF LEASE AGREEMENT FOR INDUSTRIAL SITE

Parties

(1) THIS LEASE, Made in...................this............day of................19...., by and between the.., a corporation, the Lessor, hereinafter called the Company, and.. having a principal office or place of business in........................ in the...................and..................., hereinafter called the Lessee, WITNESSETH;

That the Company in consideration of the agreement of the Lessee herein contained, hereby leases unto the Lessee, all those certain premises, situated in..................., County of..................., State of..................., described as follows:

Description

(2) .... the location and dimensions of said premises being more definitely shown on the plan hereto attached, designated as..and dated.. and hereby made a part hereof.

Term

(3) To have and to hold the same from.......................... 19...., to..........................19..., unless sooner terminated, as hereinafter provided.

Termination

(4) Either party hereto may terminate this lease at any time, by giving to the other party................days' written notice to that effect. Acceptance of rent in advance by the Company shall not act as a waiver of the right to terminate this lease.

Notice

(5) Any notice given by the Company to the Lessee shall be deemed to be properly served if the same be delivered to the Lessee, or if left with any of....................agents, or if posted on said premises, or if deposited in the postoffice, postpaid, addressed to the Lessee at.......... ....last known place of business.

Rent

(6) The Lessee shall pay a rental of............................. per...................., payable............................in advance, beginning on..........................., for the use of said premises, payable to the.................of the Company, at...................

Refund

(7) Rent paid in advance for a period extending beyond the termination of this lease shall be repaid to the Lessee within thirty days after demand, unless such termination shall be on account of violation of non-fulfillment of any of the terms of this lease by the Lessee, or on account of abandonment of said premises by the Lessee, in which case the amount paid as rental shall be retained by the Company.

Taxes

(8) The Lessee shall pay all taxes, licenses and other charges which may be assessed or levied upon said premises, improvements thereon, and upon the business of the Lessee upon said premises, or against the Company by reason of occupation or use of said premises by the Lessee.

Purpose

(9) The said premises shall be used for the following purposes:
....
....

Assignment

(10) This lease shall not be assigned or in any manner transferred nor said premises or any part thereof sub-let, used or occupied by any party other than the Lessee, nor for any purpose other than that specified herein, without the written consent of the Company.

Abandonment

(11) The failure of the Lessee to occupy or use said premises for the purpose herein mentioned for....................days at any one time shall be deemed an abandonment thereof. An abandonment of said

premises by the Lessee, shall operate as an absolute and immediate termination of this lease without notice.

Improvement

(12) The Company hereby gives to the Lessee, subject to all of the conditions hereof, the privilege of erecting, maintaining and using on said premises, suitable buildings and other structures for the aforesaid purposes; provided that such buildings and other structures shall be first approved by .... of the Company, and thereafter maintained as to meet with the approval of the .... of the Company; that the Lessee shall, so long as this lease continues, keep all buildings and other structures on said premises in good repair, including painting, so as to present a good appearance, so far as required by such .... and that the Lessee shall install, re-arrange and maintain such improvements as may reasonably be required by said Company for the reduction of fire hazard.

Clearance

(13) The Lessee shall neither erect nor place, nor permit to be erected or placed, upon said premises any structures or obstruction that will in any way imperil the safety of trains, engines or cars upon such railroad tracks as are now or may hereafter be located on, or adjacent to said premises, or the safety of persons or property in, upon, or about such trains, engines, cars or tracks. The minimum horizontal and vertical clearances from the tracks shall be prescribed by .... of the Company upon request.

Removal of Improvements

(14) Upon the termination of this lease in any manner, the Lessee, upon demand of the Company, without further notice, shall deliver up to the Company the possession of said premises, and shall if required, remove all the improvements placed thereon by the Lessee, and restore said premises to substantially their former state, and in case the Lessee shall fail, within .... days after the date of termination of this lease, to make such removal or restoration, then the Company may, at its election, either remove said improvements and restore said premises for the account and at the sole cost of the Lessee, or may take and hold the said improvements as its sole property.

Inflammables

(15) No goods of an explosive, dangerous or inflammable nature or character shall, in any case, be stored in or upon said premises without the written consent of the Company.

Condition of Premises

(16) The Lessee shall at all times keep said premises and the vicinity thereof, in a safe, clean and sanitary condition. The Lessee shall not mutilate, damage, misuse, alter or commit or suffer waste in premises.

Advertising

(17) No advertising shall be placed upon said premises or upon any structures thereon, except for the Lessee's own legitimate purposes, and all advertising so placed shall be to the satisfaction of the .... of the Company.

Laws and Regulations

(18) The Lessee shall in all respects abide by and comply with all laws, rules, regulations and ordinances affecting the said premises.

Miscellaneous Charges

(19) The Lessee shall pay all charges for water and lighting and for street or road sprinkling, sweeping or oiling, that may be levied or assessed against said premises, covering the period of occupancy.

Snow and Ice

(20) The Lessee shall at all times keep the sidewalks in front of said premises free and clear of snow and ice, and any expense to the Company by reason of the failure of the Lessee so to do shall be paid by the Lessee to the Company upon demand therefor; such expense to include all loss or damage of whatsoever character, either to persons or property.

Use of Tracks

(21) The Lessee shall not permit nor allow tracks belonging to others than the Company to be constructed upon said premises, and the Lessee will not permit nor allow trains or engines belonging to others than the Company to be used upon or given access to said premises, without the written consent of the Company.

Company's Right of Entry

(22) The Company shall have the right at all times to enter upon and to construct railroad tracks on said leased premises, and to maintain and operate, and to extend or change the location at any time, of such tracks as are then on said premises, upon .... days' written

notice to the Lessee. If any structure on said premises shall obstruct or interfere with the construction of additional main or passing tracks of the Company, or if required for proper clearance of tracks, the Lessee at .... expense, shall promptly move such structure to another location, either on or beyond said premises as may be necessary, upon .... days' written notice to the Lessee.

Access to Premises

(23) In the event it is necessary for the Lessee or his agents, servants, workmen and customers to pass over other lands of the Company and railway tracks of the Company, to have access to and from said premises, all such persons shall make use only of the way indicated by the ...., of the Company for that purpose, and the Lessee hereby expressly assumes all the risk of accident and injury to the person and property of all such agents, servants and workmen, and all others resorting to the leased premises in connection with the Lessee's business, whether the same be occasioned by the negligence of the Company's servants or in any other manner whatever, and the Lessee shall indemnify the Company from and against all claims, suits, costs and charges made upon or incurred by the Company by reason or in consequence of any such accident, loss and injury.

Liability

(24) (a) The Lessee assumes all responsibility for and agrees to indemnify the Company against loss or damage to property of the Lessee or of others upon said premises, regardless of negligence of the Company, arising from fire caused by locomotives operated by the Company in serving the Lessee upon said premises, or in the vicinity thereof, except to rolling stock belonging to the Company or to others, and to shipments in the course of transportation.

(b) The Lessee agrees to indemnify, protect and save harmless the Company for loss of, damage to, or destruction of property of the Lessee or of others upon said premises whether caused by fire or otherwise (except fire caused by locomotives as hereinbefore provided for), or for death of or injury to, any person or persons, arising out of the construction, maintenance, use, or operation on said premises (except where such death or injury was due solely to negligence of the Company).

Forfeiture

(25). Any breach of any covenant, stipulation or condition herein contained to be kept and performed by the Lessee, shall after ....

days' written notice, if continued, at once terminate this lease, and all rights of the Lessee hereunder. No further notice of such termination or declaration of forfeiture shall be required, and the Company may at once re-enter upon said premises and repossess itself thereof, and remove all persons therefrom, or may resort to an action of forcible entry and detainer, or any other action to recover the same.

Right of Inspection

(26) The said premises shall be open at all reasonable times to the inspection of the Company, its agents, and applicants for purchase or lease.

Renewal

(27) If the Lessee, with the consent of the Company, holds over and remains in possession of said premises after the expiration of said term, this lease shall be considered as extended, and shall continue in effect from, ..., to ....
subject, however, to termination as herein provided, and upon the same terms and conditions as are herein contained. Until terminated as hereinbefore provided, this lease shall inure to the benefit of and be binding upon the parties hereto, their heirs, executors, administrators, successors and assigns.

IN WITNESS WHEREOF, the parties hereto have executed this lease on the day and year first above written.

....

COMPANY.

....

....

WITNESS:..

WITNESS:..

By..

Appendix D

Condensed Replies to Questionnaire Sent Out by Chairman of Committee.

(Where precise answers were not given, the Chairman has endeavored to insert replies to conform to answer received.)

(*) Questions in full below.

Name of Railroad (Answer furnished by Chief Engineer.)	*Question No. 1.	*Question No. 2.	*Question No. 3.	*Question No. 4.
	Referring to forms of Standard Uniform Contracts now published in the Manual of this Association, together with the supplements to the Manual containing other reports, I will be glad to know which of these uniform contracts your company uses in its practice, substantially as recommended by the Association. (Please answer by naming the contract.)	If you do not use any of these contracts substantially as written in the Manual or supplements, does your company use the majority of clauses recommended in these contracts?	If your company does not use a form in anywise similar to the A. R. E. A. recommended practice, do you use the A. R. E. A. standard forms as a guide in the preparation of your contracts?	Are you interested in the standardization work which is being endeavored to be done by Committee XX, American Railway Engineering Association? If not, why not?
New York, New Haven & Hartford	General Contract, Proposal Form, Bond Form (not exactly identical but essentially the same)	....	In preparation of new and revision of old forms	Yes, as a guide.
Central Railroad of New Jersey	No	No	No	Own form favored by Legal Department.
Chicago & Northwestern	No, although in many respects similar	No, although in many respects similar	Do not know that forms have been used	Forms of contract prescribed by Legal Department.
Minneapolis & St. Louis	No	Guided by majority of clauses	Yes	Yes.
Missouri Pacific	No	No	Contract Attorney uses such information as applicable	Yes.
Yazoo & Mississippi Valley	No. Use Standard forms of Illinois Central R. R.	....	....	....

Appendix D—Continued

Canadian Pacific	Construction Contract	Yes, majority of clauses	Yes, practically so	Yes.
Norfolk & Western	No	No	Yes	Yes.
Boston & Albany	Construction Contract Form. Agreement. General conditions			Yes.
Colorado Southern	No	Uses own form	Yes	Yes, favors standardization.
Chicago, Rock Island & Pacific	No	No	No. Most provisions in own contract, using slightly different language	Yes. Legal Department thinks all contracts should be approved by that department.
Philadelphia & Reading	No	No	No	Yes, recommended forms should be followed as close as consistent.
El Paso & Southwestern Sys	No, written by Legal Department	No, have substantially equivalent clauses		Yes.
Southern Pacific Lines	No	No	No	Yes, work of great value.
Missouri, Kansas & Texas	None	No. Forms prepared by Legal Department	In revision of Construction Contract a number of clauses are being used	Yes, it is valuable work.
Chicago, St. Paul, Minneapolis & Omaha	Construction Contract	Yes, majority of clauses	Yes	Not familiar with work.
International & Great Northern	Not exactly	Many clauses as recommended	Yes, as general guide	Very much interested.
St. Louis Southwestern	No, not in their entirety	Yes, a number of clauses	Yes	Yes, hopes to see standard contract adopted.
Chicago, Milwaukee & St. Paul	Little used	Have own forms		Believes in standardization but thinks Committee should submit information and suggestions, and not ask for approval of form as standard.
Baltimore & Ohio	No	Majority of clauses are used	Yes, prove valuable in revising	Yes.

Appendix D—Continued

Condensed Replies to Questionnaire Sent Out by Chairman of Committee.

(Where precise answers were not given, the Chairman has endeavored to insert replies to conform to answer received.)

(*) Questions in full below.

Name of Railroad (Answer furnished by Chief Engineer.)	*Question No. 1.	*Question No. 2.	*Question No. 3.	*Question No. 4.
	Referring to forms of Standard Uniform Contracts now published in the Manual of this Association, together with the supplements to the Manual containing other reports, I will be glad to know which of these uniform contracts your company uses in its practice, substantially as recommended by the Association. (Please answer by naming the contract.)	If you do not use any of these contracts substantially as written in the Manual or supplements, does your company use the majority of clauses recommended in these contracts?	If your company does not use a form in anywise similar to the A. R. E. A. recommended practice, do you use the A. R. E. A. standard forms as a guide in the preparation of your contracts?	Are you interested in the standardization work which is being endeavored to be done by Committee XX, American Railway Engineering Association? If not, why not?
Norfolk & Southern	No	Legal Department prefers to draw contracts	Yes	Yes, endeavoring to have A. R. E. A. Standard adopted as rapidly as possible.
Chesapeake & Ohio	Construction Contract Form. Will use others when practicable			Yes.
Northern Pacific	No	Yes, in different form	No	Yes.
New York Central	No, use own form very little, different	Differences with A. R. E. A. not very great	Used as guide for making revisions	Yes, decidedly.
Chicago, Burlington & Quincy	Use individual forms	No	No	Yes, much interested and expect to profit by reports.
Mobile & Ohio-Southern Ry. in Mississippi	Uniform General Contract	General Contract substantially as written	No	Yes.
Los Angeles & Salt Lake	Construction Contract Form	Yes	Yes	Yes.

Appendix D—Continued

Western Maryland	No	Grading contract agreement and bond very similar	Expect to revise contract and specifications for construction, using A. R. E. A. as guide	Yes.
Boston & Maine	Legal Department adopts certain contracts	......	......	......
Texas & Pacific	Majority separate paragraphs embodied relating to contract work	Yes	Yes, prove useful	Yes.
Maine Central	Sidetrack agreement substantially	Yes	......	......
Atlantic Coast Line	Does not use exact form	Differences exist	Yes	Does not think will come in general use because of differences with Legal Department and court decisions.
Chicago & Eastern Illinois	Standard Construction Contract. No occasion to use others since adopted	Yes	Yes	Yes.
Louisville & Nashville	Have own standard	......	Yes, when possible	Yes.
Gulf Coast Lines	Yes, pages 653-665, 1915 Manual.	......	......	Yes.
Chicago & Alton	Yes, substantially Construction Contract	......	Yes, as guide	Yes.
Southern Pacific Co.	No	No	No	Yes.
Union Pacific System	None used in their entirety	Yes, followed substantially	Yes, in general way	Yes.
The Cleveland, Cincinnati, Chicago & St. Louis	Do not use any standard forms, although many have good points	Great many clauses correspond	Forms which are standard are used without reference to A. R. E. A. Standard Form as guide	Are interested in standardization but have not committed as to extent.
Seaboard Air Line	Not using A. R. E. A. Standard Forms	Good many clauses cover similar ground	Yes, used as guide in any revisions	Very much interested.

REPORT OF COMMITTEE IX—ON SIGNS, FENCES AND CROSSINGS

Arthur Crumpton, *Chairman;*
Arthur Anderson,
F. W. Bailey,
F. D. Batchellor,
F. T. Darrow,
G. N. Edmondson,
S. C. Jump,
L. C. Lawton,
Maro Johnson, *Vice-Chairman;*
S. L. McClanahan,
W. S. McFetridge,
L. A. Mitchell,
T. E. Rust,
W. D. Warren,
K. G. Williams,
D. R. Young,

Committee.

To the American Railway Engineering Association:

The following subjects were assigned to the Committee:

(1) Make thorough examination of the subject-matter in the Manual, and submit definite recommendation for changes.

(2) Report on the subject of "Signs," and the principles of design and rules for their use, considering the adoption of a sign for general use, as far as possible. Also consider the location of signs, bearing in mind the matter of safety of employees obliged to use the roadway.

(3) (a) Make final report, if practicable, on grade crossings, crossing gates, crossing signal bells, warning signals.

(b) Over- and under-grade crossings, study the laws and requirements of the Federal Government and of the various states, provinces and municipalities, which affect the distribution of cost as between the carrier and the public.

Committee Meetings

Meetings of the Committee were held in Chicago, May 13th, August 6th and November 12th, 1920. The names of members in attendance have been given in the Minutes of the Meetings which have been printed in the Bulletin.

(1) Revision of Manual

In Appendix "A" the Committee submits proposed changes in the Manual, together with the reasons therefor, and its recommendations are given under the heading of Conclusions.

(2) Signs

In Appendix "B" the Committee submits the results of its review of the various signs covered by previous reports and the minutes of Committee Meetings. Its recommendations are given under the heading of Conclusions.

(3) Highway Crossings

In Appendix "C" the Committee submits the results of its studies in connection with the following subjects:

(a) Grade Crossings, including tentative specifications and summary of the requirements and practice of the various States and Canada.

Crossing gates, warning signals and bells.

(b) Over and under-grade crossings.

Revision of Statement of State and Canadian laws relating to the separation of grades at highway crossings.

Bibliography on Elimination of Grade Crossings.

Conclusions

(1) The Committee recommends that the changes in the Manual in Appendix "A" be approved and the revised matter be substituted for the present recommendations in the Manual.

(2) The Committee recommends that the following paragraphs be approved and published in the Manual at the bottom of page 316 in lieu of its recommendation adopted at the last Convention. The additional signs covered are End of Block, Lack of Clearance, Corporation or Subdivision and Passing Siding.

Roadway Information Signs

Signs for Dump Ashes, Blind Siding, Water Station, Fuel Station, Beginning of Double Track, End of Double Track, End of Block, Lack of Clearance, Corporation or Sub-division and Passing Siding to be similar to sketch shown on page 318, 1915 Manual, for Trespass Signs.

Length of sign plate to be changed, if necessary, on account of wording and corners to be square on last two signs.

The Committee recommends that the designs submitted of Mile Post, Section Sign, Sub-Division and Section Sign, Property Post, Bridge Number, Curve and Elevation Number and Valuation Section signs be approved and published in the Manual.

Recommendations for Future Work

The Committee recommends that the following subjects be assigned for future work:

(1) Report on the location of signs, bearing in mind the matter of safety of employees obliged to use the roadway.

(2) Prepare plans and specifications for round and square concrete fence posts. In this connection follow up the data relating to the use of, and results obtained from concrete posts used on the different railroads.

(3) Make a revised study of the relative economy of steel, wood and concrete fence posts and present the data in such form as will enable comparisons to be made as to the relative economy of the various types, as the prices of steel, concrete and wood vary due to local conditions or fluctuations in the market.

(4) Prepare specifications for Highway Grade Crossings.

(5) Report on the various substitutes for wooden crossing plank both at highway crossings and on city streets, including concrete slabs, Tarvia and rock preparations, and oiled macadam.

Respectfully submitted,

THE COMMITTEE ON SIGNS, FENCES AND CROSSINGS.

ARTHUR CRUMPTON, *Chairman.*

Appendix A

(1) REVISION OF MANUAL

T. E. Rust, *Chairman;*
B. J. Dalton,
L. A. Mitchell,
Sub-Committee.

The Sub-Committee to which was assigned the work of studying the subject matter in the Manual and recommending definite changes in the same, reports as follows:

(1) No changes are recommended in the definitions appearing on pages 297 and 298 of the Manual.

(2) The following changes are recommended in the Specifications for Standard Right-of-Way Fences, appearing on pages 298 and 303, inclusive, of the Manual. Recommended changes, omissions or additions are underscored.

Present Specifications	*Recommended Specifications*
Class A Fence.	*Class A Fence.*
2. A Class A fence shall consist of nine longitudinal smooth galvanized steel wires; the top and bottom wires shall be No. 7 gage; the intermediate and stay wires shall be No. 9 gage.	2. Class A fence shall consist of nine longitudinal smooth galvanized steel wires; the top and bottom wires shall be No. 7 gage; the intermediate and stay wires shall be No. 9 gage.
The spacing of the longitudinal wires, commencing at the bottom, shall be 4, 4½, 5, 5½, 6, 7, 8 and 9 inches. The bottom wires shall be 5 inches above the ground and the stay wires shall be spaced 12 inches apart.	The spacing of the longitudinal wires, commencing at the bottom, shall be 4, 4½, 5, 5½, 6, 7, 8 and 9 inches. The bottom wires shall be 5 inches above the ground and the stay wires shall be spaced 12 inches apart.
When used as a hog-tight fence, the bottom wire shall be not over 3 inches above the ground, with a strand of barbed wire 1½ inches below same.	When used as a hog-tight fence, a strand of barbed wire shall be added 2½ inches below the woven wire.
Class B Fence.	*Class B Fence.*
3. A Class B fence shall consist of seven longitudinal smooth galvanized steel wires; the longitudinal and stay wires shall be No. 9 gage.	3. Class B fence shall consist of seven longitudinal smooth galvanized steel wires; the longitudinal and stay wires shall be No. 9 gage.
The spacing of the longitudinal wires, commencing at the bottom, shall be 6½, 7, 7½, 8, 8½ and 9 inches. The bottom wire shall be 7 inches above ground and stay wires shall be spaced 18 inches apart.	The spacing of the longitudinal wires, commencing at the bottom, shall be 6½, 7, 7½, 8, 8½ and 9 inches. The bottom wire shall be 7 inches above the ground and stay wires shall be spaced 12 inches apart.

Class C Fence.

4. A Class C fence shall consist of five longitudinal smooth galvanized steel wires; the longitudinal and stay wires shall be No. 9 gage. The spacing of the longitudinal wires, commencing at the bottom, shall be 7½, 8, 8½ and 9 inches. The bottom wire shall be 9 inches above the ground and the stay wires shall be spaced 24 inches apart.

Class C Fence.

4. Class C fence shall consist of woven wire fencing 24½ inches high with three strands of barbed wire above. The woven wire fencing shall consist of seven longitudinal, smooth, galvanized steel wires: The longitudinal and stay wires shall be No. 9 gage and the stay wires shall be 12 inches apart. The spacing of the longitudinal wires, commencing at the bottom, shall be 3, 3½, 4, 4½, 5 and 5½ inches and the bottom wire shall be 2 inches above the ground. The spacing of the barbed wires above the woven wire shall be 4½, 10 and 12 inches.

Concrete Posts.

10. Omit this paragraph.

End Post, Etc.

11. Omit this paragraph.

Intermediate Posts.

12. Omit this paragraph.

Braces.

13. Omit this paragraph.

Intermediate or Line Posts.

20. Intermediate or line posts shall be set at least 2 feet 4 inches in the ground and 16½ feet apart.

Intermediate or Line Posts.

20. Intermediate or line posts shall be set at least 2 feet 4 inches in the ground and not more than 20 feet apart, center to center. The first line post from any corner, anchor or gate post shall be set 10 feet, center to center, from the same.

Bracing.

24. Wood end, corner, anchor and gate posts shall be braced by using an intermediate or line post or a piece of 4-inch by 4-inch sawed lumber of a quality equal in durability to that of the posts, gained into the end, corner, anchor or gate post, about 12 inches from the top and into the next intermediate or line post about 12 inches from the ground and be securely spiked. A cable made of a double strand of No. 9 galvanized soft wire looped around the end, corner, anchor or gate post near the ground line, and around the next intermediate or line post about 12 inches from the top, shall be put on and twisted until the top of the next intermediate or line post is drawn back about 2 inches. Four-inch by 4-inch reinforced concrete braces shall be used with concrete posts.

Stretching.

25. Longitudinal wires shall be stretched uniformly tight and parallel; stays shall be straight, vertical and uniformly spaced. Wires shall be placed on the side of the post away from the track.

Splicing.

27. Approved bolt clamp splice or a wire splice made as follows may be used: The ends of the wires shall be carried 3 inches past the splicing tools and wrapped around both wires backward from the tool for at least five turns, and after the tool is removed, the space occupied by it shall be closed by pulling the ends together.

The use of smooth wire in preference to barbed wire is recommended for right-of-way fences.

The use of heavy smooth wire, or a plank at the top of a barbed wire fence, is recommended.

Bracing.

24. Wood end, corner, anchor and gate posts shall be braced by using an intermediate or line post or a piece of 4-inch by 4-inch sawed lumber of a quality equal in durability to that of the posts, gained into the end, corner, anchor or gate post, about 12 inches from the top and into the next intermediate or line post about 12 inches from the ground and be securely spiked. A cable made of a double strand of No. 9 galvanized soft wire looped around the end, corner, anchor or gate post near the ground line, and around the next intermediate or line post about 12 inches from the top, shall be put on and twisted until the top of the next intermediate or line post is drawn back about 2 inches.

Stretching.

25. Longitudinal wires shall be stretched uniformly tight and parallel; stays shall be straight, vertical and uniformly spaced. Wires shall be placed on the side of the post away from the track, except that on curves of 1 degree or more the wires shall be placed on the side of the post away from the center of the curve.

Splicing.

27. Approved bolt clamp splice or a wire splice made as follows may be used: The ends of the wires shall be carried 3 inches past the splicing tools and wrapped around both wires backward from the tool for at least five turns, and after the tool is removed, the space occupied by it shall be closed by pulling the ends together.

(3) The Sub-Committee recommends that the two paragraphs on page 303 of the Manual headed "Galvanized Wire Fencing" be omitted.

(4) No change is suggested in the recommendations regarding "Gates for Right of Way Fences," appearing on page 310 of the Manual, although it is thought that under present market conditions the use of a steel gate may not be justified.

(5) The Sub-Committee recommends that the dimensions of flangeways for steam and electric railways, adopted by the Association in 1918, be referred to the Committee on Track and published in the next edition of the Manual in the chapter devoted to the work of that Committee. It is thought that as these dimensions apply to frogs, crossings and guard rails, the Track Committee would be primarily interested, that members would naturally look under the report of that Committee for data of this nature, and that its consideration by Committee No. 9 would be a duplication of effort. There is also the danger that if two committees are handling the same subject conflicting recommendations may be adopted at different times and published in the Manual.

The Sub-Committee's reasons for recommending the above changes are as follows:

Specifications for Standard Right of Way Fences.

Class A Fence.—A fence 4 ft. 6 in. high is required by the laws of a great many states. The specifications as they now appear in the Manual provide that when this fence is used for hogs the bottom wire shall be not over 3 in. above the ground with a strand of barbed wire below. This would make the fence only 4 ft. 4 in. high, which would prevent its use in states requiring a 4 ft. 6 in. high fence. The Sub-Committee believes that the use of a barbed wire 2½ in. below the fencing will serve the purpose without lowering the woven wire.

Class B Fence.—The change from stays 18 in. apart to 12 in. apart is recommended because our largest makers of woven wire fencing do not fabricate this fence with 18 in. stays. It is also our opinion that the use of 12 in. stays is fully warranted.

Class C Fence.—The Class C fence specified in the Manual is one that, in our opinion, is only suitable under special conditions and in special locations. A fence 3 ft. 6 in. high is not suitable for general use, would be a legal stock fence in few, if any, states, and when used should be so placed as to suit the special conditions which caused its adoption. In its place the Sub-Committee has recommended a fence which is being used to some extent and which gives most of the advantages of the Class A fence at a considerably lower cost.

Concrete Posts.—The specifications for concrete posts, paragraphs 10, 11, 12 and 13 and the last sentence of paragraph 24 are obsolete, being largely amended by the conclusions adopted by the Association in 1918. Inferentially, also, they exclude the use of steel posts which have been adopted by several roads. The Sub-Committee thought it best, therefore, to omit all reference to concrete posts. Later on, if thought best, specifications of fence with concrete posts and with steel posts can be prepared by the Committee.

Intermediate or Line Posts.—The present specifications for line posts provide that the same shall be 16½ ft. apart, without any reference to a short panel at the corners or ends. The Sub-Committee believes that a shorter panel should be used at these corners and ends and recommends 10 ft. If this panel is too long an unnecessarily heavy brace is required and if it is too short there is a tendency for the end post to lift out of the ground. Ten feet is thought to be about the right length. The change in the distance apart of other line posts is to meet the practice of those roads which use 20 ft. centers, and, apparently, with good results.

Stretching.—The Sub-Committee is of the opinion that on curves it is desirable to have the fence on the outside of the curve from the posts so that the fence pulls against the posts instead of away from them. If this is not done it is thought that the staples would be likely to pull out when the wood in the post gets old and loses its holding power.

Splicing.—The Sub-Committee recommends the omission of the last two sentences as it seems to us that while the use of smooth wire may be proper in some places it certainly is not desirable in all places. On the western plains, for instance, smooth wire would scarcely be suitable for cattle fences. Cattle will reach through and bend down a fence of smooth wire in an endeavor to reach the grass on the right of way. If it is conceded that there are localities where the use of smooth wire is undesirable the Sub-Committee feels that the two sentences are much too general and should be omitted. If this is done there is nothing in the specifications to conflict with the use of smooth wire where the protection of high-priced stock from being injured by barbed wire, or other reasons, make it seem better to use smooth.

Galvanized Wire Fencing.

It seems entirely unnecessary to recommend that wire which meets the Association's specifications be used in the manufacture of fencing. The adoption of such a specification carries with it the recommendation for its use. As to the rest of the recommendations they seem both conflicting and not based on sufficient knowledge of the manufacture of such fencing. The first paragraph says that a second coating of zinc should be applied to electrically welded fencing after it is fabricated and the second paragraph says that all the galvanizing is to be applied after it is fabricated, so that the two recommendations are not consistent. As a matter of fact, the Sub-Committee believes that neither of the two methods are practicable. It is very probable that an extra heavy coating of zinc on the fence wires is desirable, but such coating should be applied in one operation. As to galvanizing the fencing after fabrication we do not believe that it is commercially practicable. The following is quoted from a letter recently received by the Committee from one of the largest manufacturers of fencing:

"Regarding your recommendation that a second coating of zinc be applied to electrically welded fence after it has been fabricated, would say that it is not feasible to apply a second coat of zinc on any galvanized wire. Wire—to be properly galvanized by the hot method—should be drawn through the molten zinc bath at such a speed as will let it acquire the temperature of the molten zinc bath during its journey through that bath. The result is that any zinc applied by a first coating will be melted in the second passage through the bath and no more zinc would be left on the wire when it emerged from the second treatment.

"There is another reason, which perhaps is more technical, and that is—any metal to be galvanized must be made chemically clean and free from all oxides immediately before it is plunged into the molten zinc. Any metal exposed to the air, even for a few minutes, is more or less affected by the oxygen of the atmosphere. Wire once galvanized is oxided by the atmosphere in this way and a second coating would not firmly adhere unless the first zinc coating was thoroughly cleaned immediately before the second treatment. There is no known way to clean zinc by chemical means. It can be cleaned by scouring, but that is not feasible under these circumstances. Therefore, this question of removing the slight oxide coating would present a double galvanizing, even if the first reason we have given above did not apply.

"Galvanizing the fence after it is manufactured, whether it is electrically welded or woven by other means, is not feasible. If the manufactured roll of fence were dipped in the spelter as a roll, the question of proper cleaning would be a serious one and we think an insurmountable difficulty and, moreover, any strands or stays that touched each other would be soldered by the molten zinc. When unrolled these wires would have to be ripped apart, which probably would mean that the galvanizing would be ripped off one wire or the other. Many rolls of fence, especially for railroad use, weigh from 600 to 1,000 lbs., making an unwieldy bundle to galvanize by this means.

"If the fabricated fence were galvanized by runing the fabric through a molten zinc bath before being finally wound into a bundle, the question of cleaning would still be a serious problem. The joints and the connections would still hold the cleaning acids as the fabric passed into the molten zinc bath and good galvanizing would not result. In this case, as in the case of galvanizing the wound roll, all of the joints and connections where the stay wire crosses the line wire would be soldered solid by the zinc. Woven wire fence must be more or less flexible to enable it to adjust itself to stretching conditions and to the contour of the ground. This would be prevented if the joints were solidly soldered together.

"Moreover, there are no manufacturers in the country equipped with galvanizing departments capable of handling the product, either by galvanizing the bundle or running the completed fabric through the galvanizing bath. It would involve changes in mill arrangements and conditions which we think no manufacturer would contemplate, even if there were not the objections first cited above. Both the fabricated fence and the completed roll would take up so much unnecessary zinc that the cost would be prohibitive and much of the zinc, because of the thick coating, would crack off while the fence was being unrolled and stretched."

It seems to the Sub-Committee that the recommendations concerning galvanized wire fencing are inconsistent in themselves, not practicable commercially, and that they should be eliminated from the Manual.

SUGGESTED REARRANGEMENT OF SUBJECT-MATTER.

1. Definitions.
2. Specifications for Standard Right of Way Fences.
3. Cut showing the four classes of fence, post spacing, etc. (New.)
4. Wire and Nail Tables, etc.
5. Concrete Fence Posts.
6. Gates for Right of Way Fences.
7. Surface Stock Guards.
8. Snow Fences, etc.
9. Cuts showing Snow Fences.
10. Signs.
11. Cuts showing Signs.

Appendix B

(2) SIGNS

J. N. Edmondson, *Chairman;*
A. Anderson,
F. W. Bailey,
F. D. Batchellor,
L. C. Lawton,
W. S. McFetridge,
S. L. McClanahan,
Sub-Committee.

The principles of design and rules for use of signs have been quite thoroughly covered in previous reports and this year we give the following resumé of the various signs, together with our recommendations.

In reviewing the old reports on work done to date by both this Committee and that of the Committee on Signals and Interlocking we find that it has generally been acknowledged that signs should be divided between those serving the public and those serving employees, the latter of course being largely in the majority. In this division certain signs have been reported by this Committee and adopted and certain signs have been reported by the Signal Committee in Volume 19, pages 76 to 91.

We will first take signs serving the public and we find the following situation:

Highway Crossing Signs

(a) At crossings.
(b) Approach warning signs.

The first sign, "at crossings," is covered in the 1915 Manual, page 317. The second sign, "approach warning signs," was adopted by the Convention at its 1920 Session.

Trespass Signs

(a) Right-of-Way.
(b) Bridge.
(c) Crossing.

These are covered on page 318 of the 1915 Manual.

Private Crossing Sign

The Committee do not believe a sign should be adopted by the Association to cover this, but consider it entirely a local matter as to their use.

Next we have the signs for the use of railroad employees.

Yard Limit

This is covered in Supplement to the Manual issued in 1918, pages 53 to 63.

Speed Limit

Permanent.
Temporary.

(a) Limit.
(b) Slow.
(c) Resume.

This is also covered by the above reference to Supplement to the Manual, no distinction being made, however, between Permanent and Temporary Signs and the "b" sign covered by a note.

Railroad Crossings

(a) Distant (1 mile).
(b) Close (Stop or 400 ft. sign).

This is covered as above by 1918 Supplement to the Manual, pages 53 to 63, as far as the "one mile" sign is concerned, but nothing was ever done with regard to the sign used by many railroads close to the crossing.

Junction—1 mile

Yard—1 mile

Station—1 mile

Whistle Post

Covered by the 1918 Supplement to the Manual.

Drawbridge

(a) Distant (1 mile).
(b) Close.

The "one.mile" sign was adopted in the 1918 Supplement to the Manual. Nothing, however, was adopted for the "close" sign to a drawbridge which is used the same as at railroad grade crossings.

Flanger Sign

Adopted in the 1918 Supplement to the Manual.

Water Station Limit

Fuel Station Limit

Cinder Station Limit

Blind Siding

Beginning and End of Double Track

Adopted at the 1920 Convention, similar to sign on page 318 of the Manual.

The above cover all the signs of both Committees that have been adopted by the Association to date and we make report below on the following signs which are still left for consideration.

End of Block

Your Committee recommends that this sign be similar in design to the sign adopted at the 1920 Convention for the Beginning and End of Double Track.

Clearance Post

As a question of safety and also due to the fact that a post of this character is not being used to any extent, your Committee recommends that no such post be adopted, but if necessary to mark clearance point where not taken care of by derails or signals that the rail and tie at the clearance point be painted to indicate such location.

Mile Post

Your Committee present design of mile post, which they recommend for adoption.

Section Signs—Sub-Division and Section Signs

Your Committee submits herewith sketch covering Section Sign, which they recommend for adoption. Also sketch covering Sub-Division and Section Sign where such are needed at the intersection of various Sub-Divisions.

Corporation or Sub-Division Signs

Your Committee recommends that this be similar to sign on page 318 of the Manual, excepting that it would be necessary to use a sign either 36 ft. x 24 ft. of 42 ft. x 24 ft. It would also be necessary to use this sign on a post flattened where fastened to the plate in order to paint both sides of the same, this sign being set at right angles to the tracks. We also recommend that this have square corners.

Property Posts

Your Committee submits sketch covering property post, which they recommend for adoption.

Passenger Station and Passing Siding Signs

Your Committee believe that the question of Passenger Station signs is one to be considered in connection with stations and not properly one for this Committee, it not being a roadway sign.

For Passing Siding signs needed your Committee recommend one similar to sign on page 318 of the Manual, excepting sign will have to be longer in order to take care of the necessary wording.

Track Pan Posts

Your Committee understand that this matter is being considered by the Signal Committee, as shown on page 77 of Volume 19 of the Proceedings of the Association.

Bridge Numbers

Your Committee submits herewith sketch of proposed sign to be used at bridges where the numbers cannot be painted directly on the structures. Where the latter can be done your Committee recommend that in preference to the erection of a sign. This would refer to through bridges or overhead bridges of any type.

Culvert Numbers

Your Committee recommend that no sign be adopted for culvert numbers, as this would require in many cases a large number of unimportant signs.

Curve and Elevation Numbers

Your Committee submits herewith sketch of proposed post to be used for that purpose and the adoption of which is recommended.

Lack of Clearance Sign

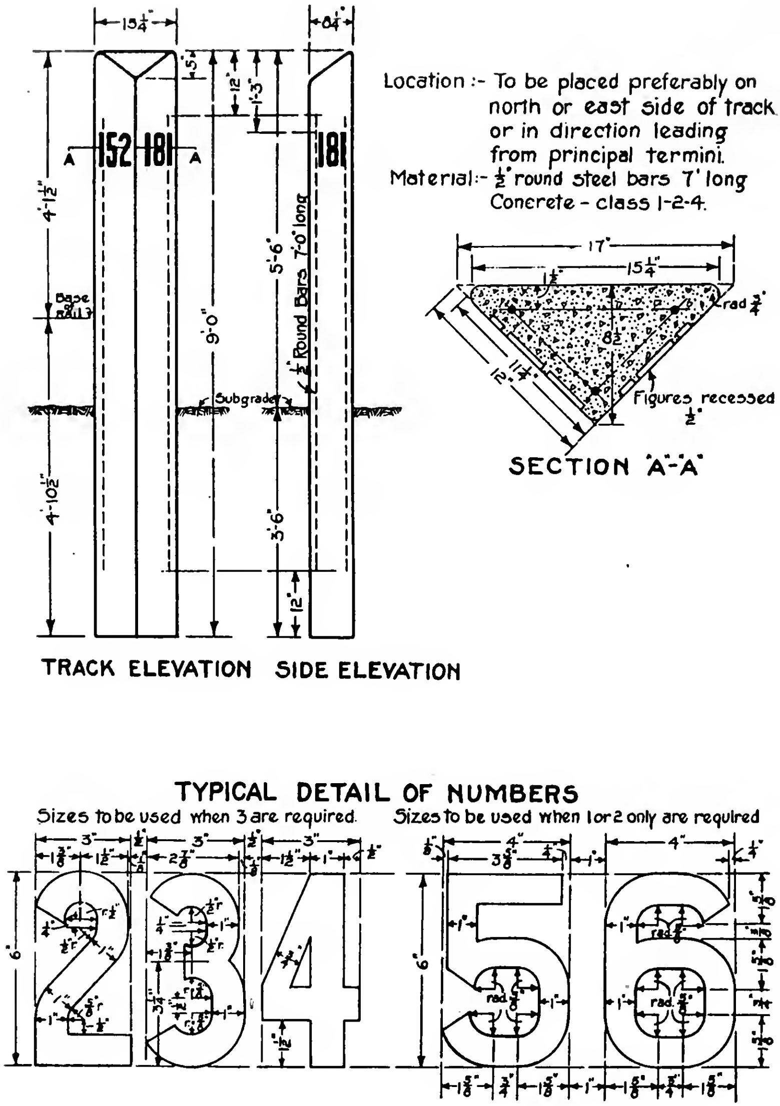
·Your Committee recommend a sign of this kind be constructed similar to sign shown on page 318 of the Manual, with the proper wording.

Valuation Section Sign

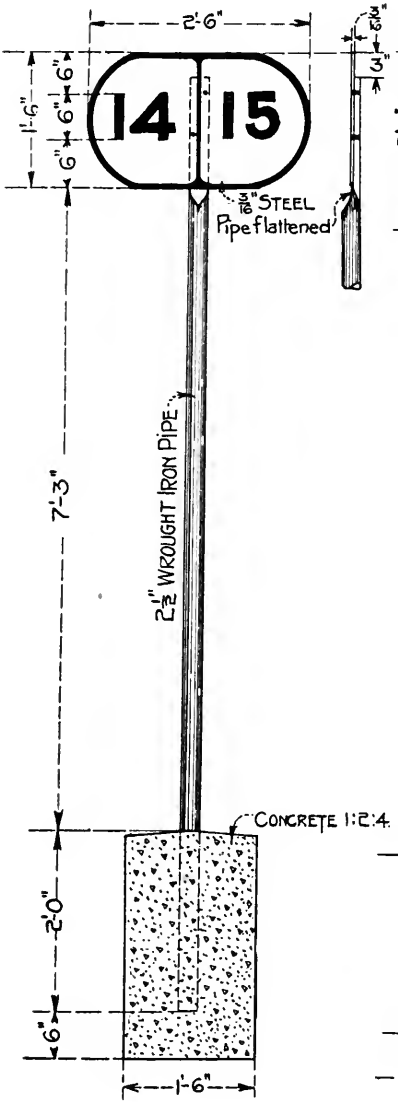
This is a sign which has recently been brought up on some railroads on account of the valuation by the Government and the continuing of reports by Valuation Sections. If such sign is desired, your Committee recommend the adoption of sketch submitted.

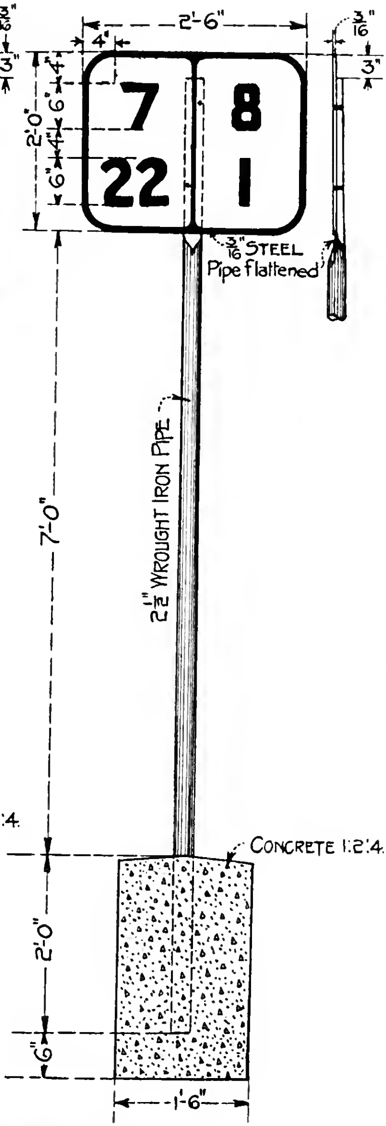
In the above signs your Committee has only recommended a general design, as we find that details will have to be followed out according to conditions existing in various locations.

With regard to the location of signs your Committee recommend that this be given further consideration the coming year and information be obtained from various railroads as to their current practice on such locations.


Location :- To be placed preferably on north or east side of track or in direction leading from principal termini.
Material:- ½" round steel bars 7' long
Concrete - class 1-2-4.
SECTION "A"-"A"
Figures recessed ½"
rad ¾"
TRACK ELEVATION
SIDE ELEVATION
Base of Rail
Subgrade
½" Round Bars 7'-0" long
9'-0"
5'-6"
3'-6"
4'-1½"
4'-10½"
152 181
181
TYPICAL DETAIL OF NUMBERS
Sizes to be used when 3 are required.
Sizes to be used when 1 or 2 only are required
23456

MILE POST

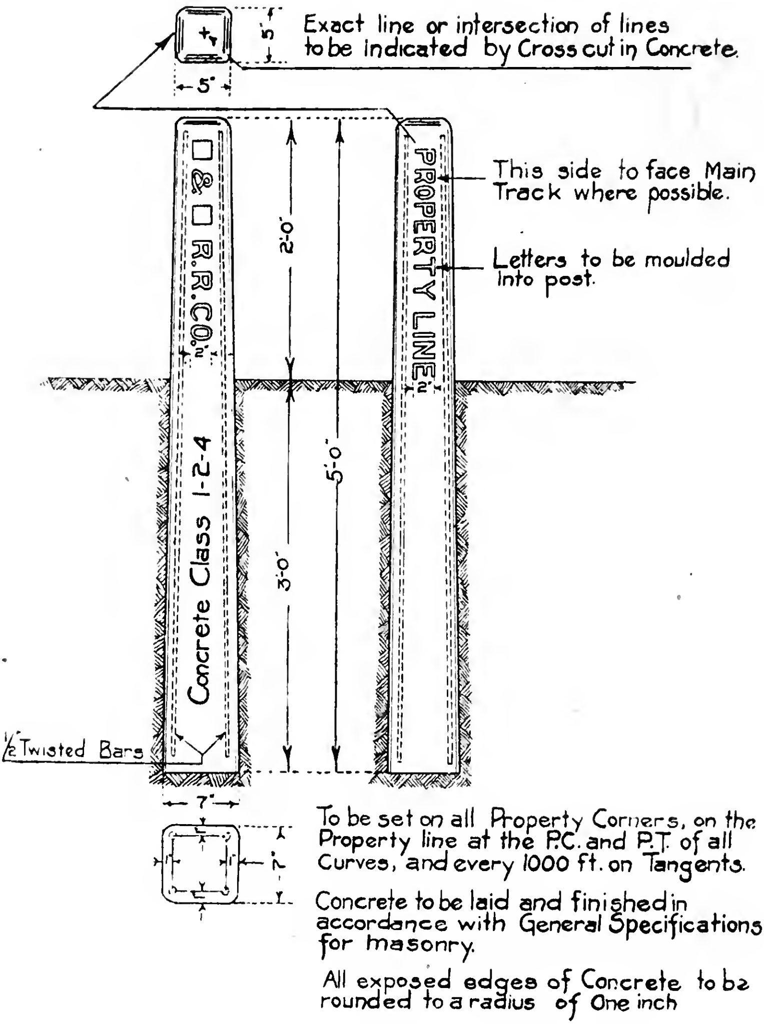




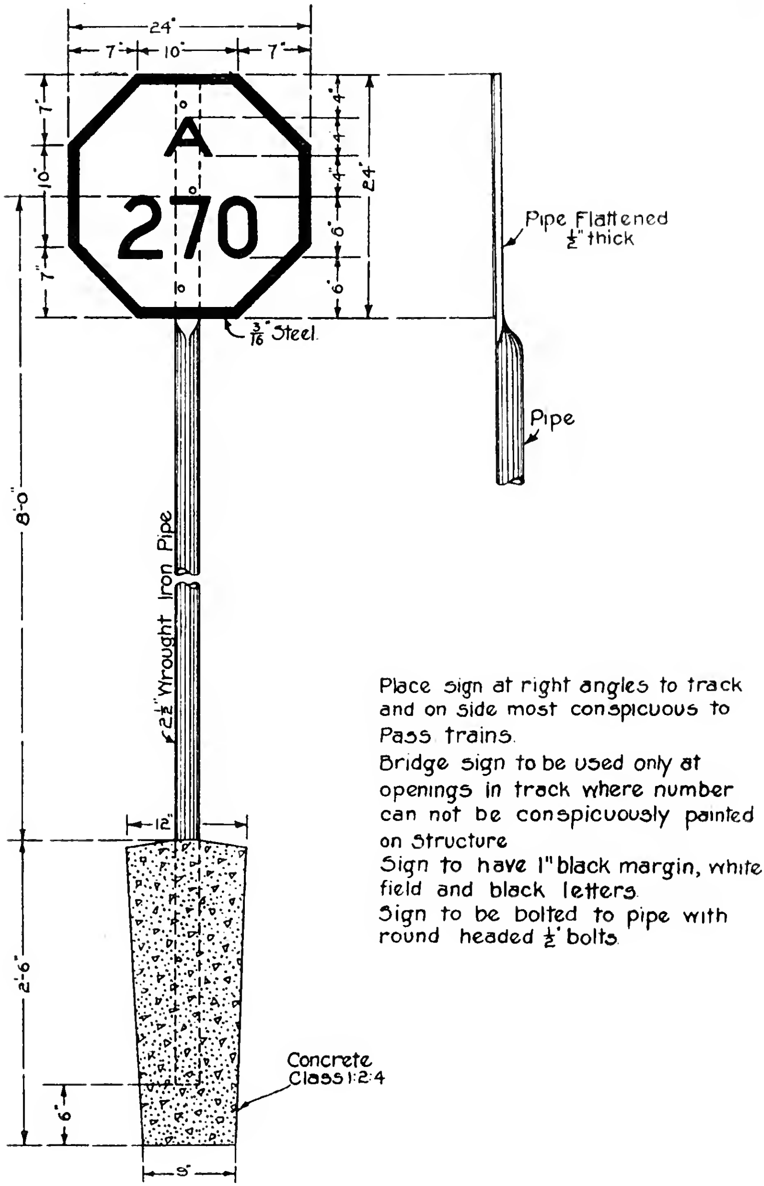
SIGNS TO HAVE 1" BLACK MARGIN,
WHITE FIELD AND BLACK LETTERS.
PLACE SIGN PARALLEL TO TRACK
NEAR RIGHT OF WAY LINE.

SECTION POST

SUB DIVISION AND SECTION POST

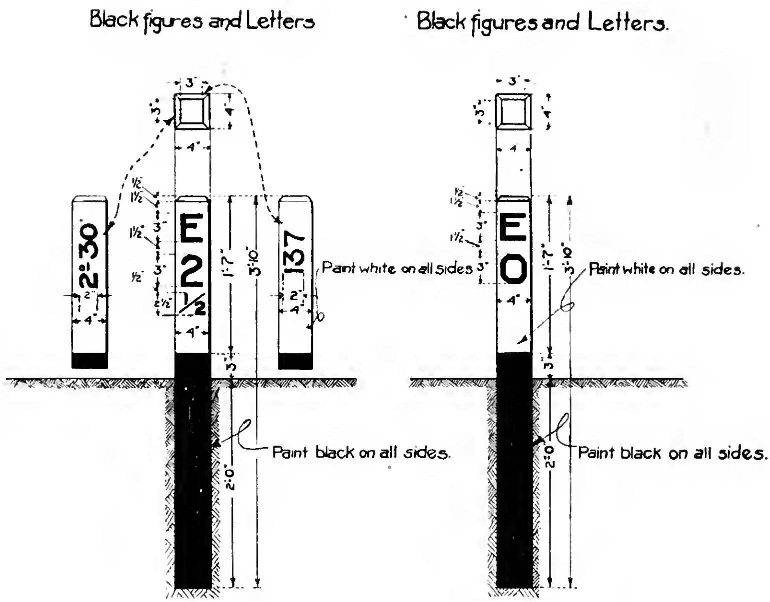


PROPERTY LINE POST



Place sign at right angles to track and on side most conspicuous to Pass trains.
Bridge sign to be used only at openings in track where number can not be conspicuously painted on Structure
Sign to have 1" black margin, white field and black letters.
Sign to be bolted to pipe with round headed 1/2" bolts.

BRIDGE SIGN



FULL ELEVATION POST
SINGLE TRACK

Set on inside of curve at each end 7'-0" from gauge side of near rail to near side of post and opposite "End of Easement" in all cases. Elevation to read approaching curve. Degree of Curve to be on side facing track, and number of Curve to be on side opposite Elevation.

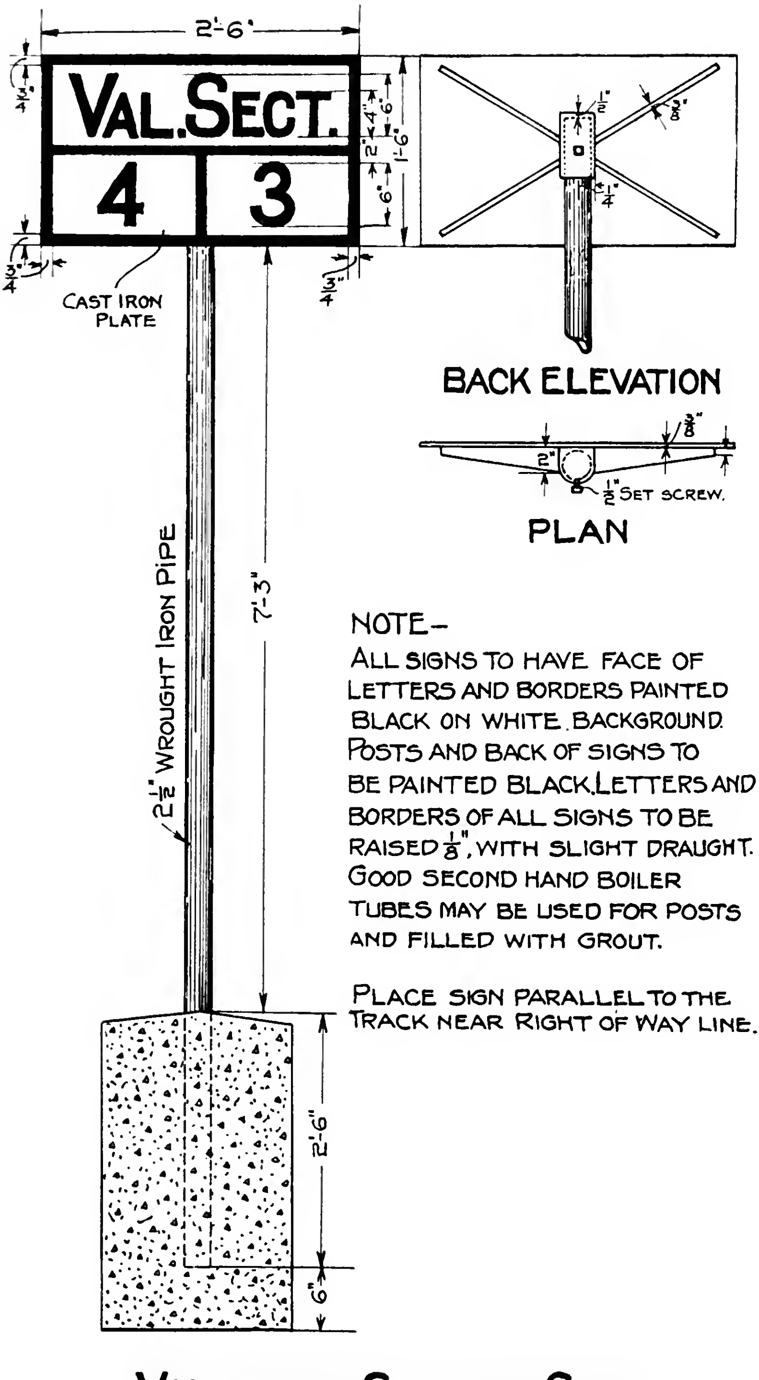
ZERO ELEVATION POST
SINGLE TRACK

Set on inside of curve at each end 7'-0" from gauge side of near rail to near side of post and opposite Beginning of Easement, or where no Spiral is used at the point of run-off on tangents. Figures to read approaching Curve.

DOUBLE OR FOUR TRACK

Above notes apply also to Double or Four Track except, that all posts must be set on outside of Tracks

ELEVATION POSTS



VALUATION SECTION SIGN

Appendix C

(3) HIGHWAY CROSSINGS

Maro Johnson, *Chairman;*
F. T. Darrow,
S. C. Jump,
K. G. Williams,
W. D. Warren,
D. R. Young,

Sub-Committee.

Grade Crossings.

Grade crossings have taken on greatly increased importance during recent years. State and local authorities have become interested and in many cases are actively co-operating in providing protection, in improving the physical conditions and in educating the public. Some states have laws with definite requirements as to grades to be used and details of construction. In others the Highway Commission has adopted rules pertaining to these features.

The Committee presents an abstract of the regulations in effect in the various states and Canada. In general, these regulations are interpreted in a liberal spirit by the officials enforcing them. On the so-called Federal Aid and State Aid projects, plans are usually prepared by the State Highway Commissions. For highways where the requirements are not stipulated by law the following specifications, which it is believed will provide an adequate crossing, are presented as information with a view to their consideration at a later date for insertion in the Manual.

Wood plank are recommended. Some roads are using concrete plank experimentally and others, bituminous concrete, at crossings. This Committee is not ready to recommend these.

Specifications for Highway Crossings

(1) A railroad grade crossing should not be so constructed that it will limit the traffic on a highway in respect to number of vehicles or load carried by them.

(2a) Under ordinary conditions the grade of the surface of the highway should be level with the top of rail for a distance of one foot outside each rail; should be three inches lower at points ten feet each side of the center of the track, and should slope upward or downward from these ten-foot points at grades not exceeding five per cent, where such grades are practicable.

(2b) Where the length of the approach is excessive, where the view is obstructed, or where an approach grade in excess of 5 per cent is necessary, the following grade line should be used: The surface of the highway should be level with the top of rail, for a distance of 1 ft. outside each rail; should be 6 in. lower at points 30 ft. each side of the center of the track, and should slope upward or downward from these

30-ft. points, at grades not exceeding 5 per cent, where such grades are practicable.

(3) The width of embankment at the crown end of cuts, exclusive of ditches, should be not less than 20 ft.

(4) Ample drainage for railway and highway should be provided.

(5) A single line of 4-in. plank not less than 10 in. wide and 16 ft. long, measured at right angles to the highway, should be placed outside and adjacent to each rail. The space between the rails should be planked solid after making provision for flangeways. The top surface of plank should not be more than ¼ in. below the top of rail, and should be chamfered at each end. Flangeways should be 2¼ in. wide and tapered to 4 in. at the extreme ends. Rail joints should not come within the limits of the planking except where the length of crossing exceeds the length of rail.

Crossing Gates—Warning Signals and Bells

This Association has adopted a standard highway crossing sign, page 317 of the Manual, and a standard approach warning sign, page 629, Vol. 21 of Proceedings. The approach warning sign has been adopted by the National Association of Railroad Commissioners and by the American Railway Association. In some states a stop sign consisting of a semi-circular metal plate with the word "stop" is located close to the track at crossings designated by the Public Service Commission or other authority. Under all ordinary conditions these signs are all the protection required. There are many crossings in prairie states where no sign is provided, the train being visible for a long distance.

The use of crossing gates, warning signals and bells should be confined to crossings in cities and towns where the view is obscured or highway and rail traffic is heavy. Their use elsewhere is not ordinarily justified, but the conditions under which they are installed are not uniform for the reason that the installation is governed by local considerations and is frequently forced by local authorities.

The American Railway Association has adopted rules for the guidance of flagmen and gatemen and has prescribed the equipment with which they must be provided. Where a flagman is on duty bells should not be installed. There is a tendency for the flagman to depend on the bell.

Gates are operated mechanically, by compressed air and by electricity. Mechanically operated gates are simple and easy to maintain. The pneumatic gate is also a satisfactory gate. Both types are subject to some trouble in the winter time. Leaky pipes which permit water to enter and freeze are one source of trouble with the mechanical gates. With pneumatic gates, during expansion of the air, there is a tendency for water to condense on the interior surface of the pipes, freeze and eventually stop up the pipe. Pneumatic gates are adapted to situations where more than one pair of gates are operated from the same gate house. Such installations should be made where the gateman has a full view of both crossings. Electrically operated gates are more expensive in first cost, in maintenance and in operation. The use of automatic electric gates actuated by approaching trains through a track circuit is not desirable. It should be possible to operate gates on opposite sides of the track independently. It requires about twenty seconds to operate one pair of gates. The crossing should be closed about one-half minute in advance of the arrival of train. Striped gate arms are more easily seen than those painted in solid color.

Wigwags should be visible 500 ft. from the track. Bells should be loud enough to be heard above the noise of trains. Either device should be operated not less than one-half minute in advance of arrival of train. The length of track circuit will vary with the grade and with operating conditions. On double track lines operation of warning devices is usually in the normal direction only. Special consideration frequently must be given installations at crossings in the vicinity of yards and switching leads.

Wigwags should be positive in action. The arrangement should be such that, when in working order, the disc will be concealed except when a train is approaching. When the device is out of order the disc should be in full view. Bells striking intermittently are more effective than those ringing continuously.

Summary of the Requirements and Practice of the Various States and Canada Pertaining to Highway Grade Crossings

Alabama.—There are no uniform requirements in regard to Grade Crossings. The matter was before the last Legislature, but owing to the shortness of the session, the bill failed to pass.

Arizona.—No report.

Arkansas.—Road commissioners are required in the improvement or construction of any highway, to locate it to cross the track at right angles, or as near right angles as is practical. Any interested person may enjoin the construction of the highway, if this is not done. So far as learned, there are no fixed requirements pertaining to construction of approaches.

California.—The Railroad Commission has control of the installation, alteration or abolition of Grade Crossings. There are no uniform requirements applying to construction.

Colorado.—The Railroad Commission has jurisdiction over highway crossings with railroads. Its requirements are as follows: State Highways—Width of roadway, 24 ft.; grade of approach, level for 20 ft. from center of track, then not more than six per cent. Other Public Highways—Width of roadway, 16 ft.; grade, as for State Highways. Gravel or other surfacing is required, and in towns, planks are required adjacent to rails.

Connecticut.—There are no uniform requirements or any regulations regarding highway crossings. Each condition is considered by the Public Utilities Commission of the state.

DELAWARE.—There are no fixed requirements governing present crossings. The State Highway Law prohibits the construction of new highway crossings with railways at grade.

FLORIDA.—There are no specifications in special reference to grade crossings, but the grades on the highways, as a rule, do not exceed five per cent; width of graded roadway, 30 ft.; width of hard surface, 16 ft. Owing to the physical characteristics of the state, few grades are in excess of three per cent.

GEORGIA.—There are no uniform requirements applying to construction of highway grade crossings.

IDAHO.—A safe crossing is required. Legislation on this question in 1921 is anticipated.

ILLINOIS.—Railroads are required by law to construct and maintain highway crossings, so that the roadway at the intersection will be flush to the rails. The grade of approaches must not exceed five per cent, unless authorized by the Public Utilities Commission. On State or Federal aid roads, the State Highway Department is making a uniform practice of building the approaches practically level for a distance of 50 ft. each side of the track, where this construction is at all feasible.

INDIANA.—There are no statutory requirements in regard to construction of highway grade crossings other than that the crossing shall be good and sufficient.

IOWA.—On the Primary Road System, which includes the main market roads, the width of roadway is 28 ft.; grade of approach, six per cent; width of crossing over tracks, 24 ft. It is customary, where practicable, to construct the crossing level with the top of rail for 50 ft. each side of the center of the track. On county roads, the width of roadway is 26 ft.; grade of approach, 6 per cent; width of crossing, 16 ft. to 20 ft. On township roads, the roadway is 24 ft. wide; grade of approach, 6 per cent; width of crossing, 16 ft.

KANSAS.—Session Laws of 1919 provide that highway crossings shall be not less than 24 ft. wide on county roads and 20 ft. wide on township roads. They must be built level for 30 ft. on each side of the track, unless County Commissioners find this feature unnecessary. The grade of approaches must not exceed 6 per cent.

KENTUCKY.—There are no laws in regard to the construction of highway crossings.

LOUISIANA.—No report.

MAINE.—There are no uniform requirements. The Public Utilities Commission prescribed the character of construction in each case that comes before it.

MARYLAND.—On state highways the minimum width of embankment is 24 ft., and the maximum grade 6 per cent. On other roads there are no uniform requirements.

MASSACHUSETTS.—There are no uniform requirements in regard to construction of highway crossings. Changes are authorized after hearing before the authorities having jurisdiction.

MICHIGAN.—The Public Utilities Commission has adopted specifications which require the width of the roadway to be not less than 24 ft. and the grade of approach to be not more than 4 per cent. Plank adjacent to the rails must be at least 16 ft. long.

MINNESOTA.—A suitable crossing of plank or other material, 32 ft. wide, is required with approaches of the same width and grades not exceeding 5 per cent.

MISSISSIPPI.—There are no standards pertaining to the construction of highway crossings except those of good engineering practice, as the exigencies of the case permit.

MISSOURI.—No report.

MONTANA.—There are no uniform requirements as to construction.

NEBRASKA.—Information received is not definite.

NEVADA.—There are no uniform requirements. The Department of Highways has charge and each case is a matter of mutual agreement between the department and the railway.

NEW HAMPSHIRE.—There are no uniform requirements. Each case is handled individually on its merits.

NEW JERSEY.—There are no uniform requirements governing the construction of grade crossings. All varieties of conditions exist. Each crossing is considered as an individual case and worked out as safety requires. On the state owned highway, the width of embankment is 30 ft. and the maximum grade is 6 per cent.

NEW MEXICO.—No report.

NEW YORK.—On state highways the approach is laid out the width of the highway and the grade is made the minimum possible after taking into consideration the surrounding topography.

NORTH CAROLINA.—Each crossing is designed on the merits of the individual case.

NORTH DAKOTA.—Each crossing is considered as a special problem to be solved in a way to secure most advantageous results. General standard of road construction is, minimum width of embankment, 24 ft.; maximum grade, 6 per cent.

OHIO.—There are no statutory requirements in regard to the construction of grade crossings.

OKLAHOMA.—The Corporation Commission has rules that grade crossings must be level with the top of rails for 7½ ft. each side the center line of the track; maximum grade, 5 per cent; minimum width, 16 ft.

OREGON.—There are no uniform requirements. State highways are paved for a width of 16 ft. with a 2-ft. macadam shoulder on each side. On these roads an effort is made to build at least 50 ft. of level approach on each side of the track.

PENNSYLVANIA.—The following standards are generally adhered to by the State Highway Department: Width of embankment, 28 ft.; width of roadway, 24 ft.; grade of approach, 5 per cent.

RHODE ISLAND.—No report.

South Carolina.—No report.

South Dakota.—The Board of Railroad Commissioners have jurisdiction. The law requires a good and sufficient crossing.

Tennessee.—There are no uniform requirements in regard to the construction of grade crossings.

Texas.—No report.

Utah.—There are no specific requirements. The Road Commission tries to keep grade at 6 per cent or below. Main roads have pavement 18 ft. wide, with 4-ft. shoulders. Dirt roads are 24 ft. wide.

Vermont.—The Public Service Commissioners have jurisdiction. So far as learned there are no uniform requirements. The standard width of roadway for new highways is 21 ft.

Virginia.—Width of embankments, state highways, 24 ft.; county highways, 20 ft. Grade of approach, state highways, 5 per cent; county highways, 7 per cent.

Washington.—The State Highways Commission requires grade crossings to be built level with the top of rail for a distance of 25 ft. each side of the track, with approach grades of 5 per cent. The width of embankments on primary highways is 28 ft. and on secondary highways 26 ft.

West Virginia.—The width of embankment on Class A roads is 23 ft., with 16 ft. pavement. The grade of approach is limited to 9 per cent.

Wisconsin.—On the State Highway System, width of approach embankments is not less than 24 ft. The grade is usually limited to 5 per cent. There are no uniform requirements for other highways.

Wyoming.—There are no specific requirements; each case is handled in accordance with local conditions.

Canada.

The Board of Railway Commissioners have prescribed rules. Approaches must have a road surface not less than 20 ft. wide, with a grade not in excess of 5 per cent. Planking or other filling is required for a length of at least 16 ft. Where the embankment of the roadway is more than 5 ft. high, a fence 4½ ft. high is required on each side. A 10-in. board must be placed at the bottom of the fence to prevent snow from blowing off the roadway.

(3b) Over- and Undergrade Crossings

During 1917 this Committee collected information in regard to the laws of the various states, and also the practice relating to the separation of highway grade crossings and the apportionment of the cost of the work. This information was published in the Proceedings, Vol. 19, pages 633 to 653. As part of the work of the Committee this year, this matter is brought up to date.

No additional information has been received from the state of Alabama.

There have been no changes in the laws in any of the following states: Arizona, Arkansas, Connecticut, Florida, Georgia, Illinois, Iowa, Kentucky, Maine, Maryland, Minnesota, Mississippi, Missouri, New Jersey, North Carolina, North Dakota, Rhode Island, Tennessee, Texas, Vermont, West Virginia and Wyoming.

In the following states changes have been made in the laws, new laws have been passed, or the information is re-stated in more complete form:

California.—The Public Utilities Act of 1912 as amended in 1917 and 1919 gives to the Railroad Commission the exclusive power to order construction, alteration, separation, relocation, abolition, etc., of grade crossings and to apportion the expense or divide the work among the interested parties. The Commission has power also to fix the compensation for any properties taken for such improvement being carried out under its order, or damaged by reason of the improvement, or during its construction. In case any of the parties to an apportionment do not make payment to other parties to the apportionment in the manner directed by the Commission, the aggrieved party has the right to sue therefor in any court of competent jurisdiction.

Delaware.—At the present time there are only a few grade crossings in this state over the state highway and the railroad and the State Highway Department have reached an agreement as to the elimination of these crossings. Delaware has no railroad or Public Utility Commission. The Public Utility law of 1911 applies only to the city of Wilmington.

Idaho.—Section 2464 of the Compiled Statutes of Idaho provides that the Public Utilities Commission may order protection of grade crossings by flagmen, bells, gates, or other suitable device, but the Commission has not passed upon this section to determine whether or not, under these provisions, the Commission may order a separation of grades.

Section 4808 gives railroads broad powers in taking land necessary for grade crossing elimination work.

In Pocatello, the railroads have borne all the cost of the work, including consequential damages. The cost of removing and replacing paving, walks, etc., has been borne by the abutting property owners, except that portion located on or over carriers' tracks and right-of-way.

Indiana.—Secretary of the Public Service Commission advised in 1917 as follows: "There is a specific law granting control of separation of grades to the Public Service Commission of Indiana. There has been no decision of the Supreme Court of Indiana on this law. Chapter 75 of the Acts of 1915 provide certain powers to cities having a population of 20,000. The expense is fixed or apportioned by law, the railway companies bearing 75 per cent, the state nothing, the county 25 per cent and the municipality and public service corporations nothing."

The Attorney-General now advises: "The Act of 1919, p. 119, provides that in constructing highways, the State Highway Commission may separate the grades where a highway outside of cities and towns crosses or intersects railroad, or it may require the Public Service Commission to act.

"When any separation of grades is made, either by agreement or by order, the State Highway Commission shall pay one-half of the total expense of such separation and treat the same as a part of the cost of such highway, the other one-half to be paid by the railroad whose tracks are involved in such separation."

"After the separation is accomplished the State Highway Commission is to maintain the highway and the structures supporting it and the Railroad Company is to maintain its roadway and track and the structures supporting the same."

In Indianapolis the Railway Company paid 75 per cent of the expense of grade elimination, the Street Railway and City 25 per cent.

In Fort Wayne the Street Railway paid 12½ per cent of the total cost of some grade separation work done by the Wabash Railroad.

KANSAS.—Section 5, Chapter 245, of Laws of Kansas of 1919, provides as follows: "That Section 18 of Chapter 264, Laws of 1917, be amended to read as follows: Section 18. That it shall be the duty of the county engineer and Board of County Commissioners, in designating the county road system, to eliminate all steam or electric road grade crossings and all other dangerous places on such highways so far as practicable, by paralleling such steam or electric roads, constructing undergrade or overhead crossings, or relocating the highways, or by the use of such other means as may be necessary to properly safeguard the traveling public. Provided, that the expense of eliminating railroad crossings shall be divided between the railroad company and the county, as the case may be, in a fair and equitable proportion, to be determined by the State Highway Commission, which shall determine the necessity for eliminating such crossing. When the elimination, protection or improvement of a railroad grade crossing, as finally determined to be necessary by the State Highway Commission, shall require the relocation, laying out, altering, widening or vacating of a highway, the Board of County Commissioners may purchase or acquire by donation any land required, and by order of said board shall cause the highway to be relocated, laid out, altered, widened or vacated, and such order of the Board of County Commissioners shall cause any land so procured to become a public highway without further action."

LOUISIANA.—The following advice is from the Secretary of the Railroad Commission of Louisiana: "This Commission has no jurisdiction in the matter of grade crossings in cities and towns, and the subject has never been agitated as to the rural communities. In any event, there is no specific act of the Legislature or article of the constitution conferring this authority on the Commission; and whatever jurisdiction it might have in the premises is only inferential."

In New Orleans two viaducts have been constructed at the joint expense of the Street Railway Company and the Railroads.

MASSACHUSETTS.—The matter presented below is more complete than given in the previous report. There has been no change in the law.

The railroad laws of Massachusetts provide for the appointment of a special commission in each case of grade crossing elimination work, whose duties shall include the apportionment of the cost among the various parties interested. The commission shall meet at once, and if it decides that the security and convenience of the public require the alterations to be made, it shall prescribe the manner and limits thereof, and shall determine which of the parties shall do the work, or shall apportion the work between each of the railroad corporations and the city or town. The railroad corporations shall pay 65 per cent of the total actual cost of the alterations including the actual cost to any street railway company of changing its railway, the cost of the hearing, the compensation of the commissioners and auditors and all damages, except as otherwise provided. The commission may, subject to a right of appeal to the superior court by the street railway company or by the commonwealth for a revision by a jury of the amount of such assessment, assess upon any street railway company made a party to the proceedings such percentage of the total cost, not exceeding 15 per cent, as may, in the judgment of the commission be just and equitable. The remainder of the total cost shall be apportioned by the commission between the commonwealth and the city or town in which the crossing is situated, and in making the apportionment the commission shall take into account the benefits to the city or town and its financial ability, and shall assess upon the city or town such percentage of the total cost, not exceeding 10 per cent as may in its judgment be just, and in case less than 10 per cent of the total cost is assessed upon the city or town, the difference between the amount so assessed and 10 per cent shall be assessed upon the railroad corporations in addition to the 65 per cent, or upon the commonwealth, or shall be apportioned between the railroad corporations and the commonwealth. The commission shall equitably apportion the 65 per cent and such additional sum as may be assessed, to be paid by the railroad corporation between the several railroads which may be parties to the proceedings. If the crossing was established after the twenty-first day of June, 1890, no part of the cost shall be charged to the commonwealth; and such part as thus becomes unapportionable shall be borne by the railroad corporation, the street railway company, if any, and the city or town, in addition to the other amounts payable by them, in such proportions as the commission shall determine.

Where a grade crossing is eliminated by agreement between the municipality and the railroad company, approved by the Department of Public Utilities, the commonwealth pays 20 per cent of the cost and the apportionment between the municipality and the company is a part of the agreement.

Michigan.—The Railroad Laws of Michigan give to the council of a municipality or corresponding governmental body of townships, counties, etc., the right to enter with railroads, railways and others interested, into agreements covering the matter of grade crossing elimination and the apportionment of the cost of such work. These agreements are subject to approval of the Railroad Commission, which body also has power to order work and apportion cost in case agreements cannot be reached by parties interested.

Under another law the State Highway Commission has jurisdiction over highways in townships and unincorporated villages, and, in conjunction with the Public Utilities Commission, may order the separation of highway grade crossings and apportion the expense between the railroads, townships, counties and state. The State Highway Commissioner, who is the custodian of all highway funds, fixes the amount to be paid by the state, which amount must not exceed 25 per cent of the total cost.

In Detroit, usually the city bears the consequential damages to abutting property, the street railway bears a part of the cost of changing its facilities; the other public service corporations bear the cost of changing their pipes, poles, wires, etc., and the railroads bear all the other expense, including paving, walks, etc.

MONTANA.—Section 7, Chapter 148, Session Laws of 1919, provides as follows:

That no railroad crossing, other than a grade crossing, shall be ordered by any board of county commissioners. The Board of Railroad Commissioners may, however, upon petition or request in writing of any board of county commissioners, order an overhead or underground crossing at any place where a railroad crossing has not been constructed and is required by the provisions of this act, provided in its judgment the safety, necessity and convenience of the traveling public require such crossing. When any such petition or request is presented, the Board of Railroad Commissioners shall fix a date for hearing the same and in the event an overhead or underground crossing is ordered, the board may, in its discretion, require the same to be constructed and maintained by, and at the expense of the railroad company, or may apportion the expense between the railroad company and the county in which the crossing is located. The part of the expense apportioned to the county, if any, shall be paid to the railroad company from the funds of said county properly applicable to the payment of such expense.

NEBRASKA.—The laws of Nebraska contain numerous and contradictory statutes regarding the matter of grade crossings and the State Railway Commission is not sure that the courts would sustain the commission in assuming all authority over grade crossings.

There is no provision for division of expense in grade separation work and carriers, as a rule, bear all expense.

NEVADA.—Sec. 18A, Chapter 109, of 1919 Statutes, reads as follows:

"After hearing and investigation of a formal complaint or complaints by the state highway department or the county commissioners of any county, or the town board or council of any town or municipality, or by any railroad company, the commission shall have the power to determine and order for the safety of the traveling public the elimination, alteration, addition or change of a highway crossing or crossings over any railroad at grade, or above or below grade, including its approaches and surface; changes in the method of crossing at grade, or above or below grade; the closing of a crossing and the substitution of another therefor; the removal of obstructions to the public view in approaching such crossing or crossings; and such other details of construction and operation as may be necessary to make grade-crossing elimination, changes and betterments for the protection of the public and the prevention of accidents effective; and in this behalf the commission is hereby authorized and empowered to determine and order that the cost of such elimination, removal, change, alteration or betterment as may be ordered shall be divided and paid in such proportion by the state, county, town or municipality and the railroad or railroads interested as shall be designated by the commission."

New Hampshire.—There has been no change in the law. Some additional information has been obtained and the report revised to comply with it.

The Board of Railroad Commissioners, upon petition of a railroad company, may authorize it to raise or lower a highway where it is crossed by the railroad, for the purpose of separating the grades of the two roads, or to change the location of the highway.

A town may, by vote, require a railroad company to raise or lower a highway where it is crossed by the railroad, or to erect and maintain gates across the highway, or to station a flagman there.

If the railroad company does not comply with such vote to the satisfaction of the selectmen of the town within six months after receiving a copy of it, the company shall forfeit one hundred dollars for each month's neglect, unless it shall make application to the Board of Railroad Commissioners, as provided in the following paragraph.

The railroad company may, within sixty days after receiving a copy of the vote, apply by petition to the Board of Railroad Commissioners for an examination of the crossing and a decision as to whether the public good requires the change proposed, or any other change, to be made; and the commissioners shall make such order as they adjudge the public good requires; and if the company does not comply with such order, it may be fined not exceeding one thousand dollars. (See Public Statutes, Chap. 159, Sec.s 13-18.)

There is no provision regarding division of expense. If the Commission orders elimination, it is presumed by the Commission that the railroad will bear the expense unless the municipality and the railroad enter into a voluntary agreement for the apportionment.

New York.—There has been no change in the law, but Secretary of the Public Service Commission has submitted a revised statement. Some additional information is given pertaining to methods followed at Buffalo.

Sections 89, 90, 91, 92, 95, 97 and 99 of Chapter 481, Section 93 of Chapter 484 and Section 94 of Chapter 240 provide that upon petition from municipalities the Commission may order separation of grades on the following basis of expense:

Where new railroads are constructed across existing streets, railroads bear 100 per cent.

Where new highway is constructed across existing railroads, railroads bear 50 per cent and municipalities 50 per cent.

Where changes are made in an existing highway or structure other than a state or county highway, the municipality pays 25 per cent, the state 25 per cent, and the railroad 50 per cent; provided that in case the municipal corporation is a village having less than 1,200 inhabitants, the share of the village must be paid by the town in which it is located. If the highway is a state highway, the cost is divided equally between the state and the railroad, in the case of a county highway, 50 per cent is paid by the railroad and 50 per cent by the state, county and town, the amount payable by each being determined in accordance with the manner in which each shared in the original cost of the highway.

Section 95 of the railroad law gives the Public Service Commission power to institute proceedings looking toward the change in an existing crossing whenever, in its judgment, public safety requires that a change shall be made.

Any person aggrieved by a determination of the Commission may appeal to the Appellate Division of the Supreme Court within 60 days and later to the Court of Appeals, if necessary. Appropriations of funds for the use of the Public Service Commission are made by the Legislature in accordance with requests from the Commission when the Legislature deems them to be necessary.

Consequential damages, expense of changing sewers, water pipes, etc., are included in joint account and distributed on proper percentages. Public service corporations bear expense of their own facilities affected. The maintenance of existing structures is on the basis of: overhead highway, framework and abutment by railroad, railroad approaches by municipalities, under grade crossings, bridge abutments by railroads, subway and approaches by municipalities.

The cities of Buffalo, Syracuse and Niagara Falls have special laws.

Buffalo.—Where new streets are laid out across railroads the Department of Public Works petitions the State Public Service Commission, which orders manner and method of crossing, expense being borne 50 per cent by railroad and 50 per cent by city. Expense generally includes paving across railroad's right-of-way.

Elimination of existing streets named in the law governing the Grade Crossing Commission of the city of Buffalo is subject to contract made between the commission and the railroads for each crossing eliminated. The division of cost is also subject to contract, but in the main runs about as follows:

All work within the street lines, including the abutments supporting the railroad bridges, divided city, 35 per cent; railroads, 65 per cent.

All work on the right-of-way of the railroad companies paid for 100 per cent by the railroad.

All land and consequential damages divided city, 45 per cent; railroads, 55 per cent.

Syracuse.—City may order elimination of crossings subject to approval of Public Service Commission, expense being borne 50 per cent by railroad, 25 per cent by city and 25 per cent by state; expense includes all changes.

Niagara Falls.—No information available.

OHIO.—The Public Utilities Commission of Ohio has no jurisdiction in the matter of grade crossing elimination. The power to deal with matters of this nature is vested in municipalities.

Section 8883 of the general code, which was amended May 10, 1910, reads as follows:

"The cost of constructing the improvement authorized, including the making of ways, crossings of viaducts, above or below the railroad tracks, and the raising or lowering of the grades of the railroad tracks and side tracks for such distance as may be required by such municipality and made necessary by such improvement, together with the cost of land or property purchased or appropriated and damages to owners of abutting property or other property, shall be borne 35 per cent by the municipality and 65 per cent by such railroad company or companies. The municipality shall have a right of action against any such railroad company for the recovery of the 65 per cent and such costs payable by it with interest from the time they become due. Such municipality and railroad company may agree as to what part of the work shall be done by the railroad and also fix the amount to be allowed or credited to the company for doing the work. Such railroad company shall be entitled to deduct from its 65 per cent of the cost of the improvement the expense incurred by it in the change of grade required by the municipality or made necessary by it under such specifications, but only in case the amount of expense has been agreed upon in writing between the municipality and the railroad company. If the amount of work done by the company, or made necessary by reason of such change of grade on lowering or raising its tracks, exceeds 65 per cent of the cost of the improvement then it shall have the right to recover the amount with interest in excess of 65 per cent of the expenses in an action at law against the municipality.

There is another provision for the elimination of grade crossings by agreement between municipalities or counties on one side and the railroad companies on the other, whereby the railroad companies shall pay not less than 65 per cent and the municipality or county not more than 35 per cent of such cost; within these limits the apportionment may be fixed by agreement hereinbefore provided for. The foregoing quotation is from Section 8868, General Code.

OKLAHOMA.—Section 2, Chapter 53 of Acts of 1919, provides: "For overgrade or undergrade public highway crossings over or under steam or electric railroad or railway, the assignment of cost and maintenance shall be left to the discretion of the Corporation Commission, but in no event shall the city, town or municipality be assessed with more than 50 per cent of the actual cost of such overgrade or undergrade crossings."

OREGON.—Sec. 4811, laws of 1917, provides: "The Commission shall have the exclusive power, . . . to require . . . a separation of grades at any such crossing . . . and to prescribe the terms upon which such separation shall be made and the proportions in which the expense of alteration or abolition of such crossings or the separation of such grades shall be divided between the railroad or street railroad corporations affected, or between such corporations and the state, county, municipality or other public authority in interest."

PENNSYLVANIA.—Prior to 1914 cities and towns were authorized by an act of June 9, 1874, to enter into contracts with railroad companies for the elimination of grade crossings. The city of Philadelphia, under this act, has an agreement with the various railroad companies for work involving an expenditure of $25,000,000, of which the city is to assume about one-half. Under the Public Service Commission law, effective January 1, 1914, the Commission has exclusive power over the manner of crossing of highway and railways. In the case of existing grade crossings it may order such changes as it deems necessary, including separation, either upon complaint or of its own motion, and may apportion the cost including consequential damages between the railroad, the city and the state.

In 1917 additional legislation was passed to enable the Commission to lay out new highways or abandon existing highways in boroughs and townships. Its purpose was to reduce the number of grade crossings. An appropriation of $200,000 was made to take care of the state's portion of the expense of projects during 1917 and 1918 and a limit of 25 per cent fixed by the state's share of any one project. A similar amount was made available by later legislation for the years 1919 and 1920 and the limit on the state's portion of the cost raised to 33⅓ per cent.

SOUTH CAROLINA.—The Legislature in 1920 amended the Act of 1915, regulating grade crossings, to provide that railroad companies share in the expense of reconstructing or relocating any highway appurtenant to the elimination of a grade crossing. Section 1 of the amended statute provides as follows:

"The Railroad Commission is given full authority to provide such rules and regulations with reference to the crossing of railroad tracks by public highways as in its judgment will be conducive to the public safety, and furthermore, upon complaint shall investigate and may require that any necessary crossings be made either above or below grade so as to avoid, as far as possible, any grade crossings. Provided, that if the Commission shall decide that such a crossing should be eliminated or relocated, it will be authorized and directed to apportion, assess and require the payment by such railroad company of its pro rata share of the expense incident to the construction and grading of any highway or road appurtenant to such elimination or relocation. Provided, further, that the cost to be assessed against such railroad company shall not exceed its pro rata share for more than one-fourth of one mile. Provided, further, that in case of railroads independently operated, having less than 80 miles of road within this state, the cost to be assessed against such railroad shall be such equitable proportion of the expense incident to grading and constructing such appurtenant highway or road as the Commission may determine, not exceeding its pro rata share for more than one-eighth of a mile. And provided, further, that such crossings as are eliminated by virtue of this section shall be closed as public highways or travel places."

In 1917 the Atlantic Coast Line entered into an agreement with the city of Florence for the construction of an underpass in an existing street. The city agreed to pay for grading, paving and drainage and the railroad company assumed the remaining cost.

South Dakota.—An Act passed by Legislature (Chapter 126), approved March 2, 1909, empowers the Mayors and Councils or Board of Commissioners to require by ordinance railroad companies to erect, construct, reconstruct, complete and keep in repair any viaduct or viaducts upon or along such street or streets and over or under such track or tracks, including the approaches of such viaduct or viaducts as may be deemed and declared necessary for the safety and protection of the public, subject to the reversal by the Board of Railroad Commissioners. The act empowers the Mayor and Council or Board of Commissioners to apportion the expense as between two or more railroads, but also provides that the city shall pay the consequential damages.

Sections 62 and 63 of Senate Bill 220, known as the Horsfall Road Law, approved March 14, 1919, provides as follows:

"It shall be the duty of the Highway Commission and Board of County Commissioners in designating the State Trunk and County Highway Systems to eliminate all railroad grade crossings and all other dangerous places on such highways so far as practicable either by paralleling the railroad or by constructing undergrade or overhead crossings, or relocating the highways or by such other means as may be necessary to properly safeguard the traveling public; provided, that the expense of eliminating railroad crossings shall be divided between the railroad company and the state or counties in a fair and equitable proportion. The Board of Railroad Commissioners of South Dakota and the Highway Commission shall determine the necessity for eliminating such dangerous crossings. If lands are appropriated for the relocation of any state or county highway, which relocation is deemed necessary to avoid one or more railroad crossings or other dangerous places, the railroad shall pay one-half of the total cost of construction of the improvement, including the necessary lands. In the building of a subway or overhead crossing on a state or county highway when no right-of-way is needed the railroad company must pay for all of such improvement within the right-of-way and provide for the necessary drainage.

"The state or county shall do the necessary grading approaching and leading from such overhead or subway undercrossing.

"In the building of a subway or overhead crossing on a state or county highway when new right-of-way is necessary, the right-of-way must be obtained by the Board of County Commissioners either by consent of the owners, or by condemnation. The railroad company must pay for all such improvement within the lines of right-of-way and provide proper drainage. The state or county shall pay for the right-of-way and necessary grading approaching and leading from such overhead crossing or subway under-crossing. The clearance or overhead room of any subway or undercrossing shall not be less than 15 ft. The width or clear roadway shall not be less than 24 ft. The approaches shall be straight and under no circumstances shall these crossings contain curves.

"If the Highway Commission shall find it impossible to deal by agreement with the companies concerned for a proper distribution and payment of the cost of the work, the Highway Commission shall formally lay before the Board of Railroad Commissioners of South Dakota all the facts in the case, and the Board shall by order apportion the cost which is to be paid by the company or companies concerned and the cost to be paid by the Highway Commission or Boards of County Commissioners."

UTAH.—The Public Utilities Act of 1917, Section 4811, provides as follows:

"No track or any railroad shall be constructed across a public road, highway, or street at grade without having first secured the permission of the Commission. The Commission shall have the right to refuse its permission or to grant it upon such terms and conditions as it may prescribe.

"The Commission shall have the exclusive power to determine and prescribe the manner, including the particular point of crossing, and the terms of installation, operation, maintenance, use and protection of each crossing of a public road or highway by a railroad or vice versa, and to alter or abolish any such crossing, and to require a separation of grades at any such crossing heretofore or hereafter established and to prescribe the terms upon which such separation shall be made and the proportions in which the expense shall be divided between the railroad corporations and the state, county, municipality or other public authority in interest.

"Whenever the Commission shall find that public convenience and necessity demands the establishment, creation or construction of a crossing of a street or highway over, under or upon the tracks or lines of any public utility, the Commission may, by order, require the establishment of such crossing."

VIRGINIA.—County boards, or city or town authorities, may petition a railroad company for the separation of grades. If the work is not started in 60 days, they may appeal to the State Corporation Commission, which after hearing will make a decision and in case of disagreement may prescribe the character of the work.

That part of Section 3974 of the 1919 Code, relating to the distribution of expense, provides as follows:

"When such improvement is to be made in any railroad, it shall be made by the corporation operating the same, and the whole expense thereof shall be paid by such corporation. When it is to be made in a county road, street or other highway, it shall be made by the corporation whose track is to be crossed and the expense shall be borne equally by said corporation and by the county, city or town having control of such county road, street or other highway. Provided, that whenever an existing crossing of a highway by a railroad or of a railroad by a highway, at grade, constructed since June 13, 1904, or hereafter constructed becomes, in the opinion of the board of supervisors of any county or the proper authorities of a city or town, a menace to the public safety, or the elimination of such crossing becomes necessary for the improvement of the highway, and the costs thereof, and by whom and in what proportion paid cannot be agreed on, the same shall be fixed and determined by the State Corporation Commission in conformity with the principles of law and equity.

"After said crossing has been constructed, the corporation whose track or work is crossed shall maintain the same."

Washington.—The Public Service Commission has jurisdiction over the elimination of grade crossings in all parts of the state, except within the limits of cities of more than 20,000 population. Under the law, it has power to apportion the cost to be borne by the interested parties, but orders in such cases, like other orders of the Commission, are subject to review in the court.

Municipalities have jurisdiction and power to order separation or elimination of grade crossings within corporate limits. The practice varies from 50 per cent to railroads and 50 per cent to municipalities to 100 per cent of expense to railroads, with exception of consequential damages, which has been borne by municipalities.

Wisconsin.—The Railroad Commission of Wisconsin has authority, whenever a petition is lodged with it by the common council of any city, the village board of any village, the town board of any town within which the crossing is located, or whenever it is so lodged by any railroad company, after notice and hearing, to reach a determination as to alterations of such grade crossings, or substitution of another crossing at grade, etc., and the Commission has the authority to fix the proportion of the cost and expense of such alterations or removals to be paid by the railroad companies. Whenever such project is part of a road improvement, being carried out under joint funds, either state or federal, the Commission may apportion the municipalities' share to be paid out of joint funds. In the case of the improvement of an existing highway or the construction of a new highway which results in the elimination of an existing highway, the Commission, after hearing, may assess a railroad company a portion of the expense if it finds that the railroad company is benefited. Where such improvement is being carried out under joint funds the joint fund shall be credited the amount of such assessment.

Another provision authorizes the Commission to take the initiative when in its opinion public safety requires an alteration of any street or crossing at grade by any railroad.

In regard to the practice as to the distribution of the cost of grade separation, the cost of grade separation is not shared by the state, other than as outlined above, except that the state bears the cost of investigation, plans and reports. The cost is assessed to the railroad companies and the municipality, town or village. The proposition assessable to each of the parties in interest is not fixed by law. It has been the practice of the Railroad Commission of Wisconsin to assess a certain percentage of the total cost of grade separation to each of the parties in interest. The percentage has been varied to conform with changes and conditions found to exist in different cases. Again, the Commission has apportioned the cost of grade separation by outlining the work to be performed by each of the parties in interest. Street and electric railways having locations upon highway crossings which are eliminated are required to bear part of the cost of grade separation.

Canada.—The Board of Railroad Commissioners of Canada has very wide powers and can order the separation of grades at highway crossings or take such other action in the interest of the public as it deems expedient.

By Act of Parliament there is available to the Board the sum of $200,000 per year for a period of ten years from April 1, 1919, for aiding in actual construction work, for the protection, safety and convenience of the public at highway grade crossings. The section of the Act relating to the apportionment of the fund is as follows:

"The total amount of money to be apportioned and directed and ordered by the Board to be payable from any such annual appropriation shall not be in the case of any one crossing exceed 25 per cent of the cost of the actual construction work in providing such protection, safety and convenience, and shall not, in any such case, exceed the sum of fifteen thousand dollars, and no such money shall in any one year be applied to more than six crossings on any one railway in any one municipality or more than once in any one year to any one crossing."

The division of expense in a few cases which have come to the attention of the Committee has been about as follows:

Railroad	35% to 50%
Municipalities	35% to 40%
Government Grade Crossing Fund	15% to 25%

Elimination of Grade Crossings

The Committee on Roadway, as a part of its work during 1907, prepared a bibliography on "Track Elevation and Depression in Cities," covering the years from about 1892 to 1907. This appeared in the Proceedings, Vol. IX, page 613.

The bibliography presented herewith was prepared by the Engineering Societies Library and covers the years 1915 to 1920. It is intended to include articles pertaining to the broader aspects of the grade separation problem, with particular reference to the apportionment of the cost, rather than detailed descriptions of individual projects. It will be noted that in addition to the references to periodicals there are a number to court decisions and the orders of Public Utility Commissions and that there is a brief synopsis with each reference.

BIBLIOGRAPHY

1915—Assessing costs of railway grade crossing removal (editorial). 1915. (In Engineering News, v. 74, p. 370.)

On division of costs in grade elimination; very brief.

Bainbridge, C. N.

Study of grade crossing elimination in cities. 1915. (In Journal, Western Society of Engineers, v. 20, p. 628-70.)

The general features which will arise, and which must be considered by the engineer in studying a problem of grade crossing elimination, in order to determine the most desirable and feasible method to accomplish the end desired at the minimum erpense; includes discussion of apportioning of expenses and advantages and disadvantages of elimination of grade crossings.

Abstract. 1915. (In Railway Age Gazette, v. 59, p. 45-48.)

Editorial. Public and grade separation. 1915. (In Railway Age Gazette, v. 59, p. 41-42.)

Bainbridge, C. N.

Track depression project at Minneapolis. 1915. (In Railway Age Gazette, v. 59, pp. 1059-63.)

The industrial concerns maintained that the railway company was liable for the cost of all changes to industries and industry tracks made necessary to continue service on the lower level after the main tracks had been depressed.

Chief engineers discuss grade-crossing law and cost distribution. 1915. (In Engineering Record, v. 71, pp. 455-56.)

Agree as to importance of subject and fairness of public participation in expense; one doubts desirability of uniform law.

Eliminating railway grade crossing crossings in Los Angeles. 1915. (In Engineering News, v. 74, p. 355.)

On the arrangement of viaducts in the industrial district of Los Angeles; very brief.

1915—Elimination of grade crossings in Dallas, Texas; report. 1915. (In Railway Age Gazette, v. 59, pp. 1087-88.)

A report on the situation in that city favors a belt line as a better solution than track elevation.

Editorial. A substitute for grade separation. 1915. (In Railway Age Gazette, v. 59, pp. 1077-78.)

Factors in grade separation. 1915. (In Engineering News, v. 73, pp. 422-23.) Grade separation problems of the city of Houston, Texas.

Grade crossing elimination (editorial). 1915. (In Railway Age Gazette, v. 59, pp. 634-35.)

On the economy of grade crossing elimination in Chicago and advantages elsewhere.

Grade crossing elimination in North Toronto, Ontario. 1915. (In Railway Age Gazette, v. 59, pp. 555-58.)

Includes data on apportionment of cost of improvement.

Reilly, L. B.

Elimination of grade crossings; apportionment of cost; manner of obtaining elimination construction. 1915. (In Journal of the Boston Society of Civil Engineers, v. 2, pp. 135-48.)

The subject is treated under the following headings; apportionment of cost; manner of obtaining elimination; construction.

Rock Island track elevation work at Chicago. 1915. (In Railway Age Gazette, v. 58, pp. 690-94.)

Detailed cost records of this work were unusually important on account of the division of expense between the roads, and in order to make the cost data of immediate value in directing operations a system was developed by which the books could be closed every night.

Smith, C. E.

Needless grade separation required of railroads. 1915. (In Engineering Record, v. 71, p. 674.)

Engineer of the Missouri Pacific Railway discusses grade-crossing law; deplores unreasonable demand by the communities.

Stark, C. W.

Grade-crossing law and its effect on grade crossing elimination. 1915. (In Engineering Record, v. 71, pp. 327-29.)

Town and State should share expense; fixed percentage basis on entire work conducive to best solution of most separation problems. Table showing division of expense in the ten states that have fixed proportions.

Editorial. Chaos in apportioning the cost of grade-crossing elimination. 1915. (In Engineering Record, v. 71, p. 319.)

To promote safety at highway crossings (editorial). 1915. (In Railway Age Gazette, v. 59, pp. 1119-20.)

The standard remedy of the public authorities for crossing accidents is elevation or depression of the tracks—if the railroads can be made to stand the expense. If there is a chance that the community may be required to share the cost of an improvement made for its benefit, the zeal of the public officials for grade separation frequently wanes.

1915—Track elevation on the Nickel Plate Railroad at Chicago. 1915. (In Engineering News, v. 74, pp. 888-91.)

Conditions necessitated abandoning the original line and building an elevated line on a new location, the line has to rise to cross one railway, then descend to pass under two railways and then rise again to connect with one of the latter.

Wonson, S. L.

Elimination of the Tower Grove crossings, St. Louis. Mo. 1915. (In Journal, Association of Engineering Societies, v. 55, pp. 95-115.)

The elimination ordinance provided that the construction cost, including the relocation of municipal sewers and water mains, should be assumed by the railways and the damages to abutting property by the city.

Abstracts. 1915. (In Railway Age Gazette, v. 59, pp. 799-802; Engineering Record, v. 72, pp. 627-29.)

1916—Extensive grade separation at Spokane, Wash. 1916. (In Railway Age Gazette, v. 60, pp. 949-52.)

The Northern Pacific is raising its tracks and terminals to eliminate numerous street crossings; an ordinance requires the railway to elevate its tracks in the business district and to provide suitable bridges over each street for a distance of two miles. It requires privately owned public utility companies to make such utilities conform to any changes made in the streets at their own expense. All other costs of the work including damages to property abutting on changed street grades and the expense of readjusting or rebuilding municipally owned public utilities are to be borne entirely by the railway.

Grade crossing elimination at Cleveland. 1916. (In Railway Age Gazette, v. 60, pp. 1335-37.)

The New York, Chicago & St. Louis will depress its tracks for a distance of 2½ miles by a novel method; as this work has been undertaken at the request of the city, 35 per cent. of the expense under the Ohio law, will be borne by the city and 65 per cent. by the railroad.

Grade crossing elimination in Camden, N. J. 1916. (In Railway Age Gazette, v. 61, pp. 69-72.)

This project involves 100,000 cu. yd. of embankment, 25,000 cu. yd. of concrete and 1830 tons of structural steel. The total cost is about $700,000, all of which is borne by the Pennsylvania Railroad except $13,000, or one-half of the cost of the bridges at Sycamore Street and Whitman Street, which are required to be built by the City of Camden after the passage of the original ordinance, under the terms of which additional bridges, when required, were to be paid for jointly by the railroad company and the city.

Improvements at Pawtucket and Central Falls, R. I. 1916. (In Railway Age Gazette, v. 60, pp. 13-17.)

It has been provided by legislation that each city should pay 35 per cent. of the actual cost of eliminating grade crossings with the tracks then existing and that the railroad should pay the remaining 65 per cent. of this cost and should also pay all additional cost resulting from increasing the number of tracks over and above the number previously existing.

Pennsylvania Railroad's improvements at Wilkinsburg, Pa. 1916. (In Railway Review, v. 59, pp. 335-37.)

The Wilkinsburg improvements as a whole involved an expenditure of $3,050,000, of which $2,750,000 was spent by the railroad and $300,000 was contributed by the city. About $1,000,000 of the cost of the railroad was in new property acquired.

1916—Selmer, W. L.

Eliminating a group of nine grade crossings on the Long Island Railroad. 1916. (In Railway Review, v. 58, pp. 536-43.)

Under the railroad law of New York State the Public Service Commission has power to order the elimination of crossings at grade on existing railroads. The cost of such elimination is divided between the state, the city and the railroad, in the proportion of one-fourth each by the city and the state and the one-half by the company.

Trite but still true (editorial). 1916. (In Engineering Record, v. 74, p. 697.)

Points out briefly, that under the national percentage basis of the New York law a comparatively satisfactory program of grade separation is being carried out, in spite of defects in the law and mistakes of administration.

1917—Elevation vs. depression, and track change vs. street change. 1917. (In Engineering News, v. 78, pp. 129-30.)

A.R.E.A. Committee discusses advantages and disadvantages of four main forms of grade separation.

Grade separation problem at Syracuse; Arnold report advocates track elevation for the Lackawanna and depression of the New York Central. 1917. (In Railway Age Gazette, v. 62, pp. 774-76.)

Arnold report advocates track elevation for the Lackawanna and depression of the New York Central.

Wagner, S. T.

Elimination of grade crossings in cities. 1917. (In Journal of the Franklin Institute, v. 184, pp. 715-16.)

A brief summary, giving six methods by which a grade crossing can be abolished.

Would depress New York Central and elevate Lackawanna through Syracuse. 1917. (In Engineering News, v. 78, pp. 402-405.)

Recommendations in report by Bion J. Arnold.

Editorial. Grade-crossing problem at Syracuse. 1917. In Engineering News, v. 78, pp. 417.)

1918—Divide cost five ways on Alton (Ill.) grade separation. 1918. (In Engineering News, v. 80, pp. 651-52.)

Extension of electric line necessitates alteration; five parties share expense.

Odell, R. F.

Grade crossing elimination at Passaic, N. J. 1918. (In Municipal Journal, v. 44, pp. 341-42.)

Gives outline of ordinances and contract apportioning cost of grade crossing elimination.

Watson, M. W.

Eliminating railway grade crossings. 1918. (In Railway Review, v. 63, pp. 880-881.)

Considerations in the layout of subways, overhead bridges and relocation of highways.

1919—Abolition of grade crossing with highways. 1919. (In Railway Review, v. 64, p. 945.)

On the economy and safety of human life in elimination of grade crossings of railroads.

Committee analyzes track-elevation costs on Rock Island work in Chicago. 1919. (In Engineering News, v. 82, pp. 83-85.)

Book figures are redistributed, freight charges and other elements of expense estimated and added in, to obtain complete unit costs for fifty items on $2,700,000 improvement.

Detroit plans comprehensive scheme for grade crossing removal. 1919. (In Engineering News-Record, v. 82, pp. 511-513.)

City engineers study problem as a whole; apportionment of cost of grade separation.

Editorial. Grade-crossing problems demand coöperation. 1919. (In Engineering News-Record, v. 82, pp. 501-502.)

General problems and aspects of grade separation. 1919. (In Engineering and Contracting, v. 51, pp. 381-84.)

A study of the general and special problems with which the city of Detroit is confronted as it looks forward to an extensive program of construction; including grade separation and city planning, new elements in street traffic, interests of public and railways, grade separation by depression or elevation of street, changing the railroad, separation by changing grade of both street and railroad.

Golinkin, A. L.

Civic and engineering features of grade crossing elimination. 1919. (In Municipal Engineering, v. 57, pp. 61-63.)

On engineering treatment of grade crossing elimination; a general article.

Grade-crossing elimination at Indianapolis. 1919. (In Engineering News, v. 83, pp. 266-67.)

History of grade crossing elimination reviewed; ordinance in regard to the apportionment of cost.

Watson, M. W.

Summary of state laws for elimination of railroad grade crossings. 1919. (In Good Roads, N. S., v. 17, pp. 22-24.)

Summary of laws, methods of carrying on work and distribution of the cost in several states.

Same. 1919. (In Engineering and Contracting, v. 51, pp. 17-19.)

DECISIONS OF PUBLIC SERVICE COMMISSION AND SUPREME COURT

1915—Illinois Public Utilities Commission, State Public Utilities Commission ex rel. Bloomington et al. vs. Illinois Central Railroad Company et al. 1915. (In Public Utilities Reports, Annotated, 1915, Pt. F, pp. 697-714.)

The cost of constructing a subway for the abolition of grade crossings in city streets, excluding changes in grade of railroad tracks and changes in street car tracks outside the subway areas, was apportioned 87½ per cent. to the railroad and 12½ per cent. to the street railway, after deducting the expense of changes in gas pipes, water pipes, sewer pipes, and other appurtenances required to be made at the sole expense of the city or gas utility; all other expenses were required to be borne by the company doing the work; and the city was required to assume the payment of all property damages.

Illinois Supreme Court. Alton & Southern Railroad Company vs. Vandalia Railroad Company. 1915. (In Public Utilities Report, Annotated, 1915, Pt. D, pp. 941-957.)

Factors to be considered in determining the necessity for an overhead railroad crossing.

Illinois Public Utilities Commission, Pittsburgh, Cincinnati, Chicago & St. Louis Railway Company et al. vs. South Park Commissioners. 1915. (In Public Utilities Reports, Annotated, 1915, Pt. B, pp. 150-57.)

The cost unless prohibitive, should not prevent the Commission from ordering the construction of bridges spanning proposed subways, where the requirement of safety of the public is under consideration, but esthetic features should not be considered when they involve excessive and unreasonable expense.

Missouri Public Service Commission. William Murphy vs. Missouri Pacific Railway Company et al. 1915. (In Public Utilities Reports, Annotated, 1915, Pt. F, pp. 149-190.)

The abolition of a grade crossing and the construction of a subway was ordered where there was a steep ascent to the railroad right of way from the street in a rapidly growing community used by many vehicles and pedestrians and the view in both directions was obstructed. The cost of a separation of the grades at two railroad crossings in a city was divided equally between the city and the railroad companies.

New York Public Service Commission. William W. Wadsworth vs. Erie Railroad Company. 1915. (In Public Utilities Reports, Annotated, 1915, Pt. C, pp. 402-15.)

The New York Commission has jurisdiction to compel a railroad company to maintain and keep in repair an overhead bridge and approaches which constitute an established farm crossing.

North Carolina Corporation Commission. Commissioners of Harnett County vs. Atlantic Coast Line Railroad Company. 1915. (In Public Utilities Report, Annotated, 1915, Pt. A, pp. 635-36.)

The cost of constructing a steel bridge over the tracks of a railroad company to accommodate a new county road was ordered to be borne one-third by the county and two-thirds by the railroad company.

Pennsylvania Public Service Commission. In re grade crossings of Delaware, Lackawanna & Western Railroad Company. 1915. (In Public Utilities Report, Annotated, 1915, Pt. C, pp. 180-83.)

Upon ordering the abolition of certain grade crossings, the railroad company was directed to pay all costs, including compensation to adjacent property owners.

1915—Vermont Public Service Commission. Selectmen of St. Johnsbury vs. Boston & Maine Railroad. 1915. (In Public Utilities Report, Annotated, 1915, Pt. A, pp. 641-42.)

The elimination of certain grade crossings was postponed because of the financial condition of the railroad company.

Wisconsin Railroad Commission. Town of Wilton vs. Chicago & Northwestern Railway Company. 1915. (In Public Utilities Reports, Annotated, 1915, Pt. B, pp. 230-33.)

Highway changes outside of a railroad right of way, necessitated by a subway crossing, ordered by the Commission, were directed to be made at the expense of the town, it appearing that the grade of the highway would be greatly improved by the proposed alteration, and that the advantages of a subway as against an overhead bridge would accrue chiefly to the town.

1916—Cleveland, C. C. & St. L. R. Co. v. State Public Utilities Commission. 1916. (In Public Utilities Reports, Annotated, 1916, Pt. F, pp. 910.)

The mere operation of interurban cars over a railroad crossing upon tracks used by a street railway does not render the interurban company liable to pay any part of the expense of separating the grades, since such expense, in the absence of an agreement between the interurban company and the street railway company must be borne by the latter.

Colorado Public Utilities Commission. Re Colorado & Southern Railway Company et al. 1916. (In Public Utilities Reports, Annotated, 1916, Pa. F, pp. 139-49.)

The Colorado Commission in ordering the elimination of a grade crossing has no power to apportion to the county or municipality any part of the expense.

Illinois Public Utilities Commission. City of Peoria v. Chicago, Burlington & Quincy Railroad Company et al. 1916. (In Public Utilities Reports, Annotataed, 1916, Pt. A, pp. 493-506.)

Apportionment of cost of viaduct for separation of grades, between the city, street railway using the viaduct and the steam railroad.

Illinois Public Utilities Commission. Illinois Central Railroad v. City of Decatur et al. 1916. (In Public Utilities Reports, Annotated, 1916, Pt. A, pp. 987-991.)

Neither the county nor the township is a party in interest in proceedings to apportion the cost of abolishing a grade crossing wholly within the corporate limits of a city under the Illinois statutes, and no part of such cost can be apportioned to either merely because they may have a general interest in the safety of the crossing.

Massachusetts Public Service Commission. Re selectmen of Winchester. 1916. (In Public Utilities Reports, Annotated, 1916, Pt. F, pp. 384-89.)

Petition alleging that a railroad bridge impedes and obstructs the safe and convenient use of a highway, being of insufficient height for the passage of vehicles under the bridge, etc.

Missouri Public Service Commission. Charles E. Knepp et al. v. United Railways Company of St. Louis, 1916. (In Public Utilities Reports, Annotated, 1916, Pt. E, pp. 56-100.)

Includes decisions by various Commissions on the elimination of grade crossings, division of costs, etc.

Vermont Supreme Court. J. M. Sayers v. Montpelier & Wells

River Railroad. 1916. (In Public Utilities Reports, Annotated, 1916, pp. 508-19.)

Proceedings growing out of the elimination of two grade crossings on the lines of the Montpelier & Wells River Railroad in the town of Newbury.

1916—Wisconsin Supreme Court. City of Milwaukee v. Railroad Commission of Wisconsin. 1916. (In Public Utilities Reports, Annotated, 1916, Pt. C, pp. 592-95.)

Apportionment of cost for separation of grade crossings.

1917—California Railroad Commission. Municipal League v. Southern Pacific Company et al. 1917. (In Public Utilities Reports, Annotated, 1917, Pt. A, pp. 486-520.)

Relates to the elimination of grade crossings in Los Angeles.

California Supreme Court. City of San José v. Railroad Commission et al. 1917. (In Public Utilities Reports, Annotated, 1917, Pt. E, pp. 689-97.)

Division of costs in elimination of grade crossings.

California Supreme Court. Civic Center Association of Los Angeles et al. v. Railroad Commission of California. 1917. (In Public Utilities Reports, Annotated, 1917, Pt. E, pp. 697-709.)

Relates to abolishing grade crossings in Los Angeles.

Establishment of subways and viaduct crossings; elimination of grade crossings. 1917. (In Public Utilities Reports, Annotated, 1917, Pt. A, pp. 1062-69.)

Citation of cases.

Iowa Board of Railroad Commissioners. Richard Rossman v. Interurban Railway Company. 1917. (In Public Utilities Reports, Annotated, 1917, Pt. A, pp. 234-37.)

An interurban railway may be required to substitute a viaduct for a grade crossing which has become more dangerous through the advent of automobiles, although the crossing, at the time of its construction, reasonably complied with the statute; the cost was divided equally between the railway and the county.

Missouri Public Service Commission. City of Moberly v. E. B. Pryor and E. F. Kearney, Receivers et al. 1917. (In Public Utilities Reports, Annotated, 1917, Pt. B, pp. 425-35.)

Apportionment of cost of improving a subway crossing railroad tracks.

Missouri Public Service Commission. Village of Greentop v. Wabash Railway Company, 1917. (In Public Utilities Reports, Annotated, Pt. C, pp. 42-45.)

A railroad will not be required to erect an overhead crossing for a street over tracks, where it appears that the greater part of the street has not been used by the public since the railroad was built.

New York Court of Appeals. People ex rel. Town of Scarsdale v. Public Service Commission of New York, Second District et al. 1917. (In Public Utilities Reports, Annotated, 1917, Pt. D, pp. 240-48.)

A town is not liable under the New York statutes, for any portion of the expense of building, within its limits, of the approach to a highway crossing over a railroad track where the crossing itself is wholly within another town.

New York Public Service Commission, First District. Re Long Island Railroad Company. 1917. (In Public Utilities Reports, Annotated, 1917, Pt. F, pp. 41-45.)

Division of expense of eliminating grade crossings. The expense incurred in relocating the pipes of a water company when eliminating a highway grade crossing forms no part of the crossing expense, since the public service corporations are required at their own expense to rearrange their structures in a public highway to conform with the grade as ordered.

Oregon Public Service Commission. Re location and establishment of county road. 1917. (In Public Utilities Reports, Annotated, 1917, Pt. A, pp. 88-89.)

The crossing is extremely hazardous, but the Oregon Commission has no jurisdiction over the elimination of grade crossings, although it has power to prevent the construction thereof.

1917—Pennsylvania Public Service Commission. W. F. Brice et al. v. Pennsylvania Railroad Company et al. 1917. (In Public Utilities Report, Annotated, 1917, Pt. F, pp. 547-54.)

A Commission is not justified in ordering the abolition of a grade crossing, where the municipal authorities were not made parties to the proceeding until after the testimony had been taken, and no notice was given to adjacent property owners, and no adequate plans showing the detail of the proposed improvement or the approximate cost thereof.

1918—California Railroad Commission. Re Atchison, Topeka & Santa Fe Railway Company, 1918. (In Public Utilities Reports, Annotated, 1918, Pt. E, pp. 450-51.)

On jurisdiction of Commissions over crossings, at grade or over or under the railroad.

California Railroad Commission. Re City of Palo Alto. 1918. (In Public Utilities Reports, Annotated, 1918, Pt. D, pp. 776-85.)

The California legislature may lawfully authorize the Commission to fix just compensation for the taking or damaging of private property in the separation of grades which it has ordered at a railroad crossing.

Indiana Supreme Court. Chicago, Lake Shore & South Bend Railway Company et al. v. Public Service Commission of Indiana. 1918. (In Public Utilities Reports, Annotated, 1918, Pt. B, pp. 398-401.)

The Indiana Supreme Court refused to modify an order of the Public Utilities Commission apportioning between the county and the utilities the cost of an undergrade highway crossing of parallel tracks of one steam and two interurban utilities, requiring each to pay 75 per cent of the cost of the subway under its right of way; the steam roads to construct one approach, and the interurban road together, the other.

Missouri Supreme Court, State ex rel. Missouri, Kansas & Texas Railway Company et al. v. Public Service Commission et al.; State ex rel. Wabash Railway Company v. Public Service Commission et al. 1918. (In Public Utilities Reports, Annotated, 1918, Pt. A, pp. 96-109.)

The fact that only a portion of the width of a highway was used by the public for a number of years as an underground crossing, after the abandonment of a grade crossing, does not show an abandonment of the remaining portion of the street so as to prohibit the Missouri Commission from ordering the widening of the subway and the apportionment of its cost.

Missouri Supreme Court. State ex rel. St. Joseph Railway Light, Heat & Power Company v. Public Service Commission. 1918. (In Public Utilities Reports. Annotated, 1918, Pt. B, pp. 767-74.)

Apportioning the cost of grade crossing eliminations among all of the parties in interest, including a street railway as well as city and steam railroads.

New Hampshire Public Service Commission, City of Manchester

v. Boston & Maine Railroad. 1918. (In Public Utilities Reports, Annotated, 1918, Pt. B, pp. 353-56.)

The New Hampshire Commission will not authorize a new crossing at grade where it would be so dangerous as to make adequate protection impossible; nor will it authorize a new overpass or underpass crossing at large expense, where the railroad is in financial difficulties and the Commission has refrained from ordering more important expenditures, and where other crossings demand more immediate attention, especially where the country is in a state of war, when the demands upon the railroad for transporting men, materials and supplies are stupendous.

1918—New York Public Service Commission, First District. Re New York Central Railroad Company et al. v. City of New York. 1918. (In Public Utilities Reports, Annotated, 1918, Pt. F, pp. 695-709.)

Railroad companies were relieved from complying with orders for the elimination of grade crossings and the construction of crossing improvements during war times where such construction was not necessary for the protection and development of transportation facilities to meet the needs of the country's business under war conditions, although the railroad companies alone were responsible for the noncompletion of the work before the war period.

New York Public Service Commission, Second District. Town of Harmony v. Erie Railroad Company. 1918. (In Public Utilities Reports, Annotated, 1918, Pt. E, pp. 705-710.)

On improving a grade-crossing elimination structure, apportionment of cost.

New York Supreme Court, Appellate Division, Third Department. Re State highway No. 5459. 1918. (In Public Utilities Reports, Annotated, 1918, Pt. C, pp. 590-96.)

Relates to the division of expense of the elimination of grade crossings. The New York statute fixing the procedure for an accounting between the parties liable for the expense of the establishment of a highway crossing over a railroad right of way primarily paid by the railroad company, specially providing for interest subsequent to the accounting where a railroad company or a municipality fails to pay the amount due, but making no provision for interest upon the failure of the Commission of Highways, as the State's representative, to make payment, nevertheless contemplates that the state pay interest up to the time the accounting has been actually completed, on the sum due from it to the railroad company, which has acted in good faith throughout the transaction.

Oklahoma Supreme Court. Atchison, Topeka & Santa Fe Railway Company v. Corporation Commission of State of Oklahoma et al. 1918. (In Public Utilities Reports, Annotated, 1918, Pt. C, pp. 598-611.)

Complaint that railroad does not maintain safe and suitable crossings at its tracks crossing streets in the city of Guthrie, Oklahoma, at or below grade.

Pennsylvania Supreme Court, Pittsburgh Railways Company v. City of Pittsburgh. 1918. (In Public Utilities Reports, Annotated, 1918, Pt. F, pp. 301-303.)

A preliminary injunction against the construction of a grade crossing without the consent of the Pennsylvania Public Service Commission which the court has the power to grant, should not be granted "pending final hearing and disposition of the case," but should provide for its dissolution if the certificate of public convenience is granted by the Commission; since the Commission, and not the courts, under the Public Service Company Law, has original jurisdiction of the issues involved.

Texas Court of Appeals. Jeff Bland Lumber & Building Company v. Railroad Commission of Texas. 1918. (In Public Utilities Reports, Annotated, 1918, Pt. F, pp. 709-718.)

The owner of a lumber business that would be materially affected if an order of a Commission to a railroad company to remove its tracks so as to enter a city over the tracks of other railroads should go into effect; the original order allowing the railroad to change the location of its tracks abolished two highway grade crossings which were dangerous to public welfare.

1918—Washington Supreme Court. State ex rel. Hayford et al. v. Public Service Commission. 1918. (In Public Utilities Reports, Annotated, 1918, Pt. B, pp. 605-607.)

Proceedings for the purpose of eliminating a dangerous grade crossing on the Great Northern Railway near Spokane; two plans were considered,—first, the construction of an underground crossing, necessitating but slight change in the highway but requiring considerable change in the railroad grade; second, the diversion of the highway south of the railway.

Wisconsin Supreme Court. Chicago & Northwestern Railway Company v. Railroad Commission of Wisconsin. 1918. (In Public Utilities Reports, Annotated, 1918, Pt. D, pp. 650-659.)

Decision on the question: Is the Railroad Commission empowered to wholly vacate street crossings, creating no new crossings in place thereof; can there be a valid vacation of part of a street without the assessment and payment of damages to lot owners on the street who are specially damaged by the vacation.

1919—Illinois Supreme Court. Chicago, Milwaukee & St. Paul Railway Company v. Lake County et al. 1919. (In Public Utilities Reports, Annotated, 1919, Pt. D, pp. 171-179.)

Apportionment of expense for alteration of grade crossing.

Massachusetts Public Service Commission. Re New York, New Haven & Hartford Railroad Company. 1919. (In Public Utilities Reports, Annotated, 1919, Pt. A, pp. 704-710.)

In the alteration of highway crossing a railroad, who shall bear the expense of relocating structures.

Massachusetts Public Service Commission. Selectmen of Northbridge v. New York, New Haven & Hartford Railroad Company et al. 1919. (In Public Utilities Reports, Annotated, 1919, Pt. E, pp. 408-412.)

The Massachusetts Public Service Commission has no power to determine whether the cost of repairs to a bridge over the tracks of a railroad should be borne by a municipality or by a street railway company using the bridge, since in such a case its statutory authority is limited to a determination of the manner and the limits in which the work shall be done.

Missouri Public Service Commission. Re City of Joplin. 1919. (In Public Utilities Reports, Annotated, 1919, Pt. B, pp. 842-848.)

Division of costs in the elimination of grade crossings.

Montana Board of Railroad Commissioners. City of Whitefish v. Great Northern Railway Company. 1919. (In Public Utilities Reports, Annotated, 1919, Pt. C, pp. 924-927.)

The Montana Commission has no jurisdiction over railroad crossings within the corporate limits of cities and towns. The city of Whitefish petitions that the Great Northern Railway be compelled to establish an additional crossing over its right of way.

Pennsylvania Public Service Commission. Enos H. Hess v. United

States Railroad Administration et al. 1919. (In Public Utilities Reports, Annotated, 1919, Pt. E, pp. 311-312.)

A statute giving a commission power to lay out, establish and open new highways, or to abandon or vacate highways or portions of highways, in connection with the abolition, abandonment, relocation or reconstruction of an existing grade crossing, does not authorize the construction of a new public highway and an overhead crossing in order to afford access to a school.

Pennsylvania Public Service Commission. . Re Pennsylvania Railroad Company. 1919. (In Public Utilities Reports, Annotated, 1919, Pt. E, pp. 645-47.)

Property located 1,200 feet from the railroad highway crossing, such road is not adjacent thereto so as to entitle the owner to damage resulting from inconvenience caused by the abolition of the crossing.

Virginia Supreme Court of Appeals. Southern Railway Company v. Commonwealth. 1919. (In Public Utilities Reports, Annotated, 1919, Pt. B, pp. 460-481.)

Relates to the elimination of grade crossings.

1920—Montana Board of Railroad Commissioners. Great Northern Railway Company v. Board of County Commissioners. 1920. (In Public Utilities Reports, Annotated, 1920, Pt. D, pp. 828-834.)

Discussion of procedure to be followed for procuring an overhead or underground crossing.

New York Court of Appeals. People vs. Delaware and Hudson Company. 1920. (In Public Utilities Reports, Annotated, 1920, Pt. E, pp. 106-118.)

On illegal construction of grade crossing and in regard to its elimination.

New York Service Commission, Second District. Re City of Yonkers et al. 1920. (In Public Utilities Reports, Annotated, 1920, Pt. D, pp. 373-378.)

A railroad company is entitled to interest on sums expended by it in behalf of a city in eliminating grade crossings, from the time the accounting is made until the time payment is actually made.

New York Public Service Commission, Second District. Re New York, Lackawanna & Western Railway Company et al. 1920. (In Public Utilities Reports, Annotated, 1920, Pt. D, pp. 183-186.)

Proceedings for elimination of grade crossing; claim for contribution by the state towards increased cost disallowed.

New York Supreme Court, Appellate Division, Third Department. People ex rel. New York Central Railroad Company v. Public Service Commission, Second District et al. 1920. (In Public Utilities Reports, Annotated, 1920, Pt. B, pp. 967-72.)

Decision on liability for maintenance of an overhead crossing of street over a railroad. A railroad company which applies to a commission for a modification of an overhead crossing construction order with reference to the maintenance of approaches and sidewalks, but which fails to appeal from the Commission's refusal to modify such order and completes the construction must be deemed to have accepted and be bound by the condition as to maintenance.

Wisconsin Supreme Court. Chicago, Milwaukee & St. Paul Railway Company v. City of Milwaukee. 1920. (In Public Utilities Reports, Annotated, 1920, Pt. A, pp. 821-837.)

Decision that under an order of the Railroad Commission that a city assume responsibility for damages to adjacent property resulting from the separation of street and railroad grades, the city is not liable to the railroad company for damages to railroad property, which is merely a taking by the railroad company of its own property for railroad purposes.

REPORT OF COMMITTEE III—ON TIES

F. R. Layng, *Chairman;*
W. A. Clark, *Vice-Chairman;*
W. C. Baisinger,
F. T. Beckett,
M. S. Blaiklock,
F. Boardman,
Carl Bucholtz,
W. J. Burton,
S. B. Clement,
E. L. Crugar,
L. A. Downs,
John Foley,
O. H. Frick,
G. F. Hand,
R. M. Leeds,
A. F. Maischaider,
A. J. Neafie,
G. P. Palmer,
George E. Rex,
L. J. Riegler,
Earl Sullivan,

Committee.

To the American Railway Engineering Association:

The following subjects were assigned the Committee on Ties for study and report:

1. Make critical examination of the subject-matter in the Manual, and submit definite recommendations for changes.

2. Report on methods for installing and keeping records of test sections for obtaining data on the life of cross-ties.

3. Continue study and report on the effect of design of tie plates and track spikes on the durability of cross-ties.

4. Study and report on the economics of the use of various classes of cross-ties and various kinds of preservative treatment.

5. Report on trials of substitute ties.

6. Report on the relative merits of metal versus wooden ties.

Committee Meetings

The Committee was organized for this year's work by correspondence in May, 1920, and meetings of the General Committee were held in Cleveland, July 12th, and in Toronto, Canada, November 16th, 1920.

The names of members in attendance have been given in the Minutes of the meetings, which have been printed in the Bulletin.

(1) Revision of Manual

In Appendix A proposed changes in the Manual are given.

(2) Report on Methods for Installing and Keeping Records of Test Sections for Obtaining Data on the Life of Cross-Ties

In Appendix B the Committee submits a report on this subject.

(3) Continue Study and Report on the Effect of Design of Tie Plates and Track Spikes on the Durability of Cross-Ties

The Committee reports progress on this subject but submits no report at this time.

(4) Study and Report on the Economics of the Use of Various Classes of Cross-Ties and Various Kinds of Preservative Treatment

Appendix C is a report on the above Subject.

(5) Report on Trials of Substitute Ties

Appendix D is the report on this.

(6) Report on the Relative Merits of Metal Versus Wooden Ties

A special report on this was prepared and forwarded to the Secretary, and was published in Bulletin No. 227, July, 1920.

CONCLUSIONS

1. The Committee recommends that the changes in the Manual in Appendix A be approved and the revised matter be substituted for the present recommendations in the Manual.

2. The Committee recommends that the reports in Appendices B, C and D, and the special report in Bulletin No. 227, be received as information.

Recommendations for Future Work

The Committee recommends the following subjects for next year's work.

1. Revision of the Manual.

2. Classifying ties for various kinds of service.

3. Care of ties after distribution.

4. Study and report on the results of improperly protecting ties from mechanical wear.

5. Report on the economics of the use of various classes of cross-ties and various methods of treatment.

6. Substitute ties.

Respectfully submitted,

THE COMMITTEE ON TIES,

F. R. LAYNG, *Chairman.*

Appendix A

REVISION OF MANUAL

JOHN FOLEY, *Chairman;*
M. S. BLAIKLOCK,
F. R. LAYNG,
GEO. E. REX,
Sub-Committee.

DEFINITIONS

PRESENT FORM	PROPOSED FORM
STRICT HEART TIE—A tie having no sapwood.	ALL-HEART TIE—A tie having no sapwood.
None.	BOXED-HEART TIE—An "all-heart" tie with the pith of the tree at or near the centers of the ends of the tie.
None.	HALF-MOON TIE—A tie hewed or sawed on top and bottom only, but with bottom of markedly greater width than the top. (Known also as "half-round" tie.)
HALF-ROUND TIE—A slabbed tie having greater width on lower than on upper face.	HALF-ROUND TIE—A tie hewed or sawed on top and bottom only, but with bottom of markedly greater width than the top. (Known also as "half-moon" tie.)
None.	HALVED TIE—A tie with the pith of the tree at or near the bottom of the tie, about midway between the two sides.
HEART TIE—A tie showing, on one or two corners only, sapwood which does not measure more than one inch on either corner, on lines drawn diagonally across the end of the tie.	HEART TIE—A tie with sapwood no wider than one-fourth the width of the top of the tie between 20-in. and 40-in. from the middle of the tie.
None.	HEART-AND-BACK TIE—A tie with the pith of the tree at or near the sire of the tie, about midway between the top and the bottom of the tie. (Known also as "wing" tie.)
POLE TIE—A tie made from a tree of such size that not more than one tie can be made from a section; hewd or sawed on two parallel faces.	POLE TIE—A tie made from a tree of such diameter that not more than one tie can be made from a cross-section. (Known also as "rifle" tie and "round" tie.)
QUARTERED TIE—A tie made from a tree of such size that four ties only are made from a section.	QUARTERED TIE—A tie with the pith of the tree at or near a corner of the tie.

None.	RECTANGULAR TIE—A tie hewed or sawed on top, bottom, or sides. (Known also as "pole" tie and "squared" tie.)
None.	RIFLE TIE—A tie with the pith of the tree at or near the centers of the ends of the tie. (Known also as "target" tie, and may be hewed or sawed on two or four longitudinal surfaces.)
None.	ROUND TIE—A tie with rounded sides made from a tree of such diameter that not more than one tie can be made from a cross-section. (Known also as "pole" tie and "rifle" tie.)
SAP TIE—A tie which shows more than the prescribed amount of sapwood in cross-section.	SAP TIE—A tie with sapwood wider than one-fourth the width of the top of the tie between 20-in. and 40-in. from the middle of the tie.
SLABBED TIE—A tie sawed on the faces only.	SLABBED TIE—A tie hewed or sawed on top and bottom only. (Known also as "pole" tie and "round" tie.)
SPLIT TIE—A tie made from a tree of such size that by splitting two or more ties can be made from a section.	SPLIT TIE—A tie riven out of a cross-section, which is generally of sufficient diameter to yield two or more ties.
None.	SQUARED TIE—A tie hewed or sawed on top, bottom, and sides. (Known also as "pole" tie and "rectangular" tie.)
None.	SQUARED-POLE TIE—A tie hewed or sawed on top, bottom and sides, made from a tree of such diameter that not more than one tie can be made from a cross-section. (Known also as "squared" tie; and may be "rifle" or "target" tie or "boxed-heart" tie.)
None.	TARGET TIE—A tie with the pith of the tree at or near the centers of the ends of the tie. (Known also as "rifle" tie, and may be hewed or sawed on two or four longitudinal surfaces.)
None.	TRIANGULAR TIE—A tie with three longitudinal surfaces, the widest of which is the top of the tie.

None.	Wing Tie—A tie with the pith of the tree at or near the side of the tie, about midway between the top and the bottom of the tie.
Sawed Tie—A tie having both faces and sides sawed.	Omit.
Hewed Tie—A tie hewed on at least two sides.	Omit.
Shakes—Separation of the wood fiber, due to the action of the wind.	Omit.
Checks—Small cracks in the wood due to seasoning.	Omit.
Face—The upper or lower plane surface of a tie.	Omit.

Specifications

The replies to a request for copies of the specification for cross-ties and the specification for switch-ties used by the railroads represented in the Association showed that none of them are using the specifications in the Manual.

The specifications for cross-ties which were submitted showed that a majority of the railroads which replied were adhering quite closely to a common standard.

The specifications for switch-ties which were submitted showed no uniformity of practice.

A review of the specifications received is given in the following tabulations, which record the references to manufacturing and physical requirements. The tabulations show the variety in the terminology used, the interchangeability of many of the terms, the superfluity of some of the terms, and the desirability of a standard nomenclature.

TABLE 1—SPECIFICATIONS FOR CROSS-TIES

Railway	Date of Issue	Physical Requirements: Strength	Durability	Decay	Splits	Shakes	Large or numerous holes or knots	Compact or dense wood	Sapwood restricted	Live, Growing, or Thrifty	Killed	Oblique fibre	Cross-grain	Twist	Checks	Ring-heart	Pitch-seams	Pecky	Worm-holes	Large knots	Loose knots	Soft or bad knots	Unsound knots	Rotten or decayed knots	Heartwood	Sound	Rot, Punk, or Dote	Red-heart	Ground rot or dry rot	Heart-rot	Straight or straight grained
Ala. and Vicksburg	8-12-20	x	x						x																x						
Ann Arbor	6-10-18	x	x	x	x	x	x																								
A. T. & S. F.	12-1-15	x	x	x	x	x			x	x	x		x		x	x		x	x	x	x			x	x	x	x	x	x	x	
A. B. & A.		x	x	x	x	x	x	x	x																						
A. C. L.	4-5-19	x	x	x	x	x	x	x	x																						
B. & O.	6-11-18	x	x	x	x	x	x	x	x																						
B. & Ar.	7-1-19	x	x	x	x	x	x																								
B. & L. E.	6-11-18	x	x	x	x	x	x	x	x																						
Bing. & Garfield	7-20-10	x	x		x	x				x			x				x				x			x		x					x
B. & A.	4-22-20	x	x	x	x	x	x																								
B. & M.	4-1-20	x	x	x	x	x	x		x																						
B. R. & P.	7-1-20									x									x		x			x							
B. & S.	5-1-20	x	x	x	x	x	x					x																			
B. A. & P.	5-1-20	x	x	x	x	x	x																								
Can. Nat'l.	3-18-19	x	x			x				x									x				x			x	x		x		x
C. P.	4-00-16	x	x			x				x									x				x			x	x				x
C. of Ga.	9-1-18	x	x	x	x	x	x	x	x																						
C. of N. J.	12-1-13	x				x													x					x	x					x	
C. of Vt.	4-12-20	x	x	x	x	x	x																								
C. H. & N.	2-21-19									x															x	x					
C. & O.	3-1-20	x	x	x	x	x	x			x																x					
C. & A.	3-1-20	x	x	x	x	x	x			x																x					
C. B. & Q.	7-1-20	x	x	x	x	x	x																								
C. & E. I.	7-1-14	x	x		x	x															x			x							x
C. G. W.					x	x				x					x				x			x		x		x					
C. I. & L.	6-7-20	x	x	x	x	x	x																								
C. M. & St. P.	6-11-18	x	x	x	x	x	x	x	x																x						
C. & N. W.	11-10-19	x	x	x	x	x	x	x	x																x						
C. R. I. & P.	6-11-18	x	x	x	x	x	x	x	x																x						
C. I. & W.					x	x				x														x		x	x				x
C. C. C. & St. L.	6-11-18	x	x	x	x	x	x																								
D. & H.	7-15-20	x	x	x	x	x	x		x																						
D. L. & W.	6-11-18	x	x	x	x	x	x	x	x																x						
D. & S. L.		x	x							x																					
D. T. & I.		x	x	x	x	x	x																								
D. & T. Sh. L.	9-4-20	x	x	x	x	x	x																								
D. & I. R.	10-1-19	x	x	x	x	x	x	x	x																x						
E. J. & E.	9-17-19			x	x	x				x	x				x				x			x				x					
E. P. & S. W.	6-11-18	x	x	x	x	x	x	x	x																x						
Erie	4-1-20	x	x	x	x	x	x	x	x																x						
F. E. C.	6-1-20				x	x				x	x													x	x					x	
F. S. & W.	2-24-19	x	x		x	x				x											x			x		x					x
F. W. & D. C.		x	x	x	x	x	x	x	x																x						
G. T. Pacf.				x	x	x				x												x									x
G. T. System	9-1-16	x	x		x	x		x		x					x						x			x	x	x	x				x
G. N.	3-1-20									x																x					
G. C. & S. F.		x	x	x		x				x								x			x			x				x		x	
G. & S. I.	6-11-18	x	x	x	x	x	x	x	x																x						
H. V.	6-11-18	x	x	x	x	x	x	x	x																						
I. C.	10-1-20		x	x	x	x				x					x									x		x					
I. H. B.	6-11-18	x	x	x	x	x	x	x	x																						
I. & G. N.	6-15-20	x	x	x	x	x	x		x																						
K. & M.	3-22-20	x	x	x	x	x	x																								

TABLE 1—Continued

Manufacturing Requirements																		Dimensions, Thickness and Width																							
Time of manufacture	Straight	Well	Square ends	Top and bottom parallel	Bark removed	Hewed	Sawed	Out of wind	Sawed straight in grain	Boxed heart	Wane	Square corners	Score-marks	Smooth	Spurs	Splinters	Time of delivery	6 x 6 inches	6 x 7 inches	6 x 8 inches	7 x 7 inches	7 x 8 inches	7 x 9 inches	5½ x 6 inches	5½ x 7 inches	5½ x 7½ inches	5¾ x 5½ inches	5¾ x 7 inches	5¾ x 8 inches	6 x 5 inches	6 x 5½ inches	6 x 6½ inches	6 x 7½ inches	6 x 9 inches	6½ x 7½ inches	6½ x 8½ inches	7 x 5 inches	7 x 6 inches	7 x 6½ inches	7 x 7½ inches	7 x 10 inches
	x																						x																		
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		
		x	x	x	x	x	x	x	x		x		x	x	x			x	x	x		x	x		x																
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		
x	x	x	x	x	x	x	x											x	x	x	x																				
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		
					x		x				x											x													x						
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		
	x	x	x	x	x	x	x						x					x	x	x	x	x	x																		
	x	x	x	x	x	x	x	x			x		x			x					x	x																			
x	x	x	x	x	x	x	x											x	x	x	x	x	x															x			
x	x	x	x	x	x	x	x															x																			
				x	x	x	x						x	x				x		x	x		x																		
			x	x	x	x	x						x	x				x		x	x		x																		
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		
			x		x	x	x			x				x							x	x	x															x			
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		
			x	x		x						x		x									x																		
	x	x	x	x	x	x	x											x	x	x	x	x	x																		
x						x	x											x	x	x	x	x																			
x	x	x	x	x	x	x	x											x	x	x		x																			
x	x	x		x	x	x	x	x						x			x			x				x																	
	x	x	x	x	x	x	x							x			x			x																					
x	x	x	x	x	x	x	x											x	x	x	x	x																			
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		
	x		x	x	x	x	x	x						x						x												x									
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		
	x	x	x	x	x	x	x							x				x	x	x	x	x	x																		
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		
					x	x	x													x																					
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		
x	x	x	x	x	x	x	x										x	x	x	x	x	x	x																		
x	x		x	x	x	x	x	x					x				x		x	x											x										
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		
			x			x	x						x							x		x	x																		
	x	x		x	x	x	x	x					x	x						x			x	x		x								x							
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		
				x		x	x						x	x				x		x	x		x																		
	x	x	x	x	x	x	x	x					x	x				x	x	x	x		x							x											
	x	x	x	x	x	x	x	x					x					x			x																	x			
		x	x	x		x	x	x					x	x	x					x																					
x	x	x	x	x	x	x	x													x	x		x																		
x	x	x	x	x	x	x	x										x	x	x	x	x	x	x																		
	x		x	x	x	x	x	x						x			x			x			x																		
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		
	x	x	x	x	x	x	x										x		x	x			x																		
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		

TABLE 1—Continued

Railway	Date of Issue	Physical Requirements																													
		Strength	Durability	Decay	Splits	Shakes	Large or numerous holes or knots	Compact or dense wood	Sapwood restricted	Live, Growing, or Thrifty	Killed	Oblique fibre	Cross-grain	Twist	Checks	Ring-heart	Pitch-seams	Pecky	Worm-holes	Large knots	Loose knots	Soft or bad knots	Unsound knots	Rotten or decayed knots	Heartwood	Sound	Rot, Punk, or Dote	Red-heart	Ground rot or dry rot	Heart-rot	Straight or straight grained
K. C. S.		x	x	x	x	x	x	x	x																						
K. C. Ter'l.	1-12-10	x	x		x	x				x											x			x							x
L. E. & Western	5-12-20	x	x	x	x	x	x																								
L. & H. R.	6-11-18	x	x	x	x	x	x	x	x																						
L. V.	4-12-16	x	x	x	x	x	x	x	x																	x	x				
L. I.	6-11-18	x	x	x	x	x	x	x	x																						
L. A. & St. Lake	10-5-20					x														x							x				
L. & N.	2-1-20	x	x	x	x	x	x		x	x								x									x				
M. C.	4-1-20	x	x	x	x	x	x			x											x					x					
Mich. Cent.	10-23-18	x	x	x	x	x	x																								
M. & St. L.		x	x	x	x	x				x										x	x		x			x					x
M. S. P. & S. Ste. M.						x				x																x	x				x
M. K. & T.	3-1-15	x	x	x	x	x			x									x	x		x			x	x						x
M. P.	3-1-20	x	x	x	x	x	x		x																				x		
Monon. South.		x	x	x	x	x	x	x	x			x													x						
M. & O.		x	x		x	x		x													x			x	x	x					x
Montour		x	x	x	x	x	x					x																			
N. C. & St. L.	3-1-20	x	x	x	x	x	x																								
N. O. G. N.	10-1-12	x	x		x	x				x											x			x							x
N. Y. C.	6-11-18	x	x	x	x	x	x	x	x																						
N. Y. C. & St. L.	6-11-18	x	x	x	x	x	x	x	x																						
N. Y., N. H. & H.	1-1-20	x	x	x	x	x	x	x	x											x	x										
N. Y. C. & W.						x			x	x									x								x				
N. S.	10-22-19	x	x	x	x	x	x	x	x																						
N. & W.	10-24-18	x	x	x	x	x	x																								
N. P.	8-1-18	x	x	x	x	x	x	x	x																						
O. S. L.		x	x		x	x			x	x			x				x				x			x		x					x
O. W. R. R. & N.		x	x		x	x				x			x				x				x			x		x					x
Penna. System	3-1-20	x	x	x	x	x	x	x	x			x													x						
P. M.	6-00-17					x				x				x	x				x			x				x					x
P. & L. E.	6-11-18	x	x	x	x	x	x		x																x						
Public Service	6-00-13	x	x		x	x			x	x									x		x		x	x		x	x	x	x		x
R. F. & P.	3-1-20	x	x		x	x														x	x			x			x				
S. L.-S. F.	9-1-14	x	x		x	x			x	x								x			x			x	x						x
S. A. & A. P.	6-11-18	x	x	x	x	x	x	x	x																x						
S. A. L.	4-20-20	x	x	x	x	x	x	x	x																x						
Southern	5-1-20	x	x	x	x	x	x	x	x																	x					
S. P.	5-8-16	x	x		x	x			x	x			x				x				x			x		x					x
S. P. & S.	11-7-17				x	x											x		x	x			x			x	x				x
T. & N. O.	12-19-16	x	x		x	x				x											x			x							x
T. & P.	6-11-18	x	x	x	x	x	x		x																						
T. & O. C.	3-22-20	x	x	x	x	x	x																								
T. St. L. & W.					x	x				x					x				x												x
T. & B. V.	6-11-18	x	x	x	x	x	x	x	x																						
U. P. System					x	x				x					x					x	x		x			x					x
Union R. R. (Memphis)	3-1-20	x	x	x	x	x	x		x																						
Union R. R. (Pittsburg)	6-11-18	x	x	x	x	x	x	x	x																						
Virginian	4-6-20	x	x	x	x	x	x	x	x																						
W. M.	3-1-20	x	x	x	x	x	x	x	x																						
W. & L. E.	6-11-18	x	x	x	x	x	x	x	x																						

TABLE 1—Continued

Manufacturing Requirements																		Dimensions, Thickness and Width																							
Time of manufacture	Straight	Well	Square ends	Top and bottom parallel	Bark removed	Hewed	Sawed	Out of wind	Sawed straight in grain	Boxed heart	Wane	Square corners	Score-marks	Smooth	Spurs	Splinters	Time of delivery	6 x 6 inches	6 x 7 inches	6 x 8 inches	7 x 7 inches	7 x 8 inches	7 x 9 inches	5½ x 6 inches	5½ x 7 inches	5½ x 7½ inches	5¾ x 5½ inches	5¾ x 7 inches	5¾ x 8 inches	6 x 5 inches	6 x 5½ inches	6 x 6½ inches	6 x 7½ inches	6 x 9 inches	6½ x 7½ inches	6½ x 8½ inches	7 x 5 inches	7 x 6 inches	7 x 6½ inches	7 x 7½ inches	7 x 10 inches
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		
	x		x	x	x	x	x	x					x					x		x																					
	x	x	x	x	x	x	x											x	x	x	x	x	x															x			
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		
x	x	x	x	x	x	x	x										x	x	x	x	x	x	x																		
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		
			x							x																															
	x	x	x	x	x	x	x													x		x	x																		
	x	x	x	x		x	x											x			x																	x			
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		
			x	x	x	x	x	x				x						x	x	x	x																				
			x	x		x	x	x					x					x	x	x	x	x																			
x	x	x	x	x	x	x	x	x				x	x			x	x			x																					
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		
x	x	x	x	x	x	x	x	x					x										x																		
x	x	x	x	x	x	x	x											x	x	x	x	x	x															x			
	x	x	x	x	x	x	x													x		x																x			
x		x	x	x	x	x	x	x					x							x				x																	
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		
x	x	x	x	x	x	x	x	x										x	x	x	x	x	x																		
		x	x			x														x		x	x											x							
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		
					x																		x													x				x	
				x	x	x	x						x								x	x	x																		
x	x	x	x	x	x	x	x											x	x	x	x	x	x															x			
x	x	x	x	x	x	x	x						x					x		x							x	x	x					x							
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		
x	x		x	x	x	x	x			x		x	x			x		x		x													x								
	x	x	x	x	x	x	x	x										x	x	x	x	x	x																		
x	x	x	x	x	x	x	x	x					x						x					x																	
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		
	x	x	x	x	x	x	x											x	x	x	x	x	x														x	x			
	x			x	x	x	x																																		x
			x							x												x	x																		
	x	x	x	x	x	x	x	x										x			x	x																			
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		
	x			x	x	x	x						x							x																					
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		
	x		x	x	x	x	x						x								x	x	x																x		
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		
x	x	x	x	x	x	x	x											x	x	x	x	x	x																		

TABLE 2—SPECIFICATIONS FOR SWITCH-TIES

Railway	Date of Issue	Physical Requirements: Strength	Durability	Sound	Sound heart	Heavy or compact wood	Straight or straight grain	Compact or dense wood	Sapwood	Heartwood	Splits	Shake	Heart rings or pitch seams	Checks or cracks	Worm-holes	Grub or knot-holes	Large or numerous holes and knots	Large knots	Loose knots	Sound knots	Unsound knots	Rotten or decayed knots	Knots or black knots
Ala. & Vicksburg	8-12-20	x	x						x	x													
A. T. & S. F.	10-15-14	x	x	x		x			x		x	x						x	x			x	x
A. C. L.				x						x													
B. & O.	9-1-19			x	x										x	x		x		x			
*B. & L. E.		x	x					x	x		x	x					x	x					
B. & M.				x						x		x			x	x			x		x		
B. R. & P.	7-1-20											x			x				x			x	
B. & S.	1-1-19	x	x	x								x											
Can. Nat'l.	3-18-19	x	x	x			x					x			x						x		
C. P.	4-00-16	x	x	x			x					x			x						x		
C. of Ga.	4-00-13			x								x							x			x	
C. of N. J.	7-6-20									x	x	x			x	x		x					
C. & O.	1-1-20	x	x	x													x					x	
C. B. & O.				x							x	x						x			x		
C. & E. I.	6-16-16	x	x	x							x	x							x			x	
C. G. W.	1-1-11																					x	
C. M. & St. P.	10-8-19	x	x		x				x		x	x			x	x	x			x			
C. & N. W.				x			x				x	x			x			x			x		
C. I. & W.												x						x		x	x		
C. C. C. & St. L.				x								x								x			
D. & H.				x						x		x			x	x			x				
D. L. & W.	1-1-17		x				x				x	x							x			x	
D. T. & I.				x								x								x			
F. E. C.										x		x										x	
F. S. & W.				x							x		x					x			x		
F. W. & D. C.	3-00-10			x			x					x		x				x				x	
*G. N.				x									x	x				x		x			
G. T. System	9-1-16			x					x														
G. & S. I.										x													
I. & G. N.	2-1-12	x	x	x			x			x		x											x
K. C. Ter'l.		x	x				x				x	x							x			x	
L. E. & W.	3-30-15										x				x				x		x	x	
L. & H.	1-1-19			x			x					x										x	
L. V.	4-12-16	x						x	x	x		x							x		x		
L. I.		x	x	x						x	x	x		x	x	x		x	x		x	x	
L. A. & St. L.	10-5-20											x						x					
L. & N.				x						x													
M. C.				x								x			x	x			x		x		
M. & St. L.		x	x	x			x				x	x						x			x		
M. St. P. & S. Ste. M.		x	x	x							x	x	x					x			x		
M. K. & T.		x	x				x			x	x	x			x				x			x	
M. P.	9-1-19			x																			
M. & O.				x			x		x			x		x				x			x		
N. C. & St. L.	9-15-18			x																			
N. Y. C.	6-00-18			x						x		x			x	x			x		x		
N. Y. C. & St. L.	12-19-17											x										x	
N. Y., N. H. & H.	5-27-20	x	x			x			x		x	x					x	x	x				
N. Y. O. & W.				x						x		x			x	x		x	x		x		
N. S.	8-21-18	x	x			x				x	x	x					x						
N. P.		x	x	x							x	x	x					x			x		
O. S. L.	1-18-13	x	x	x			x				x	x	x						x			x	

TABLE 2—Continued

Physical Requirements													Manufacturing Requirements																			Thickness and Width							Length Differences				
Pin or tight knots	Encased or grouped knots	Decay	Rot	Rotten heart	Red heart	Doty heart	Dote	Unsound parts	Growing	Green	Live	Thrifty	Hewed	Sawed	Split	Straight	Well	Ends square	Faces parallel	Bark removed	Score marks	Smooth	Splinters	Spurs	Square edge	Wane	Out of wind	Parallel to grain or heart	Cross-grain	Time of manufacture	Time of delivery	6 x 8 inches	6 x 9 inches	7 x 8 inches	7 x 9 inches	7 x 10 inches	8 x 8 inches	8 x 10 inches	1 inch	1, 2 and 3 inches	3 inches	6 inches	12 inches
x		x							x				x	x			x	x							x										x							x	
										x	x		x	x		x				x		x					x	x							x							x	
																										x																	
		x												x		x	x	x	x																x							x	
																	x	x							x																		
										x	x			x		x	x	x	x	x	x		x				x									x				x			
			x									x		x		x		x								x		x								x							x	
			x								x		x	x				x	x	x	x	x													x							x	
			x								x		x	x				x	x	x	x	x													x							x	
	x	x									x			x			x	x									x																
		x												x		x	x	x							x	x									x								
											x					x	x			x															x						x	x	
			x								x			x			x							x	x	x								x									
											x			x				x	x	x							x								x							x	
								x		x	x			x		x	x	x	x																x							x	
		x											x	x		x	x	x	x	x						x						x			x				x				
		x				x					x			x												x						x											
			x				x				x							x							x	x																	
		x												x				x								x									x							x	
														x			x								x	x									x							x	
									x				x	x		x	x	x	x	x		x					x			x	x							x					
		x												x				x								x									x								
				x	x						x															x									x								
			x				x				x		x							x	x	x											x										
											x		x	x		x			x	x	x	x					x			x						x								
x																	x									x									x								
																									x					x					x								
													x	x																						x							
			x								x		x	x				x																		x							
									x				x	x		x				x		x					x								x								
		x	x							x	x	x														x				x				x								x	
										x			x	x				x	x	x															x						x		
	x													x				x								x										x							
			x											x		x	x	x	x	x					x	x	x								x								
			x											x												x																	
																									x																		
														x			x								x	x						x											
		x							x				x	x				x	x		x	x			x	x	x								x							x	
			x								x			x				x								x																	
		x	x						x				x	x		x	x	x	x	x	x	x	x					x								x								
											x		x	x		x		x	x		x	x					x								x								x
											x		x	x		x		x	x	x	x	x					x																
													x	x													x							x									x
x														x			x								x	x																	
							x			x	x																								x							x	
		x														x	x			x															x								
														x			x								x																		
		x																x	x							x									x							x	
			x								x			x			x	x								x																	
											x			x						x									x														

TABLE 2—Continued

Railway	Date of Issue	Physical Requirements: Strength	Durability	Sound	Sound heart	Heavy or compact wood	Straight or straight grain	Compact or dense wood	Sapwood	Heartwood	Splits	Shake	Heart rings or pitch seams	Checks or cracks	Worm-holes	Grub or knot-holes	Large or numerous holes and knots	Large knots	Loose knots	Sound knots	Unsound knots	Rotten or decayed knots	Knots or black knots
Penna. System	8-15-17	x	x					x	x		x	x					x	x					
P. M.		x	x	x								x							x	x		x	
P. & L. E.	12-1-11	x	x						x		x	x						x	x			x	
R. F. & P.	5-1-20	x	x								x	x						x	x			x	
S. L. & S. F.	4-2-19	x	x								x	x					x						
S. A. L.	6-1-14									x													
Southern	5-1-19			x			x		x			x						x			x		
S. P.	5-8-16	x		x			x		x		x	x	x			x			x		x	x	
S. P. & S.				x							x	x	x						x			x	
T. & N. O.	12-19-16	x	x				x				x	x							x			x	
T. P.	2-00-19	x	x				x				x	x						x	x				
T. & O. C.	3-12-15			x							x	x		x	x				x		x	x	
T. St. L. & W.	7-29-20			x			x				x	x											
U. P.				x								x		x				x				x	
Union R. R. (Memphis)	9-1-19			x																			
Virginian							x					x							x			x	
Wabash		x	x	x							x	x						x	x			x	
W. M.		x	x									x											

TABLE 2—Continued

Physical Requirements													Manufacturing Requirements																			Thickness and Width							Length Differences				
Pin or tight knots	Encased or grouped knots	Decay	Rot	Rotten heart	Red heart	Doty heart	Dote	Unsound parts	Growing	Green	Live	Thrifty	Hewed	Sawed	Split	Straight	Well	Ends square	Faces parallel	Bark removed	Score marks	Smooth	Splinters	Spurs	Square edge	Wane	Out of wind	Parallel to grain or heart	Cross-grain	Time of manufacture	Time of delivery	6 x 8 inches	6 x 9 inches	7 x 8 inches	7 x 9 inches	7 x 10 inches	8 x 8 inches	8 x 10 inches	1 inch	1, 2 and 3 inches	3 inches	6 inches	12 inches
		x												x		x	x	x	x																x								x
											x			x		x			x																								
			x											x		x	x	x	x	x							x																
			x										x	x		x	x	x	x	x							x																
		x														x	x	x	x	x							x								x							x	
														x																					x						x		
													x	x				x	x	x	x	x				x	x								x								x
	x		x														x									x																	
																	x									x									x							x	
									x					x		x	x	x	x								x			x					x								
		x							x				x	x		x	x	x	x	x		x					x									x					x		
											x			x		x				x						x									x							x	
			x								x			x				x	x	x						x	x								x								
											x		x	x		x		x	x	x	x	x																					
											x		x	x		x		x	x	x	x	x					x																
											x		x	x				x	x	x	x		x							x					x							x	
											x		x	x		x		x	x	x		x							x	x													
			x				x			x	x				x																												

The Committee presents the following "Specification for Cross-Ties" and "Specification for Switch-Ties" and recommends that they be adopted and be printed in the Manual in substitution for the specifications approved in 1916 and appearing on pages 243 to 246 of Volume 17 of the Proceedings of the Association.

SPECIFICATION FOR CROSS-TIES

Material

Kinds of Wood

1. Before manufacturing ties, producers shall ascertain which of the following kinds of wood suitable for cross-ties will be accepted: Ash, Beech, Birch, Catalpa, Cedar, Cherry, Chestnut, Cypress, Elm, Fir, Gum, Hackberry, Hemlock, Hickory, Larch, Locust, Maple, Mulberry, Oak, Pine, Poplar, Redwood, Sassafras, Spruce, Sycamore and Walnut. Others will not be accepted unless specially ordered.

Physical Requirements

General Quality

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, or grain with slant greater than one in fifteen.

Resistance to Wear

Ties from needle-leaved 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

Ties for use without preservative treatment shall not have sapwood wider than one-fourth the width of the top of the tie between 20 inches and 40 inches from the middle, and will be designated as "heart" ties. Those with more sapwood will be designated as "sap" ties.

Design

Dimensions

2. 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.

All ties shall be eight (8) feet, eight (8) feet six (6) inches, or nine (9) feet long.

All ties shall measure as follows throughout both sections between 20 inches and 40 inches from the middle of the tie:

Grade.	Sawed or Hewed Top, Bottom and Sides.	Sawed or Hewed Top and Bottom.
1	None accepted.	6″ thick x 6″ wide on top.
2	6″ thick x 7″ wide on top.	6″ thick x 7″ wide on top.
3	6″ thick x 8″ wide on top.	6″ thick x 8″ wide on top.
		7″ thick x 7″ wide on top.
4	7″ thick x 8″ wide on top.	7″ thick x 8″ wide on top.
5	7″ thick x 9″ wide on top.	7″ thick x 9″ wide on top.
6	7″ thick x 10″ wide on top.	7″ thick x 10″ wide on top.

Notes

(1) It is expected that each railroad will specify only the kind or kinds of wood it desires to use.

(2) It is expected that each railroad will specify only the length or lengths, shape or shapes, and size or sizes it desires to use; but each railroad will use the standard designation for whatever size of tie it specifies. For example, a railroad desiring 6 inch x 8 inch ties only will designate them as Grade 3; a railroad desiring 7 inch x 9 inch ties only will designate them as Grade 5. A railroad shall not designate 6 inch x 8 inch ties as Grade 1 and 6 inch x 6 inch as Grade 2, or 7 inch x 9 inch ties as Grade 1 and 7 inch x 8 inch as Grade 2. A railroad which desires to use ties less than 6 inches thick or 6 inches wide on top, or ties rejectable under the standard specification for other reasons, shall not give to such ties a standard designation (1 to 6), but shall designate them as Grade 0 or as "usable rejects."

(3) It is expected that railroads which specify both 6 inch x 8 inch and 7 inch x 9 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 Grade 3A.

Manufacture

All ties, except those of ....,
(Specify kind or kinds of wood)
shall be made from trees which have been felled not longer than one month.

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

Ties will be inspected after delivery at suitable and convenient places satisfactory to the railroad, which reserves the right to inspect ties at points of shipment or at destination. Ties will be inspected at points other than the railroad's property whenever in the judgment of the railroad there is sufficient number to warrant it; but the shipper shall provide accommodations for the inspector while away from rail or steamer lines and transport him from or to a railroad station or steamer landing.

Inspectors will make a reasonably close examination of the top, bottom, sides, and ends of each tie. Each tie will be graded independently without regard for the grading of others in the same lot. Rafted or boomed ties too muddied for ready examination will be rejected. Ties handled over hoists will be turned over as inspected.

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."

A large hole in woods other than cedar is one more than ½ inch in diameter and 3 inches deep within, or more than 1 inch in diameter and 3 inches deep outside the sections of the tie between 20 inches and 40 inches from its middle. Numerous holes are any number equalling a large hole in damaging effect. Such holes may result in manufacture or otherwise.

A large knot is one exceeding in width more than ¼ of 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 20 inches and 40 inches from its middle. Numerous knots are any number equalling a large knot in damaging effect.

A shake is a separation of one ring of annual growth from another. One which is not over 4 inches long or ¼ inch wide will be allowed.

A split is a break across annual rings. One which is not over 10 inches long will be allowed provided a satisfactory anti-splitting device has been properly applied.

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; (2) when a straight line along a side from the middle of one end to the middle of the other is everywhere more than 2 inches from the top and the bottom of the tie.

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.

The lengths, thicknesses, and widths specified are minimum dimensions. Ties over 1 inch more in thickness, over 3 inches more in width, or over 2 inches more in length will be degraded or rejected.

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-quarter (6¾) inches wide; or one end may be six and three-quarter (6¾) inches while the other is seven and one-quarter (7¼) inches thick.

All thicknesses and widths apply to the sections of the tie between 20 inches and 40 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.

Ties which are oversize will be accepted as follows: 8 inch to 9 inch x 9 inch to 12 inch as Grade 4; 9 inch to 10 inch x 9 inch to 12 inch as Grade 3. Ties over 10 inches thick or over 12 inches wide on top 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.

Delivery

All ties, except those of ....,
(Specify kind or kinds of wood)
shall be delivered to the railroad within one month after being made.

Ties delivered on the premises of the railroad for inspection shall be stacked not less than ten (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 railroad. Ties shall be stacked in alternate layers of two (2) and seven (7), the bottom layer to consist of two (2) ties kept at least six inches above the ground. The second layer shall consist of seven (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 twelve layers high, and there shall be five feet between stacks to facilitate inspection. Ties which have stood on their ends on the ground will be rejected.

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.

All ties are at the owner's risk until accepted. All rejected ties shall be removed within one month after inspection.

Ties shall be stacked as grouped below. Only the kinds of wood named in a group may be stacked together.

Class U—Ties Which May Be Used Untreated

Group Ua	*Group Ub*	*Group Uc*	*Group Ud*
"Heart" Black Locust	"Heart" Douglas Fir	"Heart" Cedars	"Heart" Catalpa
"Heart" White Oaks	"Heart" Pines	"Heart" Cypress	"Heart" Chestnut
"Heart" Black Walnut		"Heart" Redwood	"Heart" Red Mulberry
			"Heart" Sassafras

Class T—Ties Which Should Be Treated

Group Ta	*Group Tb*	*Group Tc*	*Group Td*
Ashes	"Sap" Cedars	Beech	"Sap" Catalpa
Hickories	"Sap" Cypress	Birches	"Sap" Chestnut
"Sap" Black Locust	"Sap" Douglas Fir	Cherries	Elms
Honey Locust	Hemlocks	Gums	Hackberry
Red Oaks	Larches	Hard Maples	Soft Maples
"Sap" White Oaks	"Sap" Pines		"Sap" Mulberries
"Sap" Black Walnut	"Sap" Redwood		Poplars
			"Sap" Sassafras
			Spruces
			Sycamore
			White Walnut

Shipment

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.

SPECIFICATION FOR SWITCH-TIES

Material

Kinds of Wood

1. Before manufacturing ties, producers shall ascertain which of the following kinds of wood suitable for switch-ties will be acceptable: Ash, Beech, Birch, Cedar, Cherry, Chestnut, Cypress, Fir, Gum, Hemlock, Larch, Locust, Maple, Oak, Pine and Redwood. Others will not be accepted unless specially ordered.

Physical Requirements

General Quality

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, or grain with slant greater than one in fifteen.

Resistance to Wear

Ties from needle-leaved 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

Ties for use without preservative treatment shall not have sapwood wider than one-fourth the width of the top between twelve (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. Before manufacturing ties, producers shall ascertain what sizes of ties will be acceptable and whether ties are to be hewed or sawed and in either case whether on the sides as well as the top and the bottom.

All ties shall be seven (7) inches thick.

Ties sawed or hewed on top, bottom, and sides shall be not less than nine (9) inches wide on top throughout the section between twelve (12) inches from each end of the tie. Ties sawed or hewed on top and bottom only shall be not less than seven (7) inches wide on top throughout the section between twelve (12) inches from each end of the tie.

Each tie shall be of a length specified below:

(Bill of Material)

1. It is expected that each railroad will specify only the kind or kinds of wood it desires to use.

2. It is expected that each railroad will specify only the shape or shapes and size or sizes it desires to use.

Manufacture

All ties, except those of ....
(Specify kind or kinds of wood)
shall be made from trees which have been felled not longer than one month.

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

Ties will be inspected after delivery at suitable and convenient places satisfactory to the railroad, which reserves the right to inspect ties at points of shipment or at destination. Ties will be inspected at places other than the railroad's property whenever in the judgment of the railroad there is sufficient number to warrant it; but the shipper shall provide accommodations for the inspector while away from rail or steamer lines and transport him from or to a railroad station or steamer landing.

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.

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."

A large hole in woods other than cedar is one more than one-half (½) inch in diameter and three (3) inches deep within, or more than one (1) inch in diameter and three (3) inches deep outside the section between twelve (12) inches from each end of the tie. Numerous holes are any number equalling a large hole in damaging effect. Such holes may result in manufacture or otherwise.

A large knot is one exceeding in width more than one-quarter (¼) of the width of the surface on which it appears; but such a knot may be allowed if it occurs outside the section between twelve (12) inches from each end of the tie.

A shake is a separation of one ring of annual growth from another. One which is not over four (4) inches long or one-quarter (¼) inch wide will be allowed.

A split is a break across annual rings. One which is not over ten (10) inches long will be allowed, provided a satisfactory anti-splitting device has been properly applied.

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; (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 two (2) inches from the top or the bottom of the tie.

A tie is not well hewed or sawed when its surfaces are cut into with scoremarks more than one-half (½) inch deep and when its surfaces are not even.

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.

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-quarter (6¾) inches wide; or one end may be six and three-quarter (6¾) inches while the other is seven and one-quarter (7¼) inches thick.

All thicknesses and widths apply to the section of the tie between twelve (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.

Delivery

All ties, except those of ....
(Specify kind or kinds of wood)
shall be delivered to the railroad within one month after being made.

Ties delivered on the premises of the railroad shall be stacked not less than ten (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 views of trainmen or of people approaching the railroad. Ties shall be stacked at least six (6) inches above the ground. No tie shall be unsupported for more than ten (10) feet of its length. The ties in each layer of ten (10) or more shall be not less than one (1) inch apart, and such layers shall be separated by stacking strips at least one (1) inch thick and not more than four (4) inches wide. If ties are used to separate the layers of ten (10) or more, and they are rectangular, such strip ties shall be laid on their sides and the two (2) outside ties as near as possible to the extreme ends of the ties in the layers of ten (10) or more. No ties shall be permitted to overhang more than two (2) feet. No stack of ties shall be wider than ten (10) feet.

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.

All ties are at the owner's risk until accepted. All rejected ties shall be removed within one month after inspection.

Ties shall be stacked as grouped below. Only the kinds of wood named in a group may be stacked together.

Class U—Ties Which May Be Used Untreated

Group Ua	*Group Ub*	*Group Uc*	*Group Ud*
"Heart" Black Locust	"Heart" Douglas Fir	"Heart" Cedars	"Heart" Chestnut
"Heart" White Oaks	"Heart" Pines	"Heart" Cypress	
		"Heart" Redwood	

Class T—Ties Which Should Be Treated

Group Ta	*Group Tb*	*Group Tc*	*Group Td*
Ashes	"Sap" Cedars	Beech	"Sap" Chestnut
"Sap" Black Locust	"Sap" Cypress	Birches	Soft Maples
Honey Locust	"Sap" Douglas Fir	Cherries	
Red Oaks	Hemlocks	Gums	
"Sap" White Oaks	Larches	Hard Maples	
	"Sap" Pines		
	"Sap" Redwood		

Shipment

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.

Appendix B

(2) REPORT ON METHODS OF INSTALLING AND KEEPING RECORDS OF TEST SECTIONS FOR OBTAINING DATA ON THE LIFE OF CROSS-TIES

W. A. CLARK, *Chairman;*
W. C. BAISINGER,
E. L. CRUGAR,
O. H. FRICK,
R. M. LEEDS,
Sub-Committee.

The work was carried on by collecting information and opinions through correspondence and interviews; also by meetings of the Sub-Committee. Some members of the Sub-Committee also met at Madison, Wis., with members of the American Wood Preservers' Association, the Wood Preservation Committee of the A.R.E.A. and representatives of the Forest Products Laboratory.

The advisability of obtaining data on tie life by means of test sections is so generally admitted that no argument on that point is considered necessary, but it may be well to point out the purposes in view, then to describe some of the methods in use and make recommendations leading toward uniform practice.

When a road uses only one kind of ties, it is not necessary to initiate any elaborate scheme to determine the life of ties on various sections of the road, for the information is of little practical value. Such cases are now rare, however. Railroads that formerly used only one kind of ties are now using several kinds. Many roads use treated ties with different kinds of wood and different methods of treatment.

It is highly important to know what life and comparative value is obtained from these various different kinds of ties in the same locality and in localties having different climatic and traffic conditions. Without reliable information of this kind, we are unable to purchase or treat ties economically or distribute them wisely.

The Association has decided that the method of test sections is the best way to obtain the necessary data. The methods of installing the test sections and of collecting and reporting the data on different railroads are not uniform, although the work of the Forest Products Laboratory has tended toward uniform methods of reporting.

Some large roads have installed only one or two test sections. Others have installed at least one on each roadmaster's district. Some have put in only a few ties of each kind and few kinds; others, not less than a hundred of each kind and many different kinds. In some cases, the test sections are inspected and reported on by the department supplying the ties; in other cases this is done by the Engineering Department and in others by the Operating Department.

On some roads the ties in the test sections are installed "out of face," on others, the test sections are marked off and the ties in the track are numbered and described according to the best information available. The latter method is varied on some roads by disregarding the ties already in the track and keeping a life record of the ties used for renewals.

The principal criticism of the test section method of obtaining data on tie life has been that it often gave abnormal results. This criticism, if merited, is probably due to the fact that the ties are in most cases selected, the maintenance is above the standard, and the renewals are watched with unusual care. The main object of the tests is *comparative* data, however, and the test sections as usually installed give this comparison, but it is believed that the tests might be made more nearly representative if care were taken to keep the conditions as near as possible to average actual practice.

Of forty railroads canvassed by this Sub-Committee, only five submitted data to show that a systematic record of test sections had been kept; namely, the Chicago, Burlington & Quincy, Great Northern, Baltimore & Ohio, Pennsylvania and Northern Pacific. Several other roads are keeping a more or less complete and comprehensive record of this kind.

Recommendations

Installing Test Sections

(1) In locating test sections, it is of first importance that a piece of track be selected that has no switches and is not likely to be disturbed by new construction or abnormal rail renewals.

It is not essential but it is recommended that the test ties all be put in at once "out of face," as this accelerates the gathering of the information and without greatly increasing the expense, as the good ties removed can be used elsewhere.

All of the different kinds of ties in a test section should, so far as possible, be installed under the same conditions of curvature, grade and drainage.

The Committee recommends that not less than 100 ties of each kind under test be installed. If installed in multiples of 100, the percentages are readily obtained. If too few ties are put in, a few abnormal failures may make the test misleading.

Each tie should be numbered and most roads think it necessary to mark each tie with its number, and in some cases with kind of timber and date of insertion. If a reliable record is kept in the office, however, it scarcely seems necessary to mark the tie with more than its number. The test sections should be marked by suitable monuments at each end.

Inspection of Test Tracks

(2) It is recommended that installation and records of the test sections be under the supervision of a technical man, experienced in that kind of work, who is qualified to make accurate observations and keep good records, so that the tests will be continuous and not affected by changes in the personnel. Regular inspection should be made of the test sections at least once a year. Ties should not be removed except in

emergencies without the approval of the official responsible for the record and should never be destroyed until inspected by him or his representative.

Tie Record

(3) The essentials of the record are covered by two forms: one being a report (Form No. 1) giving the location and principal data, such as traffic, weight of rail, kind of ballast, kind of tie, treatment, etc., and the other a record of the inspections (Form No. 2) showing the condition of each tie at each inspection.

For convenience in recording the information on Form No. 2, a set of abbreviations is recommended, similar to the following: N.S.—Represents joint ties; B.—Broken but still in service; B.D.—Badly bruised account derailment; C.—So decayed as to warrant renewal; P.D.—Partly decayed but still serviceable, etc.

If many kinds of ties are under test in the test sections, a chart showing the location of the different kinds will be helpful and it is necessary to have a full record of the treatment of each different lot of ties under test. It is also advisable to send to all, who are in any way responsible for the tests, a set of rules or instructions, governing the installing, maintaining and inspecting of the test sections. These instructions will vary with the organization of the road and the extent of the tests.

In case the ties in the test sections are not put in "out of face," but the existing ties in the track are considered as test ties, the forms must be modified accordingly. Or if the test sections are to be built up by keeping a record of the ties used in renewals, still different forms are needed.

As renewal "out of face" is recommended in installing test sections, only the one set of forms is offered, though it is agreed that reliable records can be secured by anyone of the three methods.

The Committee earnestly hopes that more roads will install test sections and begin keeping accurate records which will be of value to themselves and to the Association.

Form No. 1.

NORTH & SOUTH RAILROAD

REPORT OF EXPERIMENTAL TEST TIE SECTIONS

District................Division................

Location ....

Kind of Ballast..

Tangent or Curve %..

Tie Plates ....

Weight of Rail..

Rail Fastenings ....

Rail Changed When..

Weight of Rail Originally in Track................................

Size of Ties..

Kind of Timber..

Where Treated ....

When Treated ....

How Treated ....

When Put in Track..

Number Originally Put in Track................................

Number Still in Track Last Inspection..........................

When Last Inspected..

Traffic ....

Remarks:

NORTH & SOUTH RAILROAD

Form No.

INSPECTION OF EXPERIMENTAL TIES

Location.......................

Between M. P.............. and M. P..............

Date Placed in Track.......................

Tie No.	Condition When Laid	Condition at Date of Inspection								
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										

(Insert year at top of each column)

Appendix C

(4) STUDY AND REPORT ON THE ECONOMICS OF THE USE OF VARIOUS CLASSES OF CROSS-TIES AND VARIOUS KINDS OF PRESERVATIVE TREATMENT

W. J. BURTON, *Chairman;*
F. T. BECKETT,
A. F. MAISCHAIDER,
G. P. PALMER,
Sub-Committee.

Meetings of this Sub-Committee were held in St. Louis on June 8th and October 18th, 1920.

The assignment has been construed by the Sub-Committee as intending that "classes" refers to both size of tie and kind of wood.

An investigation of existing data indicates that not only is satisfactory tie life data far from plentiful, but, also that much of it has been obtained, primarily, for the purpose of justifying treatment and without very much regard to the question of size of tie or kind of wood. Some of the more recent tie data is one-sided, in that certain variables, especially the treatment details, are recorded with particularity out of proportion to the provisions for other equally important or even more important variables. Such service test data as there is, however, is too limited to permit satisfactory conclusions on the subject assigned.

Some of the many variables which influence the life of ties are:

Kind of wood
Dimensions
Preservative treatment
Ballast
Fastenings
Climate
Traffic—

but wrong conclusions might easily be drawn if these are based on present data exclusively. For instance, it is reasonable to presume that ties 7 inch x 9 inch will out-last 6 inch x 8 inch ties when subjected to identical conditions, but, owing to the fact that the larger ties are more frequently used under heavy traffic, the available statistics, which do not adequately take into account the traffic, indicated the apparent absurdity that the smaller ties will out-last the larger.

Having in mind this incomparability of much of the limited data existing, as well as to elicit discussion, the Committee sent out a questionnaire dealing with the subject, and asking for opinion data where actual results were not available.

It would seem from the returns that in some cases "conventional" ideas as to life of ties of certain kinds are reported, and it is also apparent that the variable of traffic, which is very difficult to handle, must receive much greater attention before proper comparisons or conclusions may be made.

A tabulation of the replies will be found in table "A." They were further condensed by simply averaging the figures and the results are given in the following table:

SIMPLE AVERAGES FROM REPORTS GIVEN IN TABLE "A"

Kind of Wood	Untreated				Treated			
	Tie Plates		Unplated		Tie Plates		Unplated	
	6 Inch Ties	7 Inch Ties	6 Inch Ties	7 Inch Ties	6 Inch Ties	7 Inch Ties	6 Inch Ties	7 Inch Ties
Ash	(2) 5.0	(2) 5.0	(1) 6.4		(2) 15.3	(2) 14.0	(1) 8.0	
Beech	(3) 5.1	(1) 4.0	(1) 6.0		(4) 15.0	(5) 12.8	(3) 11.0	(1) 12.0
Birch	(3) 4.6	(1) 2.0	(1) 6.0		(3) 13.5	(2) 14.0	(2) 10.0	
Cedar	(14) 14.2	(5) 13.2	(11) 11.5	(7) 12.3	(2) 18.5		(2) 14.0	
Cherry	(1) 8.0	(1) 5.0	(1) 7.0	(2) 7.5	(1) 14.0	(1) 11.5	(1) 8.0	
Chestnut	(7) 7.1	(8) 8.3	(5) 5.0	(6) 8.1	(2) 6.5	(1) 7.5	(2) 4.5	
Cypress	(9) 8.8	(9) 10.2	(7) 6.4	(12) 9.1	(5) 11.9	(3) 9.8	(3) 8.3	
Elm	(5) 5.4	(2) 4.8	(3) 4.3	(1) 5.0	(3) 11.1	(2) 13.0	(2) 5.5	
Fir	(3) 8.0	(8) 7.3	(3) 6.7	(4) 6.4	(1) 15.0	(4) 11.0	(1) 12.0	(1) 8.0
Gum	(7) 5.0	(3) 4.8	(5) 4.1	(2) 4.5	(8) 10.6	(4) 11.2	(7) 8.0	(2) 9.5
Hackberry		(1) 2.5			(1) 14.0	(1) 9.0	(1) 8.0	
Hemlock	(4) 5.3	(3) 5.0	(5) 5.8	(2) 5.6	(2) 11.8	(3) 10.7	(1) 8.0	(1) 6.0
Hickory	(2) 5.0	(1) 3.0		(1) 3.0	(2) 13.7	(2) 14.0	(1) 8.0	
Larch (Tamarack)	(5) 6.9	(3) 7.0	(2) 5.9	(1) 8.0	(2) 12.8	(2) 12.0	(1) 9.0	
Locust	(1) 20.0	(2) 10.0		(1) 12.0	(1) 14.0	(1) 13.0	(1) 8.0	
Maple	(4) 4.4	(1) 3.0	(2) 5.0		(5) 12.7	(2) 13.7	(4) 10.3	
Mulberry		(1) 8.0						
Oak, R. or B.	(10) 4.4	(9) 4.4	(14) 4.5	(9) 3.8	(13) 13.7	(6) 15.0	(12) 11.5	(3) 12.3
Oak, White	(15) 8.0	(13) 8.8	(20) 7.7	(18) 7.6	(3) 14.8	(3) 15.3	(2) 12.0	(2) 11.0
Pine, Jack	(4) 8.2		(5) 7.0		(1) 16.0		(1) 10.0	
Pine, Loblolly	(2) 4.1	(1) 3.0	(1) 2.5	(1) 3.0		(2) 11.8		(2) 5.9
Pine, So. Yellow	(7) 6.9	(7) 8.5	(4) 4.3	(12) 6.6	(7) 12.0	(3) 12.5	(5) 8.4	(3) 14.5
Pine, W. Yellow	(2) 5.0	(4) 7.6	(1) 5.0	(4) 6.2	(2) 12.8	(2) 12.0	(1) 8.0	
Redwood	(1) 12.0	(1) 11.0		(1) 6.0				
Spruce	(1) 7.0	(1) 8.0	(1) 5.0	(1) 6.0		(1) 13.5		
Sycamore	(2) 3.1	(1) 2.0			(2) 14.8	(1) 9.0	(1) 8.0	
Walnut	(1) 12.0	(2) 8.3		(2) 9.5		(1) 5.5		

Numbers in parentheses are the numbers of replies averaged.

This table is produced principally for the purpose of pointing out the fact that, without taking into account such variables as traffic and climate, conclusions, as, for instance, between ties 7 inches thick compared with those 6 inches, are out of the question.

Exhibit A contains a digest of the replies to the questionnaire.

There is evidently a considerable lack of agreement among the engineers replying as to the functions of the tie. Question 3, for instance, was intended to bring out discussion as to the relative desirability of beam strength and bearing area. The 7 inch x 7 inch tie, which is cut from a tree slightly smaller than that required for the 6 inch x 8 inch tie, has a beam strength (moment of inertia) practically 50 per cent. greater. The additional inch of width, as bearing surface, for both the rail and ballast, is considered by many as of greater advantage than this 50 per cent. increase in beam strength.

A comparison of the moments of inertia of the several grades of cross-ties is made in the following table:

Grade	*Size*		*Area of Cross-Section*		*Moment of Inertia*	
						(a)
	Inches	*Inches*	*Sq. In.*	*Sq. in.*	*In.*	*In.*
1	None	6x6	..	46.37	..	123
2	6x7	6x7	42	51.12	126	139
3	6x8	6x8	48	56.20	144	156
3	..	7x7	..	63.00	..	228
4	7x8	7x8	56	68.23	229	254
5	7x9	7x9	63	74.46	257	280

(a) Calculated with formula $1 = \frac{d3}{12}\left(\frac{D-b}{3} + b\right)$ where $D =$ diameter of tree, $b =$ width of face of tie and $d =$ thickness of tie. This gives results slightly (3 per cent.) greater than by mathematically exact formula.

Similarly, there is a disagreement as to whether a 6 inch x 8 inch tie offers greater or less protection against failure from mechanical wear than the 7 inch x 7 inch tie. One argument is that the additional inch in depth of the latter permits of adzing to that extent, while another thought is that the increased rail bearing area will result in less wear.

There are other angles to the question when viewed from the standpoint of maintaining track already existing, such, for instance, as the effect of introducing 7-inch ties in track tied with 6-inch ties.

Conclusions

In view of the lack of data and the conflicting ideas, the Committee desires to report progress on the subject, but to draw no conclusions this year. The information in the exhibits is presented as having value in considering the subject.

TABLE A—RESULTS REPORTED WITH TIES 7 IN. THICK

Kind of Wood	Railroad	Reported by	Years' Service Obtained				Remarks
			Untreated		Treated		
			T. P.	U. P.	T. P.	U. P.	
Ash	Hock. Val.	A. Crable	7	5			Ohio, failures mechanical.
	Penna.	W. C. Cushing	3		10		Heavy traffic, failures mechanical.
	Penna.	W. C. Cushing	3		16		Light traffic.
	N. P.	B. Blum			15		Wis., Minn., N. D., failures mechanical. Lowry process, 22- creosote per 7"x8" tie.
Beech	L. & N.	R. M. Leeds		3	12		Treated with creosote. Untreated used in mine tracks.
	Penna.	W. C. Cushing	4		8		Heavy traffic, failures mechanical.
	Penna.	W. C. Cushing	4		14		Light traffic.
	C. C. C. & St. L.	C. A. Paquette			18	12	Creosote oil, empty cell.
	Southern	B. Herman			12		Illinois—Fail by decay.
Birch	Penna.	W. C. Cushing	2		8		Heavy traffic, failures mechanical.
	Penna.	W. C. Cushing			1		Light traffic.
	N. P.	Bernard Blum			16–18		Wis., Minn., N. D., failures mechanical. Lowry process, 22- creosote per 7"x8" tie.
Cedar	B. & M.	F. A. Merrill	8 to 9				
			10				Location New England.
	D. & I. R.	W. A. Clark	12 to 18				Minn. Many fail by mechanical wear.
	H. Val.	A. Crable		20			Ohio, storage tracks only. Fail by decay.
	Long I.	J. R. Savage		13			90% of failures due to decay.
	Bost. & A.	F. B. Freeman		8.8			Location Mass. Very heavy and dense traffic. 60% failures due to decay.
	Southern	B. Herman	16	6			North Carolina.
	B. & O.	E. Stimson	15	15			Ohio & Ind. High speed. Mechanical wear.
	S. P. Co. (Pac. Sys.)	J. D. Isaacs	11	8			Oregon, Cal., Nev., Utah, Ariz., N. M.
	N. P.	B. Blum		12–20			Mont., Ore., Idaho, Washington.
Cherry	H. V.	A. Crable		8			Ohio. Fail by decay.
	L. & N.	R. M. Leeds		7			Kentucky. Fail by decay.
	Penna.	W. C. Cushing	4		7		Heavy traffic, failures mechanical.
	Penna.	W. C. Cushing	6		14		Light traffic.
Chestnut	B. & M.	F. A. Merrill	7–9				Location New England.
	D. & H.	J. MacMartin	10	7			N. Y., Penn., Vt. Failures 50% mechanical.
	H. V.	A. Crable	7	5			Ohio. Failures mechanical.
	Long I.	J. R. Savage		10			90% of failures due to decay.
	Penna.	W. C. Cushing	3		3		Heavy traffic. Failures mechanical.
	Penna.	W. C. Cushing	12		12		Light traffic.
	R. F. & P.	S. B. Rice	6				Va. Failures 50% decay.

TABLE A—RESULTS REPORTED WITH TIES 7 IN. THICK—(Continued)

Kind of Wood	Railroad	Reported by	Years' Service Obtained				Remarks
			Untreated		Treated		
			T. P.	U. P.	T. P.	U. P.	
Chestnut	Bost. & A.	F. B. Freeman	8	7			Mass. Heavy and dense traffic. Mechanical wear increases with decay. 60% of failures due to decay.
Cypress	Southern	B. Herman	12	7.5			Va., N. C., S. C., Ga., Ky.
	B. & O.	E. Stimson		12			Western, fail by decay. Middle Atlantic and Central.
	A. B. & A.	L. L. Beal	10–12	6–7			
	A. C. L.	L. L. Sparrow		9			Location S. C., Ga., Fla. and Ala. Failure by decay and mechanical wear.
	B. & M.	F. A. Merrill	4–5		11		Location New England.
	C. P. R.	J. Fairbairn	8	6			
	C. of Ga.	C. E. Weaver		15			Location Ga. and Ala. Failure by mechanical wear. Medium and light traffic.
	G. F. & A.	A. S. Butterworth		5			Alabama. Moderate traffic, fail by decay.
	I. & G. N.	F. S. Schwinn	12–15	8–10			Texas. Moderate traffic. Failure in case of unplated ties, decay and mechanical, with plated ties, decay.
Elm	M. P.	E. A. Hadley		10			Ark. and La. Failure by decay principally.
	Penna.	W. C. Cushing	4		4		Heavy traffic, failures mechanical.
	Penna.	W. C. Cushing	12		14		Light traffic.
	S. A. L.	J. L. Kirby		7			Failures mechanical.
	Bost. & A.	F. S. Freeman		7			Mass. Heavy and dense traffic. Failures 40% mechanical.
	Southern	B. Herman	14	9			Ala., N. C., S. C., Ga.
	S. P. Lines	J. D. Isaacs	11.5	10			Tex. and La. Failures mechanical.
	G. H. & S. A.	A. W. P. A.	15.2	15.2			Note "A". Watkins, C. O.
	H. V.	A. Crable	7	5			Ohio, failure mechanical.
	Penna.	W. C. Cushing	2		6		Heavy traffic, failures mechanical.
	Penna.	W. C. Cushing	3		12		Light traffic.
	N. P.	B. Blum			16–18		Wis., Minn., N. D., failures mechanical. Lowry process, 22# creosote per 7"x8" tie.
Fir	B. & Gar.	H. C. Goodrich	5				Location Utah. Heavy traffic. Failure by mechanical wear. No decay.
	D. & H.	J. MacMartin	10	6			N. Y., Penna., Vt. Failures 50% mechanical.
	Penna	W. C. Cushing	5		7		Heavy traffic, failures mechanical.
	Penna.	W. C. Cushing	8		16		Light traffic.
	U. P.	R. L. Huntley	7–8		10–11		Zinc chloride treatment.
	D. & R. S.	J. G. Gwyn	9	6			Usually fail by decay.
	S. P. Co. (Pac. Sys.)	J. D. Isaacs	7	6	10	8	Ore., Cal., Nev., Utah, Ariz., N. M. Fail principally by decay. Four-tenths pound per cubic foot zinc chloride treatment.
	N. P.	A. W. P. A.		7.5			Note "A." Heavy traffic, Maywood, Washington.
	N. P.	B. Blum	6–7		12–15		Mont., Ore., Idaho, Washington. Lowry process, 22# creosote per 7"x8" tie.

TABLE A—RESULTS REPORTED WITH TIES 7 IN. THICK—(Continued)

Kind of Wood	Railroad	Reported by	Years' Service Obtained: Untreated T. P.	Untreated U. P.	Treated T. P.	Treated U. P.	Remarks
Gum	I. & G. N.	F. S. Schwinn	5	3	10–12	8–10	Texas, moderate traffic. Plated ties fail by decay, unplated by mechanical wear and decay.
	L. & N.	R. M. Leeds			12		
	Penna.	W. C. Cushing	2		10		Heavy traffic, failures mechanical.
	Penna.	W. C. Cushing	2		14		Light traffic.
	S. P. Lines	J. D. Isaacs	7	6	10	10	Tex. and La., fail by decay.
Hackberry	Penna.	W. C. Cushing	3		12		Light traffic.
	Penna.	W. C. Cushing	2		6		Heavy traffic, failures mechanical.
Hemlock	Grand Trk.	M. S. Blaiklock	6	4	8	6	Heavy traffic.
	Penna.	W. C. Cushing	3		7		Heavy traffic, failures mechanical.
	Penna.	W. C. Cushing	4		14		Light traffic.
	N. P.	A. W. P. A.		7.3			Note "A." Maywood, Washington, heavy traffic.
	N. P.	B. Blum	5–6		12–15		Mont., Ore., Idaho, Washington. Lowry process, creosote 22# per 7"x8" tie.
Hickory	H. V.	A. Crable		3			Ohio, failure due to worm eaten.
	L. & N.	R. M. Leeds			15		Kentucky.
	Penna.	W. C. Cushing	3		10		Heavy traffic, failures mechanical.
	Penna.	W. C. Cushing	3		16		Light traffic.
Larch	D. & I. R.	W. A. Clark	9	8			Minn., failure of tie, plated ties principally decay. Heavy traffic.
	Penna.	W. C. Cushing	3		7		Heavy traffic, failures mechanical.
	Penna.	W. C. Cushing	6		14		Light traffic.
	N. P.	B. Blum	7–8		12–15		Wis., Minn., N. D. Treated ties fail by mechanical wear. Lowry process, 22# creosote per 7"x8" tie.
Locust—Honey	Penna.	W. C. Cushing	3		10		Heavy traffic, failures mechanical.
	Penna.	W. C. Cushing	3		16		Light traffic.
Locust—Black	Southern	B. Herman	17	12			S. C., Va.
Maple	Penna.	W. C. Cushing	4		10		Hard maple, heavy traffic. Mechanical failures.
	Penna.	W. C. Cushing	4		14		Hard maple, light traffic.
	Penna.	W. C. Cushing	2		6		Soft maple, heavy traffic. Mechanical failures.
	Penna.	W. C. Cushing	2		12		Soft maple, light traffic.
	N. P.	B. Blum			16–18		Wis., Minn., N. D., failures mechanical. Lowry process, 22# creosote per 7"x8" tie.
Mulberry	H. V.	A. Crable	8				Ohio, failure by decay.
Oak—Red or Black	B. & M.	F. A. Merrill	4–5				Location New England.
	C. of Ga.	C. E. Weaver	3		15		Location Ga. and Ala. The 15 years' life secured with creosote. Same ties with zinc treatment only last 6 years.
	G. F. & A.	A. S. Butterworth		3			Ala. Moderate traffic, fail by decay.

TABLE A—RESULTS REPORTED WITH TIES 7 IN. THICK—(Continued)

Kind of Wood	Railroad	Reported by	Years' Service Obtained: Untreated T. P.	Untreated U. P.	Treated T. P.	Treated U. P.	Remarks
Oak—Red or Black	H. V.	A. Crable	4	4			Ohio. Fail by decay. Red oak superior to black.
	I. & G. N	F. S. Schwinn	6	4	12	10	Texas. Moderate traffic. Plated ties fail by decay, unplated by mechanical wear and decay.
	Long I	J. R. Savage		3.5			90% of failures due to decay.
	L. & N	R. M. Leeds		4	15		
	M. & O	B. A. Wood	4	3			Mississippi. 25% fail mechanically.
	Penna	W. C. Cushing	5		10		Heavy traffic, failures mechanical.
	Penna	W. C. Cushing	5		16		Light traffic.
	N. Y. C. & St. L	C. E. Denny		6		15	Failures mechanical. Treatment creosote and zinc chloride.
	C. C. C. & St. L	C. A. Paquette	4	4	18	12	Empty cell creosote.
	Southern	B. Herman	3	3			Va., N. C., S. C., Ga., Ala., Ky., Ill.
	Penna. L	A. W. P. A	5.8				Note "A," Scio, Ohio.
	N. P	B. Blum			16–18		Wis., Minn., N. D., failures mechanical. Lowry process, 22# creosote per 7"x9" tie.
Oak—White	A. B. & A	L. L. Beal		7			
	A. C. L	L. L. Sparrow		10			Location Va., N. C. and S. C. Failure by decay.
	B. & M	F. A. Merrill	7–9				Location New England.
	C. of Ga	C. E. Weaver		7			Location Ga. and Ala. Failure by decay. Medium and light traffic.
	D. & H	J. MacMartin	12	8			N. Y., Penna., Vt. Failures 50% mechanical.
	E. P. & S. W	J. L. Campbell		8			Failure by decay.
	H. V	A. Crable	12	8			Ohio. Failure mechanical.
	I. & G. N	F. S. Schwinn	9–10	6–8			Texas. Moderate traffic. Plated ties fail by decay, unplated by decay and mechanical wear.
	Long I	J. R. Savage		8			90% of failures due to decay.
	L. & N	R. M. Leeds		7			
	M. & O	B. A. Wood	8	7			Illinois. 25% fail by mechanical wear.
	Penna	W. C. Cushing	9		10		Heavy traffic, failures mechanical.
	Penna	W. C. Cushing	12		16		Light traffic.
	R. F. & P	S. B. Rice	8	7			Virginia. Failures 50% decay.
	S. A. L	J. L. Kirby		7			Failures by decay.
	U. P	R. L. Huntley	9–10				
	N. Y. C. & St. L	C. E. Denney	10	8	15	10	Failures mechanical. Treatment creosote and zinc chloride.
	S. P. Lines	J. D. Isaacs	8	8			Tex. and La. Failure by decay.
	C. C. C. & St. L	C. A. Paquette	4	6	18	12	Empty cell creosote.
	Southern	B. Herman	7	4			Va., N. C., S. C., Ga., Tenn., Ky., Ala.
	B. & O	E. Stimson	9	8			Middle Atlantic and Central Western. Fail by decay.
	N. P	B. Blum		12			Wis., Minn., North Dakota.

TABLE A—RESULTS REPORTED WITH TIES 7 IN. THICK—(Continued)

Kind of Wood	Railroad	Reported by	Years' Service Obtained: Untreated T. P.	Untreated U. P.	Treated T. P.	Treated U. P.	Remarks
Pine—Loblolly	C. of Ga.	C. E. Weaver			15		Ties creosoted empty cell. Location Ga. and Ala. Failure by mechanical wear. Medium and light traffic.
	I. & G. N.	F. S. Schwinn	3	3	7–10	5–7	Texas. Moderate traffic. Failure by decay.
	G. H. & S. A.	A. W. P. A.				5.7	Note "A," Bay View Zn. Cl.
Pine—So. Yellow	A. B. & A.	L. L. Beal		6			
	A. C. L.	L. L. Sparrow	6				Location Va., N. C., S. C., Ga., Fla. and Ala. Failure by decay.
	C. of Ga.	C. E. Weaver		7			Location Ga. and Ala. Failure by decay. Medium and light traffic.
	D. & H.	J. MacMartin	12	8			N. Y., Penna., Vt. Failures 50% mechanical.
	E. P. & S. W.	J. L. Campbell		6–8	12–15		Untreated fail by decay. Treated ties fail by mechanical wear. Treatment creosote. Reuping.
	G. F. & A.	A. S. Butterworth		5			Florida and Ala. Moderate traffic. Fail by decay.
	Long. I.	J. R. Savage		9		18	90% of failures due to decay.
	M. & O.	B. A. Wood	7	6			Ala. 25% fail mechanically.
	Penna.	W. C. Cushing	6		8		Heavy traffic, failures mechanical.
	Penna.	W. C. Cushing	12		16		Light traffic.
	N. Y. C. & St. L.	C. E. Denney		7		10	Failures mechanical. Treatment creosote and zinc chloride.
	Bost. & A.	F. S. Freeman	8.5	7.5			Location Mass. Traffic heavy and dense. Failures 60% decay.
	Southern	B. Herman	8	6			Va., N. C., S. C., Ga., Ala., La., Miss.
	G. H. & S. A.	A. W. P. A.		4.0		15.6	Note "A." Zinc creosote treatment.
	B. & O.	E. Stimson	9	7			Pa., Md., W. Va. Fail by decay.
	S. Air Line	J. L. Kirby		7			Failures by decay.
Pine—Western Yellow	U. P.	R. L. Huntley	6–7		10–11		Zinc chloride treatment.
	D. & R. G.	J. G. Gwyn	8	6			Usually fail by decay.
	Southern	B. Herman	8	6			Va., N. C., S. C., Ga., Ala., La., Miss.
	S. P. Lines	J. D. Isaacs	8	6			Tex. and La. Fail by decay.
	N. P.	B. Blum			12–15		Mont., Ore., Idaho and Wash. Lowry process, 22# creosote per 7"x8" tie.
Redwood	S. P. Co. (Pac. Sys.)	J. D. Isaacs	11	6			Ore., Cal., Nev., Utah, Ariz., N. M., failures principally decay.
Spruce	D. & R. G.	J. G. Gwyn	8	6			Failures usually decay.
	N. P.	B. Blum			12–15		Mont., Ore., Idaho, Wash. Failures mechanical. Lowry process, 22# creosote per 7"x8" tie.
Sycamore	Penna.	W. C. Cushing	2		6		Heavy traffic, failures mechanical.
	Penna.	W. C. Cushing	2		12		Light traffic.
Walnut	H. V.	A. Crable	15	12			Ohio, failure by decay.
	L. & N.	R. M. Leeds		7			Kentucky.
Walnut (White)	Penna.	W. C. Cushing	1		1		Heavy traffic, failures mechanical.
	Penna.	W. C. Cushing	2		10		Light traffic.

TABLE A—RESULTS REPORTED WITH TIES 6 IN. THICK

Kind of Wood	Railroad	Reported by	Years' Service Obtained				Remarks
			Untreated		Treated		
			T. P.	U. P.	T. P.	U. P.	
Ash	C. G. W.	C. G. Delo	5		15–18		Location Illinois to Wyoming and Missouri to So. Dakota.
	C. B. & Q.	A. W. Newton	5.0				97.4% of ties placed in 1909 removed account decay.
	Lake Sup. & I.	R. C. Young		6.4			Heavy traffic. Failures mostly decay.
	St. L.-S. F.	F. G. Jonah			14	8	Mo., Kans., Okla., Ark. Lowry process, 2½ gals. per tie.
Beech	C. P. R.	J. Fairbairn	7	6			
	C. G. W.	C. G. Delo	4.1		15–18		Location Ill. to Wyo. and Mo. to So. Dak. Untreated ties fail by decay. Treated ties by mechanical wear.
	Grand Trunk	M. S. Blaiklock			11	6	Canada.
	Mich. Cent.	Geo. H. Webb			15	15	None removed after 11 years. Lowry process, 2½ gals. creosote per tie.
	C. B. & Q.	A. W. Newton	4.2				96.1% of ties placed in 1909 removed account decay.
	C. C. C. & St. L.	C. A. Paquette			18	12	Empty cell creosote treatment.
Birch	C. P. R.	J. Fairbairn	7	6			
	C. G. W.	C. G. Delo	3.4		12–15		Location Ill. to Wyo. and Mo. to So. Dak. Untreated ties fail by decay.
	C. B. & Q.	A. W. Newton	3.5				100% of ties placed in 1909 removed account decay.
	Grand Trunk	M. S. Blaiklock			12	5	Canada.
	Mich. Cent.	Geo. H. Webb			15	15	None removed after 11 years. Treatment Lowry creosote 2½ gals. per tie.
Cedar	Ann Arbor	L. J. Allen	10	5			Fail mechanically. Location Michigan.
	Bang. & A.	M. Burpee	15	11			Location Maine. Moderate traffic. Failure by mechanical wear.
	C. P. R.	J. Fairbairn	20	12			Under light traffic.
	C. G. W.	C. G. Delo	15				Location Ill. to Wyo. and Mo. to So. Dak. Fail by decay.
	C. M. & St. P.	F. S. Pooler	20				Michigan.
	C. R. I. & P.	C. F. Ford	17.2				Heavy traffic, failure mechanical.
	D. T. & I.	H. B. Watters		10			Ohio, failure mechanical.
	Grand Trunk	M. S. Blaiklock	16.5	10			Light traffic.
	Lake S. & I.	R. C. Young		13.4			Light traffic, failures mechanical.
	Maine Cent.	G. F. Black	8.5	1–10			New England. Mostly light traffic.
	Mich. Cent.	Geo. H. Webb	6				Failure mechanical. Same ties in side track last 10 years.
	M. K. & T.	F. Ringer	12	8	12	8	Okla. Failures mechanical.
	W. C. F. & N.	T. E. Rust	12	8			Iowa. Electric line, light traffic, failures mechanical.
	G. C. & S. F.	F. Merritt	16	12	25	20	Tex., La. and Okla. Treatment creosote. Failures of treated ties mechanical under heavy traffic.
	C. C. C. & St. L.	C. A. Paquette	15	8			
	C. & N. W.	W. J. Towne	15	12			Illinois. Failures mechanical.
Cherry	C. P. R.	J. Fairbairn	8	7			
	St. L.-S. F.	F. G. Jonah			14	8	Mo., Kans., Okla., Ark. Lowry process, 2½ gals. per tie.

TABLE A—RESULTS REPORTED WITH TIES 6 IN. THICK—(Continued)

Kind of Wood	Railroad	Reported by	Years' Service Obtained				Remarks
			Untreated		Treated		
			T. P.	U. P.	T. P.	U. P.	
Chestnut	C. P. R.	J. Fairbairn	8	7			
	C. G. W.	C. G. Delo	9				Location Ill. to Wyo. and Mo. to So. Dak. Failures by crushing.
	Grand Trunk	M. S. Blaiklock	6	4	7	4	Failures mostly mechanical.
	Mich. Cent	Geo. H. Webb	4	4			Failures both mechanical and decay. Same ties in side track last 6 years.
	N. Y. C. & St. L.	C. E. Denney	5	4	6	5	Failure by mechanical wear. Treatment creosote and zinc chloride.
	C. B. & Q.	A. W. Newton	10.0				About 40% of ties placed in 1909 still in track.
	C. C. C. & St. L.	C. A. Paquette	8	6			
Cypress	C. G. W.	C. G. Delo	7		15–18		Location Ill. to Wyo. and Mo. to So. Dak. Treated ties fail by mechanical wear, untreated by decay.
	C. B. & Q.	A. W. Newton	8				About 20% of ties placed in 1909 still in track.
	F. E. C.	H. N. Rodenbaugh		4			Florida. Failure mechanical.
	Grand Trunk	M. S. Blaiklock	12				Light traffic.
	I. & G. N.	F. S. Schwinn	8–10	5–7			Texas. Moderate traffic.
	M. K. & T.	F. Ringer	10	7	10	7	Texas.
	St. L.-S. F.	F. G. Jonah	4	3	14	8	Ark., Mo. Lowry process, $2\frac{1}{2}$ gals. creosote.
	N. Y. C. & St. L.	C. E. Denney		6	12	10	Failures mechanical. Treatment creosote and zinc chloride.
	G. C. & S. F.	F. Merritt	14	11			Tex., La. and Okla.
	Tex. & Pac.	R. H. Gaines	10	8			La. Fail by decay.
	C. & N. W.	W. J. Towne	5		7		Illinois.
Elm	C. P. R.	J. Fairbairn	7	6			
	C. G. W.	C. G. Delo	6		12–15		Location Ill. to Wyo. and Mo. to So. Dak.
	C. B. & Q.	A. W. Newton	4.8				92.5% of ties placed in 1909 removed account decay.
	St. L.-S. F.	F. G. Jonah			14	6	Lowry process, $2\frac{1}{2}$ gals. creosote per tie.
	N. Y. C. & St. L.	C. E. Denney	5	4	6	5	Failures mechanical. Treatment creosote and zinc chloride.
	G. C. & S. F.	F. Merritt	4	3			Tex., La. and Okla.
Fir	C. P. R.	J. Fairbairn	10	8			
	C. G. W.	C. G. Delo	6		14–16		Location Ill. to Wyo. and Mo. to So. Dak.
	Grand Trunk	M. S. Blaiklock	8	6			Medium traffic.
	N. Y. C. & St. L.	C. E. Denney		6		12	Failures mechanical. Treatment creosote and zinc chloride.
Gum	C. G. W.	C. G. Delo	5		12–15		Location Ill. to Wyo. and Mo. to So. Dak.
	C. B. & Q.	A. W. Newton	3.3				All placed in 1909 removed account decay.
	I. & G. N.	F. S. Schwinn	4	2	7–10	6–7	Texas. Moderate traffic.
	M. K. & T.	F. Ringer	8	6	12	8	Oklahoma and Texas.
	St. L.-S. F.	F. G. Jonah			14	7	Lowry process, $2\frac{1}{2}$ gals. creosote per tie.
	N. Y. C. & St. L.	C. E. Denney	5	4	6	5	Failures mechanical. Treatment creosote and zinc chloride.
	G. C. & S. F.	F. Merritt	4.5	3.5	16	12	Tex., La. and Okla. Creosote treatment. Failures of treated ties under heavy traffic mechanical.

TABLE A—RESULTS REPORTED WITH TIES 6 IN. THICK—(Continued)

Kind of Wood	Railroad	Reported by	Years' Service Obtained — Untreated T. P.	Untreated U. P.	Treated T. P.	Treated U. P.	Remarks
Gum —Cont'd	C. C. C. & St. L.	C. A. Paquette			15	9	Empty cell creosote.
	S. P. Lines	J. D. Isaacs	5	5	8	8	Tex. and La., fail by decay.
	G. H. & S. A.	A. W. P. A.				8.5	Note "A"—Bay View—zinc creosote.
	G. H. & S. A.	A. W. P. A.			6.7		Note "A"—Bay View—zinc chloride.
Hackberry	St. L.-S. F.	F. G. Jonah			14	8	Lowry process, 2½ gals. per tie.
Hemlock	C. P. R.	J. Fairbairn	6	5			
	C. G. W.	C. G. Delo	4.7		12–15		Location Ill. to Wyo. and Mo. to So. Dak.
	C. B. & Q.	A. W. Newton	4.6				99.5% of ties placed in 1909 removed account decay.
	Lake S. & I.	R. C. Young		8.1			Heavy traffic, failures mostly decay.
	Mich. Cent.	Geo. H. Webb	6	5			Side tracks in Mich. only, failures both mechanical and decay.
	C. & N. W.	W. J. Towne		4	10	8	Ill. Failures by decay.
	C. & N. W.	A. W. P. A.		6.5			Note "A"—Jonesville, Wis.
	C. & N. W.	A. W. P. A.		6.3			Note "A"—Jonesville, Wis.
Hickory	C. G. W.	C. G. Delo	5		12–15		Location Ill. to Wyo. and Mo. to So. Dak.
	St. L.-S. F.	F. G. Jonah			14	8	Lowry process, 2½ gals. per tie.
	C. B. & Q.	A. W. Newton	4.9				90.5% of ties placed in 1909 removed account decay.
Larch	C. P. R.	J. Fairbairn	10				
	C. G. W.	C. G. Delo	4.6		12–15		Location Ill. to Wyo. and Mo. to South Dakota.
	N. P.	F. S. Pooler	7.3				Reported by C. M. & St. P. Ry.
	D. W. & P.	J. L. Pickles	7–9				
	Lake S. & I.	R. C. Young		6.8			Heavy traffic, failures mostly decay.
Locust	C. G. W.	C. G. Delo	20				Location Ill. to Wyo. and Mo. to So. Dak., failure by decay.
	St. L.-S. F.	F. G. Jonah			14	8	Lowry process, 2½ gals. creosote per tie.
Maple	C. P. R.	J. Fairbairn	7	6			
	C. G. W.	C. G. Delo	3.6		12–15		Location Ill. to Wyo. and Mo. to So. Dak.
	C. B. & Q.	A. W. Newton	3.9				Hard maple, 98% of ties placed in 1909 removed account decay.
	Grand Trunk	M. S. Blaiklock			12	10	Heavy traffic.
	Mich. Cent.	Geo. H. Webb			15	15	None removed after 11 years. Treatment Lowry creosote 2½ gals. per tie.
	St. L.-S. F.	F. G. Jonah			14	8	Lowry process, 2½ gals. creosote per tie.
	C. B. & Q.	A. W. Newton	3.2				Soft maple, 98.4% of ties placed in 1909 removed account decay.
	C. & N. W.	W. J. Towne		4	9	8	Illinois.
Oak—Pin	C. B. & Q.	A. W. Newton		5.5			92.8% of ties placed in 1909 removed account decay.
	Ann Arbor	L. J. Allen	4	4			Fail by decay. Location Mich.
Oak—Red or Black	C. P. R.	J. Fairbairn	5	4			
	C. & A.	H. T. Douglas, Jr.				13	Zinc treated, failure 75% decay, moderate traffic.
	C. G. W.	C. G. Delo	5		15–18		Location Ill. to Wyo. and Mo. to So. Dakota.
	C. M. & St. P.	F. S. Pooler				15	Wisconsin.

TABLE A—RESULTS REPORTED WITH TIES 6 IN. THICK—(Continued)

Kind of Wood	Railroad	Reported by	Years' Service Obtained				Remarks
			Untreated		Treated		
			T. P.	U. P.	T. P.	U. P.	
Oak—Red or Black—Cont'd	D. T. & I.	H. B. Watters		4			Ohio, failure by decay.
	E. J. & E.	A. Montzheimer			11–14		Zinc, chloride treatment, A. R. E. A. spec. Heavy traffic, failure principally decay.
	Grand Trunk	M. S. Blaiklock			11	11	
	I. & G. N.	F. S. Schwinn	3	2	9–10	8–9	Texas, moderate traffic.
	Mich. Cent.	Geo. H. Webb			15	15	None removed after 11 years. Treatment Lowry creosote, 2½ gals. per tie.
	M. K. & T.	F. Ringer	6	5	12	8	Mo., Kans. and Okla.
	M. P.	E. A. Hadley				10	Mo., Kans. and Neb., zinc chloride treated. Failures principally by decay.
	St. L.-S. F.	F. G. Jonah			15	10	Lowry process, 2½ gals. per tie.
	W. C. F. & N.	T. E. Rust		5	14		Electric line, light traffic.
	G. C. & S. F.	F. Merritt	4	4	16	14	Tex., La. and Okla. Treatment creosote.
	C. B. & Q.	A. W. Newton		4.9			93.7% of ties placed in 1909 removed account decay.
	C. C. C. & St. L.	C. A. Paquette	4	4	18	12	Empty cell creosote.
	Tex. & Pac.	R. H. Gaines	4	3	15	12	Tex. and Ark., creosote treatment.
	S. P. Lines	J. D. Isaacs	4	4			Tex. and La. Fail by decay.
	B. & O.	A. W. P. A.		7.7			Note "A," Medora, Ind. Chestnut, oak.
	C. & N. W.	W. J. Towne	5	5	10	8	Ill., untreated ties fail by decay.
Oak White	Ann Arbor	L. J. Allen	8	8			Fail by decay. Location Mich.
	C. P. R.	J. Fairbairn	7	6			
	C. G. W.	C. G. Delo	8		15–18		Location Ill. to Wyo. and Mo. to So. Dakota.
	C. M. & St. P.	F. S. Pooler		8			Iowa. Heavy traffic.
	D. T. & I.	H. B. Watters		8			Ohio, failure by decay.
	E. J. & E.	A. Montzheimer	8–9	7–8			Ill. and Ind. Heavy traffic. Fail by decay.
	Grand Trunk	M. S. Blaiklock	8	8			Heavy traffic.
	G. F. & A.	A. S. Butterworth		5			Ala., moderate traffic, fail by decay.
	I. & G. N.	F. S. Schwinn	7–8	5–7			Tex., moderate traffic.
	Lake S. & I.	R. C. Young		11.3			Heavy traffic, failures mostly decay.
	Mich. Cent.	Geo. H. Webb	7–8	7–8			Failure by decay.
	M. K. & T.	F. Ringer	9	8	12	10	Mo., Kans. and Okla.
	M. P.	E. A. Hadley		12			Eastern Colo. Failure by decay principally.
	M. P.	E. A. Hadley		10			Mo. and Kans. Failure by decay principally.
	M. P.	E. A. Hadley		9			Ark. and La. Failure by decay principally.
	N. & W.	J. E. Crawford	8	8			Practically all fail by decay.
	St. L.-S. F.	F. G. Jonah	8	7			
	T. R. R. A. of St. L.	H. J. Pfeifer	7–8	7–8			Heavy traffic, failures principally decay.
	Bost. & Alb.	F. S. Freeman	6	6			Location Mass. Heavy and dense traffic, failures 60% decay.
	G. C. & S. F.	F. Merritt	8.5	8.5	16	14	Tex., La. and Okla. Treatment creosote.
	C. B. & Q.	A. W. Newton					40.3% of ties placed in 1909 removed account decay and 4.1% other causes.

TABLE A—RESULTS REPORTED WITH TIES 6 IN. THICK—(Continued)

Kind of Wood	Railroad	Reported by	Years' Service Obtained				Remarks
			Untreated		Treated		
			T. P.	U. P.	T. P.	U. P.	
Oak—White—Cont'd	C. C. C. & St. L.	C. A. Paquette	11	8	....	....	Failure by decay.
	Tex. & Pac.	R. H. Gaines	7	5	....	....	Tex. and Ark. Fail by decay
	C. & N. W.	W. J. Towne	....	11	....	....	Illinois
Pine—Heart	C. G. W.	C. G. Delo	9	....	....	....	Location Ill. to Wyo. and Mo. to So. Dak.
	C. M. & St. P.	F. S. Pooler	12.1	....	....	....	Wisconsin.
Pine—Jack	Alg. Cent. & H. B.	R. S. McCormick	8	8	....	....	Failure by decay, light traffic. Location Ontario.
	C. P. R.	J. M. Fairbairn	8	6	....	....	....
	Grand Trunk	M. S. Blaiklock	8	5	....	....	Heavy traffic.
	Temis. & N. O.	S. B. Clement	9	7	....	....	Light traffic.
Pine—Loblolly	G. C. & S. F.	F. Merritt	3.5	2.5	16	10	Tex., La. and Okla. Treatment creosote. Failures of treated ties under heavy traffic mechanical.
	C. B. & Q.	A. W. Newton	4.7	....	....	....	91.9% of ties placed in 1909 removed account decay.
Pine—Princess	Bost. & Alb.	F. S. Freeman	....	9	....	....	Location Mass. Heavy and dense traffic, failures 60% decay.
Pine—So. Yellow	B. & M.	F. A. Merrill	6–9	....	....	....	Location New England.
	C. G. W.	C. G. Delo	4	....	12–15	....	Location Ill. to Wyo. and Mo. to So. Dak.
	F. E. C.	H. N. Rodenbaugh	....	4	....	....	Fla. Failures account "bled" timber.
	Grand Trunk	M. S. Blaiklock	....	....	10	8	Heavy traffic.
	I. & G. N.	F. S. Schwinn	2	2	5–8	4–6	Texas. Moderate traffic.
	M. P.	E. A. Hadley	....	....	10	....	Mo., Kans., Ark. and La. Zinc chloride treated. Failures by decay.
	St. L.-S. F.	F. G. Jonah	....	....	16	7	Lowry process, $2\frac{1}{4}$ gals. creosote per tie.
	G. C. & S. F.	F. Merritt	7	6	16	12	Longleaf—Tex., La. and Okla. Creosote treatment.
	G. C. & S. F.	F. Merritt	4.5	3	16	12	Shortleaf—Tex., La. and Okla. Creosote treatment.
	Tex. & Pac.	R. H. Gaines	8	6	12	10	La., Tex. and Ark. Failures by decay. Creosote treatment.
Pine—Western Yellow	C. G. W.	C. G. Delo	4	....	12–15	....	Location Ill. to Wyo. and Mo. to So. Dak.
	M. K. & T.	F. Ringer	6	5	12	8	....
Redwood	C. G. W.	C. G. Delo	12	....	....	....	Location Ill. to Wyo. and Mo. to So. Dak.
Spruce	C. P. R.	J. Fairbairn	7	5	....	....	....
Sycamore	C. G. W.	C. G. Delo	3	....	12–15	....	Location Ill. to Wyo. and Mo. to So. Dak.
	C. B. & Q.	A. W. Newton	3.3	....	....	....	87% of ties placed in 1909 removed account decay.
	St. L.-S. F.	F. G. Jonah	....	....	16	8	Lowry process, $2\frac{1}{4}$ gals. creosote per tie.
Tamarack	C. B. & Q.	A. W. Newton	4.7	....	....	....	97.9% of ties placed in 1909 removed account decay.
	C. & N. W.	W. J. Towne	....	5	12	9	Illinois.
Walnut	C. G. W.	C. G. Delo	12	....	....	....	Location Ill. to Wyo. and Mo. to So. Dak.

T. P. stands for tie plated.
U. P. stands for unplated.
Note "A"—Taken from 1917 Proceedings of American Wood Preservers 'Association

Exhibit A

Assuming that the different sizes (grades) of ties will be received more or less mixed, in application to track, which would you prefer putting together—

(a) Ties of the same width on top, or

(b) Ties of the same thickness, and why?

Those favoring (a), ties of the same width on top:

Railroad	Reported By	Reasons
A. B. & A.	L. L. Beal	More uniform bearing.
Bangor & Aroostook	M. Burpee	....
Bingham & Garfield	H. C. Goodrich	To obtain full bearing surface for tie plates and rail.
C. G. W.	C. G. Delo	More uniform spacing.
D. & H	James MacMartin	No preference.
D. T. & I.	H. B. Watters	Uniform spacing, uniform bracing.
E. J. & E.	A. Montzheimer	So as to secure equal bearing. This might be accomplished in case ties were of different widths by judicious spacing, but it would be difficult, if not impossible, to secure uniform bearing.
E. P. & S. W.	J. L. Campbell	No preference.
F. E. C.	H. N. Rodenbaugh	Account uniform bearing and better to maintain tracks.
K. C. T.	John V. Hanna	For new work on account of better bearing for rail and tie plates for main line work and getting the small ties into sidetrack work.
Lake Superior & I.	R. L. Young	Not material except in rock ballast.
L. & N.	R. M. Leeds	Tamping area more uniform and weight distributed to ballast equally. Resistance to mechanical wear greater.
N. & W.	J. E. Crawford	Prefer putting together ties of same width on top rather than of same thickness, as some advantage may be gained in renewing ties from this method, although believe it is immaterial whether or not ties are separated in this manner.
Penna.	W. C. Cushing	It is believed the bearing will be more uniform.
T. R. R. A. of St. L.	H. J. Pfeifer	A more uniform track will be secured by using the ties as they come.
Boston & Albany	F. B. Freeman	Account of standard spacing of ties, prefer same width to get uniform bearing throughout panel.
D. & R. G.	J. G. Gwyn	....
Texas & Pacific	R. H. Gaines	To get uniform spacing.
C. & N. W.	W. J. Towne	For renewals would use the ties mixed but for new work would prefer to keep separated.
B. & O	E. Stimson	With specifications providing for only 1" more than standard thickness, would prefer ties of the same width, as this would give uniform bearing.
Nor. Pacific	Bernard Blum	In order to obtain more uniform bearing support

Those favoring (b), ties of the same thickness:

Railroad	Reported By	Reasons
Algoma Cent. & H. B.	R. S. McCormick	To obtain better surface.
Ann Arbor	L. J. Allen	Easier to keep track in surface.
Atl. Coast Line	L. L. Sparrow	Difference in width may be corrected by spacing.
B. & O. Ch. Term.	G. P. Palmer	To obtain better bearing.
Boston & Maine	F. A. Merrill	Account of frost.
Canadian Pac.	J. M. R. Fairbairn	In order not to distort bed of track.
Cent. of Ga.	C. E. Weaver	More important to have uniformity of thickness, in order to have tie beds in the same plane.
C. M. & St. P.	E. S. Pooler	Because of more uniform strength.
C. R. I. & P.	C. F. Ford	For sake of uniformity.
D. & Hudson	J. MacMartin	No preference.
Duluth & Iron Rg.	W. A. Clark	Account more uniform disturbance of ballast.
D. W. & Pac.	J. L. Pickles	Account surface.
E. P. & S. W.	J. L. Campbell	No preference.
Grand Trunk	M. S. Blaiklock	Because bearing on ballast would be on a uniform plane and be more easily tamped, ties would be uniformly resisting and give more uniform and longer waves in deflection of rail.

Exhibit A

Question 2—(Continued)

Those favoring (b), ties of the same thickness:

Railroad	Reported By	Reasons
C. C. C. & St. L.	C. A. Paquette	Better tamping can be obtained.
B. & L. E.	F. R. Layng	When renewals are made there is less disturbance of the tamped bed and less labor required to insert the new tie.
Southern	B. Herman	Better sub-drainage and uniform support. Less labor to renew. Less disturbance to roadbed in renewals.
S. P. Lines	J. D. Isaacs	Better surface and drainage.
S. P. Co. (Pac. Sys.)	J. D. Isaacs	Southern Pacific Co., Pacific System, has two standard ties, 7"x10" for primary main lines and 7"x9" for secondary main lines and branch lines. These standards are rigidly adhered to and specifications do not permit of more than 1" variation in width, or ½" over in thickness for fir ties, or ½" one way in redwood or cedar ties. Ties of the same thickness should be used to keep track more uniform and maintenance less difficult.
W. C. F. & N.	T. E. Rust	To obtain uniform depth of ballast. Ties of varying widths can be spaced to compensate.
N. Y. C. & St. L.	C. E. Denny	Ties of same thickness, better surface can be maintained on established bed.
G. C. & S. F.	F. Merritt	To secure uniform depth of surfacing material under the tie.
C. B. & Q.	A. W. Newton	Prefer ties of same thickness. This insures better track conditions and maintains uniform ballast depth under ties—assuming that ballast is generally of the same depth over a given stretch of track.
G. & S. I.	H. V. Gardner, Jr.	Account not disturbing bearing.
G. F. & A.	A. S. Butterworth	Ease of surfacing.
Hocking Valley	A. Crable	So that bed under ties will be uniform.
I. & G. N.	F. S. Schwinn	Account desirable to maintain uniform thickness of ballast.
K. C. T.	John V. Hanna	For renewal purposes same thickness as those already in track, in order that disturbance of tie beds might be a minimum.
L. E. & W.	J. K. Conner	This would result in less disturbance to the roadbed, assuming that ties of the same thickness were available when repairs and renewals were necessary.
Lake Superior & I.	R. C. Young	Not material except in rock ballast.
Long Island	J. R. Savage	Account of more uniform bearing surface.
Maine Central	G. F. Black	Account of frost.
Michigan Central	Geo. H. Webb	Account of least disturbance to old bed in renewals—bearing surface of rail on ties may be kept uniform per rail length by increasing or decreasing number of ties per rail irrespective of widths.
M. K. & T.	F. Ringer	Account better surface.
M. P.	E. A. Hadley	Smoother track with less disturbance of tamped ballast bed.
M. & O.	B. A. Wood	Better surface.
R. F. & P.	S. B. Rice	Account of the rigidity of the thick ties.
St. L.-S. F.	F. G. Jonah	Renewals can be made with less disturbance, of old tie bed.
S. A. L.	J. L. Kirby	Account of bearing.
Tenn. & N. O.	S. B. Clement	Ties can be renewed more readily and in the spring when the frost is coming out of the roadbed a more uniform bearing can be obtained. If there is an appreciable difference in the thickness of adjoining ties, the thicker ones will have a solid bearing on the frozen ballast, when the thinner one is resting on yielding ballast free from frost.

Exhibit A

Question 3

Assuming that you were to receive only ties with rounded sides of grade 3, which would you prefer, all 6 in. by 8 in. or all 7 in. by 7 in., and why?

Those favoring all 6 in. by 8 in. ties:

Railroad	Reported By	Reasons
Ann Arbor	L. J. Allen	Better top surface for holding tie plates and better bottom surface for bearing in ballast.
A. B. & A	L. L. Beal	More bearing surface.
B. & O. C. T	G. P. Palmer	Seven by seven inch tie should be eliminated or placed in a new class. Two and one-half cents per tie lost sorting No. 3 ties now.
C. P. R	J. M. R. Fairbairn	For branch line track.
C. of Georgia	C. E. Weaver	Preferable account 14% more bearing area on tie bed.
C. R. I. & P	C. F. Ford	Tie with 8" face will permit the use of larger tie plate and better distribution of the load.
D. T. & I	H. B. Watters	Without tie plates and spacing for 6"x8".
D. W. & P	J. L. Pickles	Account more surface on tie.
E. J. & E	A. Montzheimer	The 7"x7" tie too narrow for the thickness and will not give as good a bearing as the 6"x8".
F. E. C	H. N. Rodenbaugh	Account better bearing, additional 1" in depth not sufficient to warrant the use of the 7"x7" as against the 6"x8".
G. & S. I	W. H. Gardner, Jr	Stronger and less liable to break under load.
G. F. & A	A. S. Butterworth	Greater bearing face.
I. & G. N	F. S. Schwinn	Greater bearing surface per tie, better support for rail.
K. C. T	J. V. Hanna	Better bearing for rail, tie plate or ballast and having slightly less sapwood.
L. E. & W	J. K. Conner	Assuming that ties in track were all 6"x8". This size has sufficient cross section for strength.
Long Island	J. R. Savage	If plated, account provision for mechanical wear for the length of the spike. If not plated, 7"x7".
L. & N	R. M. Leeds	More ballast tamped under ties. Tie acts as a beam only in center bound track, or where ties are swinging.
Michigan Central	Geo. H. Webb	Less ties per mile required to give necessary percentage of bearing surface of rail on ties per rail length.
M. K. & T	F. Ringer	Greater width of bearing surface, reducing mechanical wear.
P. R. R	W. . Cushing	Account greater width although deficient in beam strength. The 6"x8" tie is not satisfactory for heavy traffic. Ties should be 7"x9" or not less than 7"x8".
St. L.-S. F	F. G. Jonah	Because we expect to use a tie plate wider than 7".
T. R. R. A. of St. L.	H. J. Pfeifer	A 6" tie is thick enough to take a spike and an 8" bearing area is more desirable than a 7" bearing. The only feature that would make a 7" tie better is its lesser liability to break under the rail.
W. C. F. & N	T. E. Rust	No reason given.
N. Y. C. & St. L	C. E. Denney	Better surface can be maintained on established bed.
Boston & Albany	F. B. Freeman	In gravel ballast, for larger base.
G. C. & S. F	F. Merritt	With same number of ties per mile the 6"x8" ties would afford greater supporting surface.
C. C. C. & St. L	C. A. Paquette	Additional bearing surface is preferred to the additional depth.
Texas & Pacific	R. H. Gaines	More bearing surface needed.
B. & L. E	F. R. Layng	Would only use these two classes on light traffic lines or side tracks, so would prefer all 6"x8" because use of wider tie will assist in maintaining surface.
S. P. Lines	J. D. Isaacs	Account increase bearing.
C. & N. W	W. J. Towne	....
B. & O	E. Stimson	More bearing surface.
N. P	Bernard Blum	With treated ties and a wide tie plate the 6"x8" ties are preferred. With untreated ties the 7"x7" tie is preferred.

Exhibit A

Question 3—(Continued)

Those favoring all 7 in. by 7 in. ties:

Railroad	Reported By	Reasons
Algoma Cent. & H. B.	R. S. McCormick....	A 6" tie not thick enough for heavy rolling stock.
A. C. L.	L. L. Sparrow	Six inches not thick enough.
Bangor & Aroostook..	M. Burpee	The six by eight would present best resistance at first, and the seven by seven would permit more adzing. The seven by seven would probably give a year or two longer service.
C. P. R.	J. M. R. Fairbairn...	For main line track.
C. G. W.	C. G. Delo	Thickness preferable to face.
C. M. & St. P.	E. S. Pooler	Prefer all 7"x7" account greater strength.
D. & H.	James MacMartin....	Account of increased life due to additional inch in thickness.
D. T. & I.	H. B. Watters	With tie plates and closer spacing.
D. & I. R.	W. A. Clark	Because of greater stiffness.
E. P. & S. W.	J. L. Campbell	Because it is larger.
Grand Trunk	M. S. Blaiklock	Greater stiffness, more sectional area, consequently less rail deflection.
H. V.	A. Crable	The 6"x8" ties too thin for use of large spikes and too liable to split.
Lake Superior & I.	R. C. Young	Because this size may be adzed and still hold spikes.
Long Island	J. R. Savage	If not plated. If plated, prefer the 6"x8".
Maine Central	G. F. Black	Because they last longer.
M. P.	E. A. Hadley	If in new track with 7" ties, account of greater strength as a beam.
M. & O.	B. A. Wood	Spike holes soon work through a 6" tie.
N. & W.	J. E. Crawford	The 6" tie is too thin to stand heavy traffic and soon breaks after weakened any by decay.
R. F. & P.	S. B. Rice	Account length of spike.
S. A. L.	J. L. Kirby	No reason given.
Temis. & N. O.	S. B. Clement	Greater strength. Within respective limits, greater stiffness is more desirable than greater bearing area.
Boston & Albany	F. B. Freeman	In stone ballast for better hold.
C. B. & Q.	A. W. Newton	Our preference is 7"x7" tie as compared with 6"x8" pole ties—assuming that they are manufactured under Government Grades—as we would surely obtain a better quality of tie.
D. & R. G.	J. G. Gwyn	Probable longer serviceable life.
Southern	B. Herman	Less failures by breaking under load and less liability of driving sliver out of bottom of t e by spiking.
Nor. Pacific	Bernard Blum	With a 7" wide tie plate, would prefer all 7"x7" ties, if untreated, in order to get longer life on account of decay. With treated ties, prefer the 6"x8" tie.

Question 4

Under the same traffic and other service conditions, will a grade 5 tie last longer than a grade 3 tie of the same kind, treatment and method of fastening, and why? How much longer do you estimate the life of the grade 5 tie expressed in percentage of the total life of the grade 3 tie?

Grade 5 will last longer:

Ann Arbor	L. J. Allen	One-third longer because of greater amount of material.
A. B. & A.	L. L. Beal	More bearing surface and larger cross section.
A. C. L.	L. L. Sparrow	100% longer because larger—no data.
Bangor & Aroostook...	Moses Burpee	20% longer account 40% more heart wood.
Bingham & Garfield..	H. C. Goodrich	25%, at least, account extra bearing and larger tie.
Central of Georgia	C. E. Weaver	15 to 20% conservative estimate. Greater amount of stock and strength in tie.
C. G. W.	C. G. Delo	20 to 25% longer. Stands to reason.
C. M. & St. P.	F. S. Pooler	20% longer account more material in it.
C. R. I. & P.	C. F. Ford	20% at least. Failure due either to decay or mechanical wear and generally decay is more rapid because of mechanical wear. The No. 5 tie being stronger by reason of increased thickness, and of greater area, will withstand rail wear better than the No. 3 tie.

Exhibit A

QUESTION 4—(Continued)

Railroad	Reported By	Reasons
D. & H.	James MacMartin	Increased life about 16%.
D. & I. R.	W. A. Clark	Smaller percentage of sapwood.
E. J. & E.	A. Montzheimer	30 to 35% longer because of greater bearing and will not weaken as soon as the grade 3. The vibration of trains will not work on grade 5 tie up and down in the ballast as much as with a smaller tie.
Grand Trunk	M. S. Blaiklock	Some woods of slow decay (cedar), larger sized ties give longer life; larger size also give greater resistance to bending and consequently less splitting and disintegration. Some experiments with cedar and hemlock demonstrated that 7"x9" cedar would last 5 years longer than 6"x8", and hemlock two years longer, both untreated.
G. & S. I.	W. H. Gardner, Jr.	25%, about, longer as there is more material and also more surface to resist rail cutting.
G. F. & A.	A. S. Butterworth	15%, no reason given.
H. V.	A. Crable	20% for hewed ties, no difference if sawed. Hewed ties last longer because more timber left after sapwood has decayed.
I. & G. N.	F. S. Schwinn	25% or two years. Better timber as a rule, as well as more timber.
K. C. T.	J. V. Hanna	15% or 1 year. Less sapwood proportionately and less likely to be split and cut up by the rail. In case of cutting by rail or tie plate, there is more timber to go on in adzing down.
Lake Superior & I.	R. C. Young	20% longer in resisting mechanical wear, but timber in No. 5 ties is not usually as good as in No. 3 ties.
Long Island	J. R. Savage	20% longer account more wood.
Maine Central	G. F. Black	Somewhat longer account of mechanical wear.
Michigan Central	Geo. H. Webb	Gives firmer foundation to rail, resulting in less working of track. Also, in case of severe cutting by rail more adzing may be done and still allow spikes sufficient hold.
M. K. & T.	F. Ringer	25% increased bearing surface reduces mechanical wear.
M. P.	E. A. Hadley	30% account greater volume of timber, the decay, in general, advancing inwardly from the surface.
M. & O.	B. A. Wood	20%. No reasons given.
N. & W.	J. E. Crawford	Grade 5 will last one year longer than a 7"x7" grade 3, and two years longer than a 6"x8" grade 3.
P. R. R.	W. C. Cushing	(1) Being stronger, the tendency to shatter and split will be less; (2) being wider, it will not be cut so much by base of rail; (3) having greater bearing area, it will not be damaged as much by frequent tamping.
R. F. & P.	S. B. Rice	A hewn grade 5 tie will last longer because the sapwood of the grade 3 will decay, making the tie too small. A sawed grade 5 will last longer, if cut from young timber, but when cut from old timber, it will not. Highland timber will last longer than lowland timber. The life of the No. 5 hewn ties about 110% of that of the No. 3 ties.
St. L.-S. F.	F. G. Jonah	25% longer in case of untreated white oak, account more mature timber.
Temis. & N. O.	S. B. Clement	10% where the number of ties per rail length is the same.
T. R. R. A. of St. L.	H. J. Pfeifer	More material in grade 5 tie and more of it can decay before it is necessary to remove from track
N. Y. C. & St. L.	C. E. Denney	30% longer account less liable to cutting by base of rail.
Boston & Albany	F. B. Freeman	30% if unplated, account greater resistance to mechanical wear to end bearing and decay. If plated, life about the same.
C. B. & Q.	A. W. Newton	It appears to us that longer service will be obtained from a grade 5 than a grade 3 tie. However, we have had an unusually large number of grade 5 ties that were so much over size as to make their handling very expensive. The ideal tie is 7"x8" maximum.

Exhibit A

QUESTION 4—(Continued)

Railroad	Reported By	Reasons
C. C. C. & St. L......	C. A. Paquette......	Grade 5 ties will last longer on account of greater bearing area. As a rule, larger ties outlast smaller ones for this reason about 20%.
D. & R. G..........	J. G. Gwyn..........	Because of retaining transverse strength for longer periods. About 25%.
Texas & Pacific.......	R. H Gaines........	Grade 5 has more volume and hence greater stability. Probably 15 to 20%.
B. & L. E...........	F. R. Layng.........	Estimate a grade 5 tie will last 25% longer on light traffic lines and 33⅓% longer on heavy traffic lines. On heavy traffic lines beam strength becomes a more important factor.
Southern............	B. Herman..........	Grade 5 will last at least 25% longer, both grades untreated, account volume of sound material without sap and greater resistance to weather and mechanical wear.
S. P. Lines...........	J. D. Isaacs..........	Grade 5 should last 15 to 20% longer than grade 3, account more timber to resist decay and wear.
B. & O...............	E. Stimson..........	Grade 5 will last about 15% longer account increased bearing surface and decreased bending moment.
S. P. Co. (Pac. Sys.).	J. D. Isaacs..........	Grade 5 tie should last longer under same traffic, etc., because decay is more rapid in a vertical direction and cross sectional area is greater. Estimate is about 25% longer life for grade 5 (7"x9") tie over a grade 3 (6"x8") tie.

No difference:

Algoma Cent. & H. B.	R. S. McCormick....	Practically same life, as they fail by decay.
C. P. R.............	J. M. Fairbairn......	Usually depends on amount of sapwood on tie and kind of wood. Small cedars do not rot as fast as larger ties.
L. E. & W...........	J. K. Conner.........	Opinions of Roadmasters. Not true where ties fail by rail wear.
L. & N..............	R. M. Leeds........	Both being sufficient for traffic, not much difference in life. Track more easily maintained on No. 5.
Temis. & N. O.......	S. B. Clement.......	Where bearing area per rail length is the same, there is no difference.
Boston & Albany.....	F. B. Freeman......	If plated. If unplated, the grade 5 tie will last 30% longer than the grade 3 tie.
C. & N. W...........	W. J. Towne........	Would depend largely on the kind of timber. A small black or red oak or elm will break easier under the rail than a large one of the same kind.
N. P................	Bernard Blum.......	This question presupposes treated ties. Do not know whether either grade would last longer than the other. Probable that a grade 5 tie would last longer, but have no data to express percentage of increase.

QUESTION 5

With a given amount and kind of timber per mile in cross-ties, which will last longer, ties 6 in. thick or ties 7 in. thick, and why?

Ties 6 in. thick will last longer:

Central of Georgia...	C. E. Weaver........	Treated 6" ties will last longer, as the crushing effect of the load is greater in the 7" tie, and where ties fail by mechanical wear, the increase in width over depth, within reasonable limits, is valuable. Where ties fail by decay, the 7" tie will last longer.
D. T. & I............	H. B. Watters.......	If unplated and under heavy traffic. If plated, the 7" tie will last longer.
I. & G. N............	F. S. Schwinn.......	Account greater bearing surface.
K. C. T.............	J. V. Hanna.........	Doubts if much difference, but ties 6" thick with broader face give better bearing both to rail and tie plate and the ballast beneath.

Exhibit A

Question 5—(Continued)

Ties 6 in. thick will last longer:

Railroad	Reported By	Reasons
L. & N.	R. M. Leeds	Greater face, larger bearing surface, and more resistance to mechanical wear.
Michigan Central	Geo. H. Webb	With poor ballast and yielding road bed 6" ties will last longer. With first class ballast and well drained roadbed, longer life will be given by 7" ties.
M. K. & T.	F. Ringer	Depends on ballast and roadbed conditions. On firm roadbed and good ballast 6" tie lasts longer; on soft roadbed where loss by breakage is greater in proportion than loss by mechanical wear, 7" tie lasts longer.
B. & L. E.	F. R. Layng	On light traffic lines resistance to deflection may be sacrificed somewhat, in order to secure a wider tie and thus distribute the load over a greater area of roadbed. On light traffic lines, the advantage of additional depth should be less apparent so that it might be possible to select a 6" tie with a wide face and closer tie spacing that would give as long life as a 7" tie.
C. & N. W.	W. J. Towne	Think the additional lumber would give as good results in 6" ties.

Ties 7 in. thick will last longer:

Railroad	Reported By	Reasons
Algoma C. & H. B.	R. S. McCormick	Thicker tie and more "bone" when decay starts to make necessary renewal of same.
Ann Arbor	L. J. Allen	Greater amount of material to resist breaking and decay.
A. C. L.	L. L. Sparrow	Six inch ties too light.
B. & O. C. T.	G. P. Palmer	Greater strength as a beam and making allowance for cutting.
Bangor & Aroostook	M. Burpee	Partly because of better wood and partly because they permit adzing to restore the working face.
Bingham & Garfield	H. C. Goodrich	Larger and stand shocks better under heavy traffic. Tie 8"x10" really preferred.
C. P. R.	J. M. R. Fairbairn	It is found that with untreated ties, such as Jack Pine and Hemlock, decay occurs first in the exposed portion of ties above ballast line, and therefore the extra inch in the ballast adds to the life of the tie. The most important advantage, however, is due to the cushion effect of the thicker tie in frozen ballast or track in rock cuts resulting in less stress in the rail and rolling stock, and thus providing an easier riding track.
Central of Georgia	C. E. Weaver	Where ties fail by decay. Otherwise, the 6" tie will last longer.
C. G. W.	C. G. Delo	Stands to reason a 7" tie will last longer than a 6" tie.
C. M. & St. P.	F. S. Pooler	Greater strength perpendicular to grain.
C. R. I. & P.	C. F. Ford	It will depend very largely on standard of maintenance. Unless track is well ballasted and tie plates are used, the 7" tie would probably give a longer life.
D. & H.	James MacMartin	Sound rail cut ties should be removed from main line when cut 1½" under the rail, when they should be turned and used in sidings. A main track tie 7" thick when being relaid in siding has 5½" thickness, which is ample for side track use; a 4½" thickness is hardly sufficient. Having in mind the adzing and mechanical wear, the shortened life of a tie of this thickness increases cost of side track tie renewals.
D. T. & I.	H. B. Watters	If plated. If unplated, the 6" tie will last longer under heavy traffic.

Exhibit A

Question 5—(Continued)

Ties 7 in. thick will last longer:

Railroad	Reported by	Reasons
E. J. & E.	A. Montzheimer	Will be damaged less by spikes than the 6″ ties. We find spikes do not break through the bottom of 7″ ties the way they do occasionally with 6″ ties. When this occurs, the tie starts to decay from the bottom, which, of course, greatly shortens the life of the tie.
F. E. C.	H. N. Rodenbaugh	More thickness to take mechanical wear of rail cutting and from ballast due to working track. Greater resistance to splitting and cutting due to spiking. Longer life due to resistance against natural decay not noticeable.
Grand Trunk	M. S. Blaiklock	Account of holding spike after being rail cut and resist decay longer.
G. & S. I.	W. H. Gardner, Jr.	Account being stronger.
H. V.	A. Crable	Six inch ties break under the rail after slight loss of wood due to decay.
Lake Superior & I.	R. C. Young	May be adzed and still hold spike.
Long Island	J. R. Savage	More strength and provision for mechanical wear.
Maine Central	G. F. Black	Will stand more adzing.
Michigan Central	Geo. H. Webb	With first class ballast and well drained roadbed longer life given by 7″ ties. With poor ballast and yielding roadbed, the 6″ ties will last longer.
M. K. & T.	F. Ringer	Depends on ballast and roadbed conditions. On soft roadbed where loss by breakage is greater in proportion than loss by mechanical wear, 7″ tie lasts longer. On firm roadbed and good ballast, 6″ ties last longer.
M. P.	E. A. Hadley	Account greater strength as beams. Thus a 7″x7″ tie is about 40% stronger as a beam than a 6″x8″ tie, but is cut from a tree slightly smaller than the tree required for the 6″x8″ tie.
M. & O.	B. A. Wood	Because of spike holes and mechanical wear.
N. & W.	J. E. Crawford	Stronger ties.
P. R. R.	W. C. Cushing	Beam strength in ties is necessary and 6″ is too thin except for less important side lines and yards.
R. F. & P.	S. B. Rice	Account thickness, makes more rigid track.
St. L.-S. F.	F. G. Jonah	Usually cut from more mature timber.
S. A. L.	J. L. Kirby	Account beaming.
Temis. & N. O.	S. B. Clement	Assuming that ites will have at least 7″ face.
W. C. F. & N.	T. E. Rust	If unplated, the 7″ tie will stand more adzing and last longer. If plated, the 6″ tie will last as long and give better distribution on subsoil and better support for rail.
N. Y. C. & St. L.	C. E. Denney	Ties 7″ thick will stand more mechanical wear, have stronger hold in ballast and less liable to breakage.
Boston & Albany	F. B. Freeman	With a given limited amount of timber per mile, I would prefer 7″x7″; the difference in spacing would be slight, but the increased life, due to a stronger end bearing, would be considerable. The 7″x7″ ties would have fewer broken ends.
B. & Q	A. W. Newton	Ties 7″ thick will last longer because rail wear and adzing for rail relaying tends to reduce thickness of tie and there are times when it is necessary to replace ties that are not rotten, but are weak because of this adzing or rail wear.
C. C. & St. L.	C. A. Paquette	Assuming same width of tie for each thickness, the 7″ ties will probably last longer in poorly ballasted track, as such ties will not be so liable to break. In well ballasted and drained track there would likely be not much difference in life.
& R. G.	J. G. Gwyn	Because of longer resistance to breaking.
exas & Pacific	R. H. Gaines	More strength.
. & L. E.	F. R. Layng	Resistance to deflection more essential on heavy traffic lines than on light traffic lines. On heavy traffic lines, if total quantity of timber assigned to a mile of track is large enough, so that ties are not spaced too far apart, 7″ ties should last longer than 6″ ties.

Exhibit A

Question 5—(Continued)

Ties 7 in. thick will last longer:

Railroad	Reported By	Reasons
Southern	B. Herman	Spikes will not penetrate so deeply. Strength is greater in direction of thrust from present day heavy loads and more of the tie remains as mechanical wear goes on.
B. & O.	E. Stimson	Account less bending moment.
S. P. Co. (Pac. Sys.)	J. D. Isaacs	Beacuse decay is vertical rather than longitudinal.
Nor. Pacific	Bernard Blum	Inclined to think that 7" ties will last longer, as they give a stiffer bearing, and owing to the deeper section afford more resistance to decay with untreated timber.

No difference:

L. E. & W.	J. K. Conner	None given.
W. C. F. & N.	T. E. Rust	If plated, the 6" tie will last as long and give better distribution on subsoil and better support for rail. If unplated, the 7" tie will stand more adzing and last longer.
S. P. Lines	J. D. Isaacs	Believe that there will be practically no difference in the life of ties 6" thick and 7" thick with the same amount and kind of timber per mile. Ties 7" thick will be a little stronger but will suffer more from mechanical wear, particularly on curves, on account of smaller rail bearing area.

Appendix D

SUBSTITUTE TIES

L. J. RIEGLER, *Chairman;* CARL BUCHOLZ, L. A. DOWNS, EARL SULLIVAN, Sub-Committee.

Bulletin No. 227 for July, 1920, contains a report of this Committee on the "Relative Merits of Metal versus Wooden Ties." This subject was referred to Section II—Engineering, of the American Railway Association by the Executive Committee, and assigned to the Committee on Ties by the General Committee on November 21, 1919. Prompt consideration and a comprehensive and conclusive report at the earliest practicable date was requested. The report was completed and submitted on January 26, 1920.

The Committee again calls attention to the desirability of extensive tests of substitute ties. Only by extensive tests and gradual development can a satisfactory substitute tie be produced. The Committee therefore urges that railroads provide adequate facilities for making such tests and that the Engineering Department take an active interest in and follow them up with a view of developing defects and determining what improvements, if any, may be made in the ties under test.

Inspection of Substitute Ties

Several members of the General Committee, at the request of President Safford, inspected an installation of Champion Steel Ties in the eastward freight track of the Atglen and Susquehanna Branch of the Pennsylvania Railroad west of Lenover, Pa., on July 2, 1920. These ties had only been installed during the two weeks preceding, and nothing as to their merits had been developed at time of inspection.

The following description is for purpose of record:

Nine hundred ninety-five of these ties were installed in the eastward low-grade Pennsylvania track (A. & S. Branch) between Atglen and Lenover stations, during the two weeks prior to June 30, 1920. The ties are placed 14 to each 33-foot rail length of track and support 130-lb. Pennsylvania section rail on cinder ballast. Type 3, Pennsylvania Standard Tie Plates, Plan 61301-B, 10½ inch x 10¾ inch with shoulders, are used, the 10½-inch dimension being parallel to the rail. Vaughn Anti-Creepers are used on about every third tie. The rail is fastened to the tie with two driven spikes for each rail.

This tie is similar in design to the Peerless tie, installed in Chicago & Alton Railroad at Chicago, and described on page 498, of Volume 18, A.R.E.A. Bulletin. It consists of an inverted steel "T" section, upon which two wooden blocks are bolted to support each rail, and to which the rail is fastened by ordinary driven spikes. The steel member is 8 feet long, ⅜ inch thick, 5 inches high and 10 inches wide, on the base, and weighs 136 lb. In some cases, two ⅜ inch x 5 inch x 5 inch angles are riveted together, in which case the weight is 180 lb.

The wooden blocks are 18 inches long, 6 inches high and 5 inches wide, all white oak, untreated, but painted on top side with a coal tar or pitch solution. One 1-inch bolt and two ½-inch dowel pins are used to hold the blocks together and to the steel member, the bolt being immediately under the rail.

The ties are being subjected to a heavy service, slow speed freight traffic.

The following reports are a continuation of those collected by the Committee for a number of years. There is also a tabulation of all the substitute ties within the knowledge of the Committee now being tested:

The Atchison, Topeka & Santa Fe Railroad System

Kind—Baird, Bronson, Carnegie, Hanna, La Guna, Universal.

Reported by C. F. W. Felt, Chief Engineer-System.

Date, August 30, 1920.

Three Baird Steel Ties at Newton, Kansas

The above ties were installed in eastbound main track, 50 feet east of Signal 1854, prior to March, 1910.

Inspected June 22nd, 1920.

The ties are in fair condition, except for rust. The sides of the ties are getting quite thin near the center of track.

Eleven Bronson Steel Ties at Chillicothe, Illinois

These ties were originally installed in Chillicothe yard on December 15th, 1914, and taken up and moved to a point in the eastbound track, 200 feet west of M. P. 128, on July 27th, 1916.

Inspected July 28th, 1920.

Eleven ties still in service.

At the time of this inspection, there was a flat spot in the curve where these steel ties are located, also a low spot on the inside rail of the curve for the length of the steel ties installed. This same condition has been found at each inspection of these ties.

The nuts are missing from six of the twenty-two clamp bolts used on these ties.

These ties are badly rusted on the sides.

Track is not bonded where these ties are used; therefore no insulation is attempted.

Carnegie Steel Switch Ties at Newton, Kansas

Forty-five (45) Carnegie steel switch ties and two head blocks were installed in a switch in south side of yard, opposite coal chute. Original installation made on April 30th, 1913. All but 11 of the ties were destroyed by a derailed engine on or about October 1, 1913.

Thirty-five (35) new ties were installed in place of those destroyed in September, 1914.

Inspected June 22, 1920.

All bolts for fastening the rails to the ties have been renewed since last inspection, and heavy washers added to assist in holding the clips in proper position.

Forty-six (46) ties are still in place.

315 clip bolts found.
2 bolts missing.
33 clip bolts loose.

Ties rusting badly and wear under the rails becoming severe.

Traffic over the switch not very heavy.

Eight Hanna Cement Ties at Rivera, California

These ties were installed in main track, in front of the Hanna Lumber Company's office, on November 31, 1912.

Still in track.

Inspected May 18th, 1920.

Tie No. 1 broken under left rail, and twice between rails.

Tie No. 2 broken once between rails.

Tie No. 3 broken twice between rails.

Tie No. 4 broken twice between rails.

Tie No. 5 in good condition.

Tie No. 6 broken twice between rails.

Tie No. 7 cracked under one rail.

Tie No. 8 cracked under one rail.

The ties marked "broken" have cracks clear through them, but the pieces are held together by the reinforcing rods.

Forty-six La Guna Concrete Ties at Vegala, California

The above ties were installed in main track, opposite station sign of Vegala in spring or summer of 1917.

Inspected May 18, 1920.

Only 33 of these ties are still in main track, each fourth tie having been removed and wood ties substituted, as a matter of precaution.

Two of the ties removed were complete failures, the concrete having broken up under one or both rails.

Eleven (11) of those removed were reinserted in side track opposite the original installation. Of those remaining in the main track, Nos. 1, 2, 3, 4, 5 and 6 show cracks under one or both rails. Nos. 7 and 9 are breaking up at the right-hand end; Nos. 19, 11 and 12 are cracking and spalling under the rail; Nos. 13 and 14 are spalling at the left-hand end; No. 15 is spalling under the rail; Nos. 16, 17, 18, 21, 23, 25, 26, 27 and 29 are spalling at the left-hand end; No. 15 is spalling under the rail; Nos. 16, 17, 18, 21, 23, 25, 26, 27 and 29 are spalling and disintegrating at the ends; No. 30 is spalling at the center of track; No. 31 is spalling at the end and center; No. 32 is breaking up under the rails. This shows two complete failures, and 25 partial failures as having already occurred out of the original installation of 45 ties installed. All of the ties reported as "spalling" have the concrete broken up enough to expose some of the reinforcing rods to the weather.

106 Universal Metallic Tie Company's Steel Ties at Florence, Kansas

These were placed on a curve west of Braddock, Kansas, M.P. 173/0064 on April 1, 1911; were taken out of track because of difficulty of maintaining line and surface, and replaced in the eastbound main track on tangent, in front of passenger depot at Florence, Kansas, on or about June 10th, 1912.

These ties are still in service. Not recently inspected.

Baltimore & Ohio Railroad

Kind—Boughton, Hardman, Metal Tie Company.

Reported by Earl Stimson, Chief Engineer Maintenance.

Date, August 31, 1920.

The Boughton steel tie in track at Akron has been removed, due to fastening becoming broken.

All of the Hardman ties have been removed from track at West Baltimore, this being done in the summer of 1919, account of their having failed by crushing as well as some of the steel bands giving way. The 50 metal ties are still in track and in good condition at Martinsburg, W. Va.

Bessemer & Lake Erie Railroad

Kind—Carnegie.

Reported by H. T. Porter, Chief Engineer.

Date, August 16, 1920.

During May and June of this year, we received from the mills approximately 25,000 new steel ties weighing 204 pounds each, the length of ties being 8 feet 6 inches. These ties are of the same section which we have used heretofore, and are known as Carnegie Steel Company, M-29, estimated weight 24 pounds a foot. Since making our last report we have developed nothing of interest, so that the above information is all that we have to furnish the Tie Committee at this time.

Cleveland, Cincinnati, Chicago & St. Louis Railway

Kind—Carnegie.

Reported by C. A. Paquette, Chief Engineer.

Date, August 16, 1920.

In the winter of 1906 three thousand Carnegie steel ties were applied on our westward track about six miles east of Greensburg, Ind. This is a high-speed point. Part of these ties are on tangent and a part around a one degree curve. Since their application one tie was removed in 1918 and eight in 1919. In all cases the ties were taken out because they broke down under the rail. Trouble is beginning to develop in tightening the clip that holds the rail to the tie; the bolt holes in the top flange of the tie are becoming so worn that the bolts cannot be properly tightened; the ties are showing considerable rust, particularly in the top flange, due in part to brine drippings, and are getting thin, some of them, particularly the joint ties, bending up. This is particularly noticeable on the low side of the curve. These ties have been in service about thirteen years.

This type of substitute tie seems to me to have been the best yet offered, but the section is not heavy enough, particularly as it is diminished at the rail by the punching of two holes in the top flange on each side of the rail base for the clip bolts. In order to get a longer life out of the tie it is necessary to protect it by some covering that will resist brine drippings and protect it from rust.

Denver & Salt Lake Railroad

Kind—Shane.

Reported by V. B. Wagner, Chief Engineer.

Date, July 26, 1920.

In our previous reports to you in connection with this matter, we stated that there were twenty-six Shane ties in place on the Northwestern Terminal Railway main line, near Mile Post 1, Denver. These ties are at the present date in good condition, the original number of twenty-six still being in service. There are no other substitute ties in place on this property.

Duluth & Iron Range Railroad

Kind—Carnegie.

Reported by W. A. Clark, Chief Engineer.

Date, July 26, 1920.

There are no changes since last year's report. We have no other substitute ties under trial.

Duluth, Missabe & Northern Railway

Kind—Carnegie, Kimball.

Reported by W. H. Hoyt, Chief Engineer.

Date, July 23, 1920.

We have about 22,000 Carnegie steel ties in use since 1908 and 1909. We have removed up to date about 100 of these ties, taking out about thirty last year. The balance of them are all in track under heavy traffic.

Ties removed were broken down in the web under the rail or the flange was torn out on account of creepage, otherwise, we have had no trouble and the balance of the ties are giving good service.

At Virginia, Minnesota, we have thirty special steel ties of the Kimball design which have been in our track about six years. These are giving very satisfactory service and there has been no change made in them.

Elgin, Joliet & Eastern Railroad

Kind—Bates, Carnegie.

Reported by Arthur Montzheimer, Chief Engineer.

Date, July 24, 1920.

We have very little information additional to that contained in reports which were published in Volume 14, page 749, Vol. 15, page 751, and Volume 16, page 530.

The Bates concrete ties seem to be in the same condition as they have been for several years and are giving very satisfactory service.

Erie Railroad

Kind—Carnegie.

Reported by R. S. Parsons, General Manager.

Date, October 5, 1920.

Relative to substitute ties applied at Jamestown, N. Y., in September, 1909. The last of these ties were removed from track in August, 1919, on account of failure. The majority of them were crushed under the rail seat, many were broken, and all were badly deteriorated so as to be of no further service.

Florida East Coast Railway

Kind—Percival.

Reported by H. N. Rodenbaugh, Chief Engineer.

Date, July 24, 1920.

Reports no change in conditions since report on page 544 of Bulletin 223, Volume 21.

Lake Champlain & Moriah Railroad

Kind—Carnegie.

Reported by Paul S. Brinswade, Assistant Secretary.

Date, August 3, 1920.

We beg to inform you that these ties are still in use and are giving good satisfaction.

Lake Erie & Western Railroad

Kind—Buhrer.

Reported by J. K. Conner, Chief Engineer.

Date, August 4, 1920.

There is no change in the report for the L. E. & W. We still have five Buhrer concrete ties in our track at Tipton, Indiana, which were installed in August, 1903.

Long Island Railroad

Kind—Carnegie, Combination Concrete and Steel.

Reported by J. R. Savage, General Superintendent.

Date, August 6, 1920.

Of the 30 Carnegie ties put in track at Hicksville in May, 1909, 24 are still in service and in good condition, except that the rail fastenings have become so worn as to necessitate renewal.

Of the 34 combination concrete and steel ties installed at Long Island City in 1911 and 1912, 26 were removed on October 19th las year, due to the concrete cracking and falling to pieces. The remaining eight are beginning to show the same trouble, and will probably be taken out of the track in the very near future.

Pennsylvania System—Eastern Region

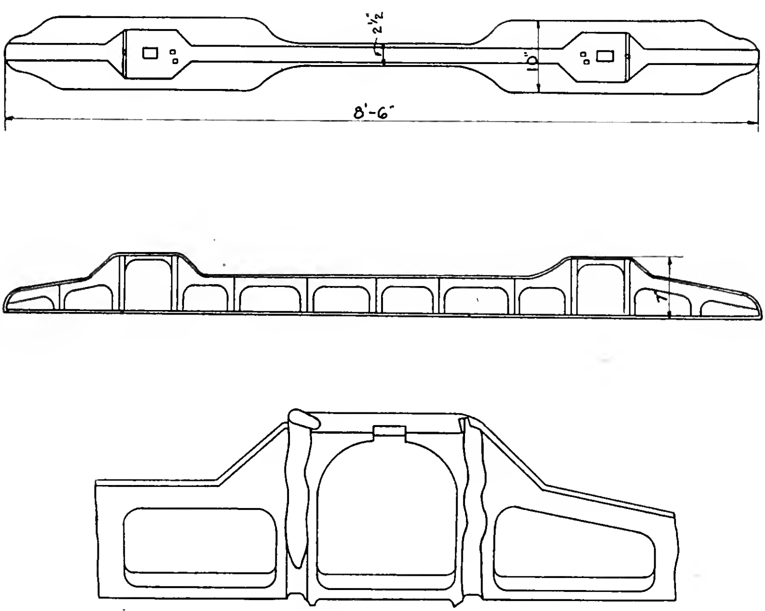
Kind—Standard Steel Ties, Maryland Steel Ties, Champion Steel Ties.

Reported by W. G. Coughlin, Chief Engineer, M. of W.

Date, August 11, 1920.

CHAMPION STEEL TIES.—995 installed in June, 1920, in eastward freight track, A. & S. Branch, Philadelphia Division, west of Lenover, Pa. Tie consists of an inverted "T" of rolled steel with two wooden blocks under each rail (described on page 498, A.R.E.A. Bulletin, Volume 18). The approximate number of loaded cars per day over this track is 2350 at slow speed.

MARYLAND STEEL TIES.—25 installed September, 1919, in eastward freight track, A. & S. Branch, Philadelphia Division, at Lenover, Pa. The approximate number of loaded cars per day over this track is 2350 at slow speed. This tie is illustrated on this page. It is of cast steel, 8 feet 6 inches long, 7 inches high and 10 inches wide on the base under the rails and 2½ inches wide at the middle. The rails are fastened to the tie by standard track spikes driven in grooved holes with sinuous sides.



MARYLAND STEEL TIE—MARYLAND METAL CROSS TIE COMPANY.

STANDARD STEEL TIES.—500 installed June, 1915, in eastward freight track, A. & S. Branch, Philadelphia Division, east of Lenover, Pa. A few of the wooden blocks have required renewal; otherwise, the ties are in good condition.

Pennsylvania System—Central Region

Kind—Carnegie Steel Switch Tie, Mechling and Smith Steel Tie, Riegler Concrete Steel Tie, Snyder Composite Tie.

Reported by W. D. Wiggins, Chief Engineer, Maintenance of Way.

Date, November 2, 1920.

Carnegie Steel Switch Ties.—Eight sets installed October, 1911, in Pitcairn Yard, Pittsburgh Terminal Division. About 90 per cent. have been removed at various times on account of damage from derailments. The remaining 10 per cent. are badly corroded and bent and should be removed before winter.

Mechling and Smith Steel Ties.—One hundred installed October, 1910, in Wilkinsburg Yard, Pittsburgh Terminal Division, 20 removed in 1915; due to bad condition of wood blocks; 11 removed in 1919 due to being damaged by a derailment; 8 removed in 1920 due to their poor condition; 61 still in track but not giving good service as the gage cannot be properly maintained.

Riegler Concrete Steel Tie.—Fifteen installed May, 1908, in No. 1 Westward Passenger Track, west of Emsworth, Pittsburgh Terminal Division, transferred to No. 3, Eastward Freight Track in December, 1914, and are still in track. The ties have been subject to a heavy service high-speed main line traffic for twelve years and seven months. Report made on page 545, Volume 21, of the Proceedings states that two were badly cracked on top, but the integrity of ties did not seem to be affected and that the first eastward tie showed signs of crushing under the north rail. Inspection made October 29, 1920, shows three ties cracking on top, but the integrity does not seem to be affected, the first eastward tie has been repaired and is in good condition. the receiving joint tie shows signs of crushing under the south rail at joint, and cracks were found at ends of two other ties between the steel and concrete. Otherwise the ties are in good condition.

Snyder Composite Tie.—821 installed October, 1907, in Derry Yard, Pittsburgh Division. All in track and giving satisfactory service.

One thousand six hundred installed October, 1907, in Conemaugh Yard, Pittsburgh Division. Between 1914 and 1916, 280 were removed on account of being damaged by derailments and on account of extension to interlocking. One thousand three hundred and twenty ties still in track and giving satisfactory service.

At both locations the ties are rusting and shell wearing thin. The clips and bolts are badly rusted and in case of rail renewals it will be necessary to cut them off and install new fastenings.

Pittsburgh & Lake Erie Railroad

Kind—Atwood Standard.

Reported by A. R. Raymer, Chief Engineer.

Date, September 10, 1920.

The ties described in Bulletin No. 227, Volume 22, A.R.E.A., July, 1920, on pages 47, 70 and 71, known as the Atwood Concrete Steel Ties, are still in use at McKees Rocks, Pa., and are giving good service. All of the ties are still in service. On December 31, 1919, Mr. Atwood, in describing these ties for the information of another engineer, stated as follows:

"The fastening used to fasten the rail to the ties is not what it should be. I am, therefore, enclosing a sketch showing a form of rail fastening, which, in my estimation, will prove entirely satisfactory and give all the freedom of application and renewal that is had by the use of the ordinary track spike. The essential feature of the track fastening is a cotter pin which is driven like an ordinary spike. This pin can be withdrawn like an ordinary spike."

The only defect noticed to date is on account of these fastenings. We may be obliged to change the fastenings or remove the ties as the present fastenings are not entirely satisfactory.

The twenty Standard steel ties placed in the main track of this railroad at Glassport, Pa., on May 4, 1914, are still in service. The wood fillers of these ties have been recently renewed. This is the only part of these ties that required any attention.

Pittsburgh, Shawmut & Northern Railroad

Kind—Carnegie.

Reported by J. N. Thompson, Secretary to Receiver.

Date, August 5, 1920.

Since the last report, it has been necessary to remove fifty of these ties account of web crushing. This leaves still in track about 550 ties.

We have no other substitute tie under trial.

Riverside, Rialto & Pacific

Kind—Wolfe.

Reported by Arthur McGuire, Chief Engineer, L. A. & S. L. R. R.

Date, September 3, 1920.

There are 58 of these ties now in track. Two of them have been broken and replaced with redwood ties. One of the concrete ties is commencing to crumble under the rail and will have to be changed out soon. Some of the screw spikes are loose and will have to be plugged and spikes screwed in. Balance of ties look all right.

Southern Pacific Company

Kind—Goodlett.

Reported by W. H. Kirkbridge, Engineer of Maintenance.

Date, August 12, 1920.

The first of these ties, twelve in number, were placed in the main switch lead, West Oakland yard, in 1914. On the first day one of the ties failed and was taken out, a second tie failed within three days, and within the course of a year all of these ties were removed from the track as completely failing.

The second lot placed in the same switch lead on November 27, 1917, 27 in number, commenced to fail by cracking under the rail, and at the present time there are 17 of these ties in the track. Recent inspection shows that 11 out of the 17 are cracked and broken under the rail, and there are only four of the ties remaining in the track that are in good shape, and it is necessary to place wooden ties between the concrete ties in order to hold track in gage.

These ties are located at a point where they are subject to very heavy traffic.

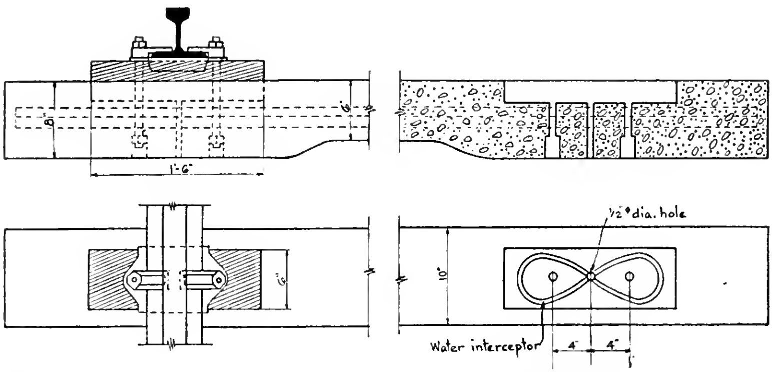
Terminal Railroad Association of St. Louis

Kind—Chamberlain.

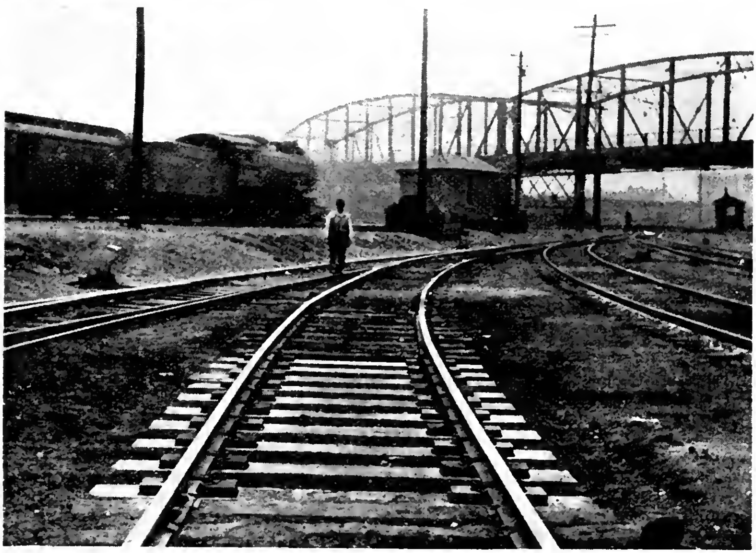
Reported by H. J. Pfeiffer, Chief Engineer.

Date, October 5, 1920.

Ten Chamberlain ties were installed in a switch track near 21st Street. The rail is 80-lb. A.S.C.E. section and the ballast cinders. The traffic over ties is light and at slow speed, the track in question being a sub-track used for the storage and cleaning of passenger equipment. A photograph and a drawing of the installation is on following pages. The tie is of concrete, 8 feet long, 10 inches wide, 8 inches thick under the rails and 6 inches thick at the middle. Two longitudinal steel reinforcing bars of special design are used. The rails are carried upon 4 inch x 6 inch x 18 inch wooden blocks set into concrete and held in place by ¾-inch bolts. These bolts extend entirely through the tie, blocks and rail clips and serve to fasten the rail to the tie.



REINFORCED CONCRETE TIE, PATENTED BY M. E. CHAMBERLAIN, ST. LOUIS.



CHAMBERLAIN CONCRETE TIES, TERMINAL RAILROAD ASS'N OF ST. LOUIS.

Tests of Substitute Ties in Progress 1920

Railroad	Name of Tie	Location	Number now in Track	Date put in prior to March, 1910
A. T. & S. F.	Baird	Newton, Kans.	3	
	Bronson	Chillicothe, Ill.	11	December, 1914
	Carnegie	Newton, Kans.	35	September, 1914
	Hanna	Rivera, Calif.	8	November, 1912
	LaGuna	Vegala, Calif.	33	July, 1917
	Universal	Florence, Kans.	106	June, 1912
Baltimore & Ohio	Metal Tie Co.	Martinsburg, W. Va.	50	May, 1909
Bessemer & Lake Erie	Carnegie	Various	Many	January, 1905, and Subsequent
Buffalo, Rochester and Pittsburgh	Carnegie	Sidings where fires are cleaned	1500	1912
C. C. C. & St. L.	Carnegie	Greensburg, Ind.	One Mile	
Cornwall & Lebanon	Snyder	Mt. Gretna, Pa.	206	1906
D. L. & W.	Universal	Dover, N. J.		
Denver & Salt Lake	Shane	Denver, Colo.	13	October, 1912
	Shane	Denver, Colo.	13	August, 1916
Duluth & Iron Range	Carnegie	Various	1833	1905
Duluth M. & N.	Carnegie	Duluth & Proctor, Minn.	22000	1908–1909
	Kimball	Virginia, Minn.	30	1914
Elgin, Joliet & Eastern	Bates	Whiting, Ind.	62	May, 1912
	Carnegie	Various	Many	Various
Florida East Coast	Percival	St. Augustine, Florida	16	March, 1906
Huntingdon and B. T. M.	Stoneback	Huntingdon, Pa.	3	April, 1915
Lake Champlain & Moriah	Carnegie		48	
Lake Erie & Western	Buher	Tipton, Ind.	5	August, 1903
Long Island	Carnegie	Hicksville, N. Y.	24	May, 1909
	Combination Concrete and Steel	Long Island City	8	1911–1912
Los Angeles Ry.	McDonald	Los Angeles, Cal.	4323	July, 1911
Pennsylvania R. R. Eastern Region	Champion	Lenover, Pa.	995	June, 1920
	Maryland	Lenover, Pa.	25.	September, 1919
	Standard	Lenover, Pa.	500	June, 1915
Central Region	Carnegie	Pitcairn Yard	10% of 8 sets	October, 1911
	Mechling & Smith	Wilkinsburg, Pa.	69	October, 1910
	Riegler	Emsworth, Pa.	15	May, 1908
	Snyder	Derry, Pa.	821	October, 1907
	Snyder	Conemaugh Yard, Pa.	1600	October, 1907
Pittsburgh & Lake Erie	Atwood	McKees Rocks, Pa.	5	October, 1908
	Standard	Glassport, Pa.	20	May, 1914
Pittsburgh, Shawmut & Northern	Carnegie	Byrndale Branch	550	Summer, 1907
Riverside Rialto & Pacific	Wolf	Riverside, Cal.	58	October, 1913
Southern Pacific	Goodlett	Oakland, Cal.	17	November, 1917
So. Pacific, Texas Lines	Indestructible	Eagle Pass, Texas	23	May, 1916
	Percival	Edgewater, Texas	67	October, 1906
	Percival	Bayou Sale, La.	96	January, 1910
	Percival	Edgewater, Texas	20	January, 1906
Union Railroad	Carnegie	Pittsburgh, Pa.	5000	Fall, 1908
Terminal R. R. Association, St. Louis	Chamberlain	St. Louis, Mo.	10	April, 1920

REPORT OF COMMITTEE XV—IRON AND STEEL STRUCTURES

O. E. Selby, *Chairman;*
F. Auryansen,
J. A. Bohland,
W. S. Bouton,
A. W. Carpenter,
M. F. Clements,
J. E. Crawford,
O. F. Dalstrom,
F. O. Dufour,
Thomas Earle,
W. R. Edwards,
G. A. Haggander,
R. L. Huntley,
P. G. Lang, Jr.,
B. R. Leffler,
F. E. Turneaure, *Vice-Chairman;*
P. B. Motley,
C. D. Purdon,
Albert Reichmann,
A. F. Robinson,
H. N. Rodenbaugh,
J. M. Salmon,
I. L. Simmons,
I. F. Stern,
H. B. Stuart,
G. E. Tebbetts,
Dr. J. A. L. Waddell,
H. T. Welty,
*Paul Wolfel,

Committee.

To the American Railway Engineering Association:

The following subjects were assigned to the Committee on Iron and Steel Structures for study and report:

1. Make thorough examination of the subject-matter in the Manual, and submit definite recommendations for changes:
   (a) Revise the rules and unit stresses for classifying and rating existing bridges.
2. Report on methods of protection of iron and steel structures against corrosion.
3. Submit specifications for erection of steel railway bridges.
4. Report on the relative economy of various types of movable bridges:
   (a) Revise the specifications for movable bridges.
5. Report on column tests:
   (a) Continue with program of column tests at the Bureau of Standards.
6. Report on the design, length and operation of turntables:
   (a) Report specifications for the design of turntables and turntable pits.
7. Report on ballast floor bridges and methods in use for waterproofing:
   (a) Report principles for detailed design of ballast floors, flashing, drainage and reinforcement for waterproofing purposes.
8. Prepare specifications for steel highway bridges.

*Died December 28, 1920.

9. Report on the electric welding of connections in steel structures, conferring with the Committee on Electricity.

Committee Meetings

Meetings of the Committee were held in: Cleveland, June 4; Montreal, August 12 and 13; Chicago, November 18 and 19. A meeting of the Sub-Committee on Specifications for Movable Bridges was held at Chicago, December 16 and 17. A meeting of the Committee is called to be held at Cleveland, February 10 and 11, 1921.

The Committee records with deep regret the loss of Mr. W. H. Moore, for eight years an active member, by death on September 5, 1920. Resolutions of regret are recorded in the Minutes and a memoir was published in the Bulletin.

The Committee has also lost by death another of its valued members—Mr. Paul L. Wolfel, who died December 28, 1920.

(1) Revision of the Manual

In Appendix A are given the Rules and Unit Stresses for Rating Existing Bridges which are offered as a conclusion for printing in the Manual. A tentative draft of these rules was published in Bulletin 228 and the discussions received were considered in the revision. These discussions are abstracted in Appendix B. Rules for the classification of bridges will be reported next year.

In these days of rapidly increasing engine loads and high interest charges on capital, the importance of care and uniformity in the rating of bridges cannot be emphasized too strongly.

(2) Methods of Protection Against Corrosion

The Committee has nothing to report on this subject and does not recommend its reassignment.

(3) Specifications for Erection

A Sub-Committee (John A. Bohland, Chairman) has worked on this subject actively during the year and it is expected that specifications will be reported for adoption next year.

(4) Specifications for Movable Bridges

The specifications published in Bulletin No. 204, and the discussions abstracted in Bulletin No. 228 are still under consideration by the Sub-Committee (B. R. Leffler, Chairman). On account of its importance and the volume of the work, this subject is expected to form the principal topic of the Committee's work next year. Further constructive suggestions are solicited.

(5) Column Tests

No progress on this work has been made this year because of conditions in the Bureau of Standards.

(6) Specifications for Turntables and Turntable Pits

This subject is in the hands of a Sub-Committee (J. E. Crawford, Chairman) and the Committee expects to report on it next year.

(7) Principles for Detailed Design of Ballast Floors, Flashing, Drainage and Reinforcement for Waterproofing Purposes

The principles published in Bulletin 223 and submitted as information to the 1920 convention have been revised and are offered as a conclusion. They appear in Appendix C.

(8) Specifications for Steel Highway Bridges

This subject has been assigned to a Sub-Committee of which H. T. Welty is Chairman, and the preparation of the specifications is in progress. Detailed information of the weights and wheelbases of motor trucks has been secured.

(9) Electric Welding of Connections in Steel Structures

This new subject is in the hands of a Sub-Committee (Geo. H. Tebbetts, Chairman). Some information has been secured but the Committee has nothing to report.

CONCLUSIONS

1. The Committee recommends that the Rules and Unit Stresses for Rating Existing Bridges as printed in Appendix A be approved and published in the Manual.

2. The Committee recommends that the Principles for the Detailed Design of Flashing, Drainage, Reinforcement and Protection for Waterproofing Purposes appearing in Appendix C be approved and published in the Manual.

Recommendations for Future Work

The Committee recommends that the following subjects be reassigned:

1. Classification of bridges.
2. Specifications for erection of steel railway bridges.
3. Specifications for movable railway bridges.
4. Column tests.
5. Specifications for turntables and turntable pits.
6. Specifications for steel highway bridges.
7. Electric welding of connections in steel structures.

SPECIFICATIONS FOR STEEL RAILWAY BRIDGES

The Committee desires to call attention to the fact that the Specifications for Steel Railway Bridges adopted at the 1920 convention are available in pamphlet form and to urge upon the railways and engineers in consulting practice their use in designing and for receiving bids. Modifications which may be desirable for individual conditions need not do away with their basic use.

Respectfully submitted,

THE COMMITTEE ON IRON AND STEEL STRUCTURES,

O. E. SELBY, *Chairman.*

Appendix A

RULES AND UNIT STRESSES FOR RATING EXISTING BRIDGES

WARRICK R. EDWARDS, *Chairman,* Sub-Committee.

(1) In fixing the carrying capacity of any bridge under traffic, its location, design, details, material, workmanship, behavior, and physical condition must be taken into account.

(2) Before recalculating an existing bridge, a careful inspection should be made to determine:

(a) Whether the actual sections and details conform to the drawings.

(b) The loss of metal due to corrosion and wear. This determination should be made by calliper measurements, after thorough removal of scale.

(c) The general physical condition. Defects such as loose rivets, worn pins, crooked or damaged members, cracked metal, etc., should be carefully noted.

Particular attention should be given to the position of the track with respect to center line of the bridge, and to undesirable details, such as forked ends of compression members, eccentricity in riveted joints and connections, unequal stress in tension members, etc.

(3) In recalculating bridges for increased loading, the equipment in actual use, or which it is proposed to use, shall be taken for determining the live load stresses. Where the design or details are such as to cause unusual eccentric or secondary stresses, these stresses shall be taken into account. It is recommended that stresses in members subject to marked secondary effects be determined by strain gage measurements.

(4) In spans exceeding 150 feet in length, and in viaduct towers, the effect of lateral (or wind) force shall be taken into account. The lateral force shall consist of a moving load equal to 15 pounds per square foot on the vertical projection of the structure on a plane parallel with its axis, and a moving load of 400 pounds per linear foot applied 8 ft. above the base of rail.

(5) On curves, the centrifugal force, based on actual speed of operation, and assumed to act 6 ft. above the base of rail, shall be taken into account.

(6) Where speeds may exceed 15 miles per hour, the dynamic increment of the live load shall be added to the maximum computed live load stresses and shall be determined by the formula,

$$I = S \frac{300}{300 + \frac{L^2}{100}}, \text{ in which}$$

I = impact or dynamic increment to be added to the live load stress.
S = computed maximum live load stress.
L = the length in feet of the portion of the span which is loaded to produce maximum stress in the member.

(7) If a bridge is so located that speeds are definitely limited, or where absolute control of speed can be secured, 50 per cent. of the impact given by the above formula shall be used when the speed is between 10 and 15 miles per hour, and 25 per cent. when the speed is less than 10 miles per hour. If the bridge is located where the locomotive must be started, the speed increased, or the brakes applied, full impact shall be used in the calculations.

(8) Impact shall be added to stresses produced by centrifugal force, but not to those produced by lateral forces.

(9) For bridges on curves, and at other places where tracks are off center, consideration shall be given to the increased load carried by any truss, girder, or floor member due to the eccentricity of the load.

(10) The limiting stresses resulting from the loads and forces mentioned in the preceding articles, in combination with the actual dead load, shall not exceed the following, in pounds per square inch:

	Open-Hearth Steel	*Wrought Iron and Bessemer Steel*
Axial tension (net section)	26000	22000
Axial compression (gross section)	$24000 - 80 \frac{l}{r}$	$21000 - 70 \frac{l}{r}$
but not to exceed	20000	17000
l = length of the member in inches.		
r = least radius of gyration of the member in inches.		
Tension in extreme fibers of rolled shapes (except rolled beams), built sections and girders (net section)	26000	22000
Tension in extreme fibers of rolled beams (net section)	24000	20000
Compression in flanges of plate girders and I-beams (gross section)	$26000 - 300 \frac{l}{b}$	$22000 - 250 \frac{l}{b}$
but not to exceed	24000	21000
l = length of the unsupported flange, between lateral connections or knee braces.		
b = flange width.		

Tension in extreme fibers of pins (figured by assuming stresses concentrated at centers of bearings)	50000	40000
If the members are packed closely on the pin, the bending stress need not be considered unless the tension in extreme fiber exceeds 60000 lbs. per sq. in. for open-hearth steel, or 50000 lbs. per sq. in. for wrought iron and Bessemer steel.		
Shear in plate girder webs and rolled beams (gross section)	18000	15000
Shear in rivets and pins	22000	19000
Bearing on rivets, pins, outstanding legs of stiffener angles, and other steel parts in contact	44000	38000
The above-mentioned values for shear and bearing shall be reduced 20 per cent. for countersunk rivets, floor connection rivets, and turned bolts.		

(11) In members subject to stresses produced by a combination of dead load, live load, impact, and centrifugal force with lateral forces, or bending due to lateral action, unit stresses 25 per cent. greater than those given in Article 10 may be allowed; but, in such cases, the unit stresses due to dead load, live load, impact and centrifugal force alone shall not exceed those given therein.

(12) In hangers having an unequal distribution of load, and in hangers or hip verticals consisting of a single member, consideration should be given to the necessity for reducing the allowable unit stress to meet this condition.

(13) Stresses in plate girders shall be computed either by the moment of inertia of their net sections; or by assuming that the flanges are concentrated at their centers of gravity. In the latter case, one-eighth of the gross section of the web, if continuous or properly spliced, may be used as flange section. For girders having unusual sections, the moment of inertia method shall be used.

(14) When the stresses exceed the foregoing limits, or when the design or physical condition makes it necessary, the structure shall be strengthened or renewed.

Appendix B

DISCUSSIONS ON RULES AND UNIT STRESSES FOR RATING EXISTING BRIDGES—AMERICAN RAILWAY ENGINEERING ASSOCIATION—BULLETIN 228

Discussions by

F. Auryansen, Bridge Engineer, Long Island Railroad, Jamaica, N. Y.
John A. Bohland, Bridge Engineer, Great Northern Railway, St. Paul, Minn.
A. W. Carpenter, Assistant Valuation Engineer, New York Central Railroad, New York, N. Y.
J. E. Crawford, Chief Engineer, Norfolk & Western Railway, Roanoke, Va.
G. A. Haggander, Bridge Engineer, Chicago, Burlington & Quincy Railroad, Chicago, Ill.
H. J. Hansen, Office Engineer, Chicago, Milwaukee & St. Paul Railway, Chicago, Ill.
J. B. Hunley, Engineer Bridges and Structures, Cleveland, Cincinnati, Chicago & St. Louis Railway, Cincinnati, Ohio.
B. R. Leffler, Engineer of Bridges, New York Central Railroad, Cleveland, Ohio.
C. D. Purdon, Consulting Engineer, St. Louis Southwestern Railroad, St. Louis, Mo.
D. B. Steinman, Assistant Engineer, New York Central Railroad, New York, N. Y.
F. E. Turneaure, Dean, College of Mechanics and Engineering, University of Wisconsin, Madison, Wis.
H. T. Welty, Engineer of Structures, New York Central Railroad, New York, N. Y.

Article 1

Insert in parentheses, after the word "location," the words "as determining its use." (Carpenter)

Article 2

In clause (a) add the words "or other working data." For some items there are no drawings available.

In clause (c) after the words "worn pins," add the words "bent and crooked members." (Carpenter)

Article 5

It seems to me that this article should be very carefully considered before adoption. I have reviewed the rule as it applies to a number of existing bridges, and find that if a bridge was not quite strong enough to carry an E-60 locomotive at full speed, by reducing the speed to 14 miles an hour it would carry safely an E-70 locomotive, and by reducing speed to 9 miles an hour it would carry safely an E-84 locomotive.

Personally, if a bridge were not safe to carry an E-60 locomotive at full speed, I would not care to run an E-84 locomotive over it at any speed; and it would seem to me that 60 per cent impact at a speed between 10 and 15 miles an hour, and 40 per cent impact at speeds below 10 miles an hour, would give safe and satisfactory results. (Crawford.)

I think the last sentence should be omitted. I cannot conceive of any bridge located where a stop, or change in speed, might not occur at some time. (Hunley)

Article 6

This article specifies that impact shall be added to stresses produced by centrifugal force, but not to those produced by lateral force. As centrifugal force is essentially a lateral force, I suggest that impact be eliminated. (Hansen)

Article 8

It seems to me that 400 lb. per linear foot is a very heavy wind load. If applied to a train of cars of 8 ft. average depth of side, it would amount to 50 lb. per sq. ft. on the car sides, which would only be realized in a hurricane which would in all probability stop the operation of trains.

The A. R. E. A. 1920 specifications provide for a corresponding load of 700 lb. per linear foot. This must provide for something more than wind. The New York Central Lines specifications, 1917, provide for a corresponding load of 360 lb. as a wind load, and that is for designing purposes. I should think that 200 lb. would be sufficient for the examination of old bridges. (Carpenter)

Article 10

In my opinion, the unit stresses provided in the proposed rules are too high, and the unit stresses to which we work are considerably more conservative.

The last sentence in paragraph 3, page 507 of the Manual, reads as follows:

"The bridge, however, will be subjected to a greater amount of motion and wear of parts having a lower margin of safety, less efficiency, and a shorter life."

I feel that the high unit stresses proposed will result in a shorter life, and it will require continual and most careful inspections to determine when the time arrives at which these high unit stresses should be no longer applicable, and feel that we should be more conservative and make a considerable reduction in the permissible unit stresses. (Bohland)

I believe the heading "Open Hearth Steel" should be qualified so as to show that it refers to the usual soft grades used for structural work, or some note explaining this should be appended.

I believe there is very little difference in the strength of columns of structural steel of the soft grade that has been commonly used in bridge work, and those of wrought iron. Wrought iron columns of the old Phoenix type were (and still should be if any exist) especially strong. (Carpenter)

I feel that the wrought iron and Bessemer steel bridges are rated a little too low, and that these bridges should not be rated more than 10 per cent below the Open-Hearth Steel bridges. (Crawford)

I have looked up some stresses in old bridges as requested in Bulletin 228. Seven cases have been worked out covering bridges carrying various classes of power. These seven cases were picked at random. I find from the results obtained that our present practice checks very closely with the proposed rules. (Haggander)

The limiting stresses as listed in this article should prove consistent with safety and economy. It must not be overlooked, however, that the adoption of a high limiting stress calls for careful investigation and sound judgment in regard to details, character of design and physical condition of the bridge, in connection with observations made in the field as to the general behavior of the structure under load, that can be exercised only by conscientious engineers experienced in handling this class of work.

A unit stress of 26,000 lb. per sq. in. is rather high for members in a steel truss intended for service over an indefinite length of time. It may be permissible in some cases to employ a unit stress of 26,000 lb. per sq. in. for a limited length of time, until the structure can be strengthened or renewed, but considering imperfections in material and details, and also bearing in mind that the calculated stresses may be considerably augmented by secondary stresses and unequal distribution of load in built-up members and eyebars, it is a question if it may not be advisable to reduce the limiting stresses to 24,000 lb. for steel and 20,000 lb. for wrought iron truss members.

The effect of unequal distribution of load and secondary stress is not so pronounced in plate girder flanges as in truss members, and the 26,000 lb. per sq. in. for steel and 22,000 lb. for wrought iron may not prove excessive for this class of structure.

The problem of rating bridge pins is a difficult one to solve, due mainly to the absence of tests on short beams with the loads applied similar to those on bridge pins. The problem, however, can hardly be satisfactorily solved by raising the allowable unit fiber stress on pins to 60,000 lb. per sq. in., which is above the ultimate strength of wrought iron, and in many cases also beyond the breaking strength of steel. It would be preferable to adopt a method conforming more closely to the actual conditions encountered in practice than does the ordinary method now prevailing.

This question can hardly be definitely settled except by a series of tests, but it may be safe to take a moment arm as short as the actual distance between bars plus ¼ in., for rating pins in existing bridges. Instead of adding a constant quantity to the clear distance, it may be more desirable to make this quantity a function of the thickness of the bars.

There can be no great objection to designing pins for new truss bridges by the prevalent method, for the additional cost of providing too large a pin is comparatively small, but, when the problem is one of rating a pin in an existing bridge, the question becomes more serious on account of the heavy expense in connection with strengthening a pin joint.

In view of the expense in connection with changing out old pins, I feel that the question is of sufficient importance to be followed up by a series of tests to determine the moment arm that should be used in designing and rating pins. These tests should conform as closely as may be to the actual conditions encountered in designing new or investigating old bridges. The cost of conducting such tests will be small as compared with the money that may actually be saved by throwing additional light on the subject, and I suggest that some tests along this line be included in next year's program of the A. R. E. A. (Hansen)

In plate girder spans, it is evident that the proposed rules will give a comparatively high rating for webs, end stiffener bearing, and flange rivet bearing, and a low rating for the compression flanges.

In truss spans they will give a comparatively high rating for all members.

It seems to me that the rules give results just contrary to safe practice. A girder span is quite a rugged structure and a sudden failure can result only from a failure of all its parts at one time, while with a truss span just the opposite is true; the failure of any one member may result in the collapse of the span.

The stresses permitted by the formula for axial compression are too high. They will apply usually to truss ratings, and I think will give results on the unsafe side. If the formula $20500\text{-}80\frac{l}{r}$ is compared with the formula $17500\text{-}78\frac{l}{r}$ it will be noted that, with $\frac{l}{r} = 100$, the proposed formula will permit stresses 30 per cent in excess of those we are using on our road. (Hunley)

Attention should be called to the stress in pins to the effect that the unit stresses apply only to pins on which eyebars, or similar members, are closely packed. Some precautionary statement should be made to prevent someone applying these high unit stresses for a pin loaded in isolated points.

The unit stresses for shear in plate girders and the unit stresses for bearing on pins, rivets, etc., should be separated from the remainder of the stresses, and a statement made to the effect that these unit stresses should not be considered in discarding a structure, provided that the other unit stresses are of comparatively low value. I do not believe any engineers would throw out girders on account of high web shear or rivet bearing if the flange stresses were low. I would regard these unit stresses in shear and bearing as of secondary importance. They should be used as indicators or signs to look for loose rivets or marked deformation of webs. (Leffler)

I think the unit stress of 22,000 lb. on iron is high, in view of the fact that most bridges having iron members specified an elastic limit of 26,000 lb. and this would be 84 per cent (Purdon)

According to the studies of the A. S. C. E. column tests by Mr. Hovey, the ultimate strength is represented by $p = 38000 - 70\frac{l}{r}$ for light columns, and by $p = 35000 - 72\frac{l}{r}$ for heavy columns. Taking ⅔ of the average of these two formulas as a proper value for rating old bridges, we have $p = 24000 - 47\frac{l}{r}$ (See Fowler's paper).

This would indicate that the $\frac{l}{r}$ reduction for columns in the present sub-committee report is too severe, and the formula $24000 - 50\frac{l}{r}$ (instead of $24000 - 100\frac{l}{r}$) is recommended for axial compression. (Steinman)

I have compared the results obtained by the use of the old and the new impact formulas with special reference to the unit stress of 26,000 lb. per sq. in. Using this stress as a basis, on the theory that the old impact formula is used, and then calculating the unit stress which would exist in the same structure using the new impact formula, gives approximately the following results:

Span Length	*Equivalent Unit Stress Using New Impact Formula*
100 ft.	26,000 lb.
150 ft.	24,800 lb.
200 ft.	24,000 lb.
250 ft.	23,300 lb.
300 ft.	23,000 lb.

These are approximately the unit stresses which would exist in the chord members of trusses of specific span lengths for single track bridges and for Cooper's E-50 loading. That is to say, if, under the old impact formula, a 200-ft. span truss showed a total actual working stress for dead load, live load and impact of 26,000 lb. per sq. in., the same truss, using the new impact formula and the same loading, would show a stress of about 24,000 lb. per sq. in. Longer spans would show somewhat smaller stresses and shorter spans higher stresses, the 100-ft. span being the same in both cases, because the impact formula gives the same result at this span length.

Of course this comparison is only of value in relating old and new practice, but it does show that the proposed stress of 26,000 lb. will allow considerably heavier loads on the longer truss than the old practice. I would raise the question, therefore, whether or not 24,000 lb. is a more reasonable figure for this purpose. (Turneaure)

Referring to comment by Mr. Steinman, the reduction factors proposed are identical with those in specifications for new work, whereas it would seem that they should be somewhat larger, in view of the greater unit stress.

I entirely agree with Mr. Leffler that attention should be called to the fact that the high unit bending stress permitted in pins should apply only to pins on which the eyebars or similar members are closely packed. (Welty)

Article 13

This article should be changed to read: "The stress in the *gross section of the* compression flanges of plate girders, etc."

It does not seem to me that reduction of compressive flange stress is justified to the extent given in the proposed formula. (Auryansen)

I see no legitimate excuse for abandoning an $\frac{l}{r}$ formula for an $\frac{l}{b}$ formula. It is true that it is a little easier to apply, but the results are not consistent.

No permissible stresses are given for flanges of rolled beams. These should be included. (Hunley)

In Bulletin No. 168 of the University of Illinois Engineering Experiment Station is found a record of some tests that were made on the buckling strength of I-beams in bending. The following gives the main substance of this Bulletin. In the following suggestions that I am making, I am assuming that the same approximate results would be found for plate girders. Let f_1 = ultimate extreme fiber stress in pounds per square inch. The ultimate bending moment for failure equals f_1 multiplied by the section modulus of the beam.

Bulletin No. 168 of the University of Illinois gives the equation $f_1 = 40{,}000 - 60\,m\frac{l}{r}$, in which m is a constant having a value of ⅔ for I-beams. Then $f_1 = 40{,}000 - 40\frac{l}{r}$. Now divide the stress f_1 by a factor of safety of 2.5 to obtain a working unit stress f. Then $f = 16{,}000 - 16\frac{l}{r}$.

The report allows an increase of ⅝ in the tension flange stress for allowable maximum overload. On this basis, the average allowable maximum unit stress in the compression flange should be $26{,}000 - 26\frac{l}{r}$.

Now $r = \frac{b}{4}$ closely. The formula then becomes $26{,}000 - 100\frac{l}{b}$ closely. The sub-committee gives $23{,}000 - 100\frac{l}{b}$. If the University of Illinois Bulletin is right, the suggested formula of the sub-committee is too severe. Since the sub-committee has considerably increased the constant in the second term of the column formula, I suggest a somewhat similar treatment of $16{,}000 - 16\frac{l}{r}$ and recommend the formula $26{,}000 - 150\frac{l}{b}$ as the maximum allowable unit stress in compression flanges of plate girders and I-beams.

In the old A. R. E. A. specifications no particular reason is given for the flange formula given in Article 30, but there is no doubt that the restraining influence of the web to side buckling was taken care of by modifying the second term. In this connection, see Article 9, page 149 of "Design of Steel Bridges," by Kunz.

It seems to me, however, that the experiments given in Bulletin 168 of the University of Illinois are a better guide in selecting a formula than anything we have, and I will not change my recommendation in this respect; I am simply trying to show the steps that were taken in deriving the formula given in the old A. R. E. A. specifications.

Looking at it from the standpoint of Bulletin 168 or from the method of treatment pursued in the old A. R. E. A. specifications, I think it is evident that Article 13 needs considerable revision. (Leffler)

The permissible extreme fiber stress in beam or girder flanges should be somewhat larger, not smaller, than the permissible direct stress in struts or ties. The main reason for this is the reinforcing action by adjacent fibers which have a lower stress.

The slenderness reduction constant (coefficient of $\frac{l}{r}$) should be less for beam or girder flanges than for columns. The main reasons for this are partial restraint by the web and stiffeners, and the tapering stress. This principle is properly observed by reducing the proportion of the $\frac{l}{r}$ coefficient about 13 per cent.

The sub-committee report for rating old bridges prescribes $24{,}000 - 100\frac{l}{r}$ for columns. Accordingly to be consistent, a proper value for compression in girder flanges would be about $26{,}000 - 94\frac{l}{r}$, taking the foregoing principles into account. This is approximately equivalent to $26{,}000 - 400\frac{l}{b}$ for plate girders, and $26{,}000 - 350\frac{l}{b}$ for I-beams (instead of $23{,}000 - 400\frac{l}{b}$ as now proposed).

Adopting the value $p = 24{,}000 - 47\frac{l}{r}$ (see discussion on Article 10) as correct for columns, the appropriate value for girder flanges would be about $26{,}000 - 44\frac{l}{r}$, which is approximately equivalent to $26{,}000 - 190\frac{l}{b}$ for plate girders, and to $26{,}000 - 170\frac{l}{b}$ for I-beams. This is very near the value $(26{,}000 - 150\frac{l}{b})$ suggested by Mr. Leffler, and based on the I-beam tests at the University of Illinois. In order to be on the safe side, as there is quite a range of variation of the ratios $\frac{b}{r}$ for different beams and girders, I would recommend $p = 26{,}000 - 200\frac{l}{b}$ for rating compression flanges of beams and girders. (Steinman)

In the case of plate girders, a reduction factor of $400\frac{l}{b}$ would usually not determine the strength of the girder. For a girder with cover plates, and assuming the top and bottom flanges alike, I believe the unit stress in tension would govern, even with such a large reduction factor. For I-beams, where the net area of the bottom flange would usually be the same as the gross area of the top flange, the reduction factor would have more bearing. In such construction, however, it would seem that a lower unit stress should be used than in the plate girder. I am inclined to think that a reduction factor of $400\frac{l}{b}$ is all right, but would suggest increasing the basic unit stress from 23,000 to 26,000 lb. (Welty)

Article 14

It is not clear that the *net sections* of "flanges are concentrated at their centers of gravity." I would suggest the following wording instead: "or by assuming that the net flange areas are concentrated at their centers of gravity." (Auryansen)

The expression "including compression side" appears to be the same as in the 1920 General Specifications, but I believe it is ambiguous. I presume the intention is to define the *net section* as that which is obtained by making proper deductions from the gross sectional area, for rivet holes on both tension and compression sides of the neutral axis. Perhaps a shorter expression can be found. The one that now stands certainly appears to me to be very defective. (Carpenter)

I think it would be well to make it clear that, where girders are rated by the moment of inertia method and the web is not continuous, the web splice should be rated for moment as well as shear. (Hunley)

RESULTS OF APPLICATION OF RULES AND UNIT STRESSES FOR RATING EXISTING BRIDGES—BULLETIN 228

Bridge 1—Through girder span, 71 ft. 6 in.

	Computed	Allowable
Girders, flange stress, full impact	21,500	17,400
Floor beams, flange stress (14-ft. panel)	22,400	21,200

Bridge 2—Skew, through girder span, 60 ft. on 6 deg. curve. Speed limit 20 mi.

		Computed	Allowable
Girders, flange stress	22,000		
Centrifugal, 10 per cent	700		
		22,700	17,600
Floor beams, flange stress (13 ft. 6 in. panel)		23,100	21,200
Approach girders (35-ft. deck span)—			
Flange stress	23,700		
Centrifugal, 10 per cent	900		
		24,600	20,600

Bridge 3—Deck girder swing span, unequal arms; channel span, 60 ft., assumed as simple span.

	Computed	Allowable
Girders, flange stress, full impact	26,500	18,200
Girders, flange stress, half impact	20,900	18,200

Bridge 4—I-beams, three to each rail, skew, on 4 deg. curve; span 27 ft. Superelevation of beams and track, 6 in.

		Computed	Allowable
Flange stress	18,200		
Centrifugal (15%, each beam one-sixth)	9,600		
		27,800	......
As single I-beams 27 ft. long		.....	6,100
As triple I-beams (width = sum of widths of 3 flanges)		.....	17,000
As single I-beams, unsupported length 7 ft.		.....	18,300

Centrifugal force should not be included, because the girders are superelevated, making the resultant load parallel with the webs.

Bridge 5—Columns of viaduct. One web 8 in. by 7/16 in. and four 6 in. by 28 lb. Z-bars. Length, 14 ft.

	Computed	Allowable
Axial stress	11,200	17,900

Bridges 1, 2, 3, 4 and 5—In no case does the shear in plate girder webs exceed the values allowed by the rules.

Bridge 6—Deck truss span, 170 ft. Built 1892.

	Computed	*Allowable*
Stringers, flange stress (wrought iron)	21,000	22,000
Floor beams, flange stress (wrought iron)	21,200	22,000
U2-U3 (wrought iron)	17,400	17,000
L3-L4 (steel eyebars)	21,500	26,000
L3-U4 (wrought iron counter)	20,700	22,000
U4-L5 (steel eyebars)	28,000	26,000

Bridge 7—Deck truss span, 160 ft. Built 1893.

	Computed	*Allowable*
Stringers, flange stress (steel)	25,300	26,000
Floor beams, flange stress (steel)	22,000	26,000
U2-U3 (steel)	19,500	19,300
L0-L2 (steel)	22,500	26,000
U2-L3 (steel eyebars)	26,600	26,000

Bridge 8—Through truss span, 110 ft., wrought iron. Built 1885.

	Computed	*Allowable*
Maximum tension	19,500	22,000

Bridge 9—Through truss span, 140 ft., wrought iron. Built 1876.

	Computed	*Allowable*
Maximum tension	21,300	22,000

Bridge 10—Through truss span, 176 ft., wrought iron. Built 1878.

	Computed	*Allowable*
Maximum tension	19,900	22,000

Bridge 11—Through truss span, 112 ft., wrought iron. Built 1882.

	Computed	*Allowable*
Maximum tension (one-fourth impact)	17,000	22,000
Maximum tension (full impact)	24,000	22,000

Bridge 12—Through truss span, 154 ft., wrought iron. Built 1879.

	Computed	*Allowable*
Maximum tension (half impact)	19,000	22,000
Maximum tension (full impact)	22,700	22,000

Bridge 13—Through truss span, 148 ft., wrought iron. Built 1887.

	Computed	*Allowable*
Maximum tension (one-fourth impact)	17,900	22,000
Maximum tension (full impact)	24,200	22,000

Bridge 14—Through truss span, 154 ft., steel. Built 1897.

	Computed	*Allowable*
Maximum tension (one-fourth impact)	20,900	26.000
Maximum tension (full impact)	29,700	26,000

Bridge 15—Deck girder span, 34 ft. 8 in., Bessemer steel. Built 1896.

	Rating by Rules	*Rating by Present Practice*
Web shear	E-76.2	E-68.2
End stiffeners, bearing	E-81.9	E-77.5
End stiffeners, compression	E-60.2	E-77.3
Flange rivets, bearing	E-55.5	E-50.1
Flanges, tension	E-56.9	E-56.9
Flanges, compression	E-49.3	E-57.7

Bridge 16—Deck girder span, 73 ft. 6 in., Bessemer steel. Built 1895.

	Rating by Rules	*Rating by Present Practice*
Web shear	E-71.8	E-64.3
End stiffeners, bearing	E-45.0	E-42.5
End stiffeners, compression	E-33.9	E-43.0
Flange rivets, bearing	E-95.0	E-89.5
Flanges, tension	E-55.0	E-55.0
Flanges, compression	E-47.8	E-56.8

Bridge 17—Deck girder span, 43 ft., Open Hearth steel. Built 1899.

	Rating by Rules	*Rating by Present Practice*
Web shear	E-79.2	E-63.0
End stiffeners, bearing	E-55.6	E-50.3
End stiffeners, compression	E-47.4	E-59.4
Flange rivets, bearing	E-69.0	E-62.5
Flanges, tension	E-59.0	E-59.0
Flanges, compression	E-51.7	E-60.2

Bridge 18—Through truss span, 159 ft. 6½ in., Bessemer steel. Built 1896.

	Rating by Rules	*Rating by Present Practice*
End post	E-58.7	E-45.3
Top chord	E-53.5	E-42.5
Bottom chord	E-37.6	E-33.4
Hip verts	E-41.9	E-37.6
Posts	E-66.6	E-53.0
Diagonals	E-47.2	E-42.0
Counter	E-29.1	E-26.4
Pin	E-57.6	E-43.8

Bridge 19—Through truss span, 123 ft., Bessemer steel. Built 1882.

	Rating by Rules	*Rating by Present Practice*
End post	E-27.3	E-20.0
Top chord	E-26.9	E-22.4
Bottom chord	E-24.9	E-22.0
Hip verts	E-31.7	E-27.0
Posts	E-51.1	E-39.3
Diagonals	E-25.8	E-22.8
Counter	E-50.8	E-46.0
Pin	E-34.6	E-26.7

Bridge 20—Through truss span, 147 ft., Bessemer steel. Built 1882.

	Rating by Rules	*Rating by Present Practice*
End post	E-29.2	E-21.4
Top chord	E-28.9	E-21.6
Bottom chord	E-26.7	E-23.5
Hip verts	E-30.8	E-27.7
Posts	E-40.8	E-30.2
Diagonals	E-26.3	E-23.2
Counter	E-40.1	E-36.5

Bridge 21—Through girder span, 87 ft., Bessemer steel. Built 1895.

$$\text{Impact } \frac{300}{L + 300}$$

	Computed	*Allowable*
Girder flanges	17,500	22,000
Stringer flanges (14 ft. 2 in. panel)	13,900	22,000
Floor beam flanges	20,300	22,000

Bridge 22—Through truss span, 200 ft. Built 1888.

$$\text{Impact } \frac{300}{L + 300}$$

	Computed	*Allowable*
Stringer flanges (wrought iron), 25-ft. panel	17,200	22,000
Floor beam flanges (wrought iron)	15,200	22,000
L0-U1 (wrought iron)	13,500	13,900
U1-L2 (steel)	22,600	26,000
U2-L3 (steel)	24,000	26,000
U3-L4 (steel)	23,400	26,000
U4-L3 (wrought iron counter)	14,600	20,000
U3-L2 (wrought iron counter)	13,300	20,000
U1-L1 (steel)	19,600	26,000
U2-L2 (wrought iron)	16,500	10,500
U3-L3 (wrought iron)	13,300	10,000
U4-L4 (wrought iron)	7,100	10,000
L0-L2 (steel)	22,600	26,000
L2-L3 (steel)	22,900	26,000
L3-L4 (steel)	22,300	26,000
U1-U2 (wrought iron)	14,500	15,200
U2-U3 (wrought iron)	14,300	15,200
U3-U4 (wrought iron)	14,400	15,200

Bridge 23—Through truss span, 123 ft. 2 in. Built 1907.

	Computed	*Allowable*
Stringer flanges (25-ft. panel)	20,100	26,000
Floor beam flanges	17,700	26,000
L0-U1	12,900	16 100
U1-L2	19,800	26,000
U2-L2	22,200	26,000
U1-L1	15,800	26,000
U2-L2	2,900	13,500
L0-L2	21,700	26,000
L2-L3	21,300	26,000
U1-U2-U2	13,100	16,700

Bridge 24—Through truss span, wrought iron. Built 1889.

	Computed	*Allowable*
Stringers, top flange (25-ft. panel)	19,200	14,700
Stringers, bottom flange	19,200	22,000
Stringers, web shear	11,400	15,000
Floor beams, top flange	17,700	16,200
Floor beams, bottom flange	12,400	22,000
Floor beams, web shear	7,900	15,000
U1-U2	16,000	17,000
U2-U3	20,700	17,000
U3-U4	21,100	17,000
U4-U5	22,900	17,000
L0-L2	20,700	22,000
L2-L3	21,300	22,000
L3-L4	20,600	22,000
L4-L5	20,600	22,000
L0-U1	12,200	13,600
L2-U2	11,400	14,300
L3-U3	11,400	14,600
L4-U4	10,000	12,600
L5-U5	9,200	13,300
U1-L2	24,300	22,000
U2-L3	24,800	22,000
U3-L4	25,900	22,000
U4-L5	21,600	22,000
U5-L4	20,500	22,000
U4-L3	25,300	22,000
L1-U1	17,300	22,000

Appendix C

PRINCIPLES FOR DETAILED DESIGN OF FLASHING, DRAINAGE, REINFORCEMENT AND PROTECTION FOR WATERPROOFING PURPOSES

F. AURYANSEN, *Chairman*, Sub-Committee.

General.

1. The following applies only to membrane waterproofing, as the "integral method" is not recommended for waterproofing railroad bridge floors.

2. The structure should be designed so that it can be waterproofed and it should be adaptable to waterproofing by ordinary methods and materials.

   Good workmanship being vital to the success of waterproofing, the design should be such that extraordinary precautions or methods will not be necessary to secure good results.

3. Strength and stiffness are desirable features in a structure which is to be waterproofed.

   The lack of these may permit destructive stresses in the waterproofing. Very shallow floors, such as shown in Figs. 3 and 4, should be avoided wherever possible.

4. The structure and its construction and expansion joints, drainage and waterproofing, should be designed together, considering their separate and combined functions, so that each will help to secure a waterproof structure.

   If any necessary feature is overlooked, it may be difficult, if not impossible, to provide a remedy after trouble appears.

5. Due regard should be had for the available methods and materials of construction.

   Traffic conditions, climate and prevailing markets or supplies, might thus control the design. Wherever possible, waterproofing under traffic should be avoided.

6. All waterproofed surfaces should be easily accessible, and as simple and smooth as possible; hence features should be avoided which would increase the difficulty of securing waterproof construction, such as open spaces, joints, holes, seams, or projections.

   The deck bridges shown in Figs. 15 and 16 lend themselves more readily to successful treatment than the trough floors, Figs. 2, 3 and 4, or the through bridges, Figs. 8, 9, 10, 11 and 13.

7. Concrete bridge floors should be of ample strength and thickness and of dense non-porous construction.

   Special attention should be given to providing the correct amount and disposition of the reinforcement, and to securing the proper amount of water used in mixing. See Figs. 5 to 10, 13, 15 and 16.

8. Where contraflexure would injure the waterproofing, special details should be provided, such as elastic joints. See Figs. 7 and 15.

9. Minimize the number of construction joints in the structure, provided an ample number of workable expansion joints can be introduced.

Concrete bridge floors should, where practicable, be built in one continuous operation for each track.

Drainage.

10. Adequate drainage should be provided by means of suitable grades which will shed water by the easiest or most direct route. One per cent. is a minimum desirable grade, but the grades away from points which are difficult to waterproof, should be correspondingly increased.

While sewer and gutter grades may be considerably less than one per cent., bridge floors, especially if ballasted, are subject to clogging by ashes, cinders, etc., and hence require steeper slopes to secure satisfactory drainage. See Figs. 1, 2, 3, 4, 8 and 15.

11. Avoid pockets which cannot be easily drained.

Water with only a slight head may find an outlet through the waterproofing, which otherwise might be tight. Standing water is undesirable on a waterproofed bridge floor, from its destructive effect, both as a solvent and also on account of frost action.

12. Where gutters or pipes are necessary, they should be of durable material, of ample size, easy of access to install and maintain, and protected against clogging or damage.

The grades should be enough to secure quick and entire escape of the water. Corrugated metal pipes are satisfactory where exposed to alternate freezing and thawing. Where sudden considerable variations in temperature occur, it is not desirable to encase drain pipes in concrete. Cleanouts and manholes should be provided where pipes cannot otherwise be cleaned. See Figs. 3, 4, 8, 10, 12, 14, 15 and 16.

13. Provide free exits for the harmless escape of drainage.

Such drainage should not be allowed to disfigure the structure nor to injure persons or property. Icicles may be prevented by a basket of rock salt inserted in the top of the drain pipe. (See Figs. 3, 4, 11, 12, 14, 15 and 16.)

14. Avoid features which would induce or permit capillary action.

For example, where the waterproofing extends up under the top of flange or beneath a flashing angle, it is very desirable to make the water drip off the edge, rather than allow it to follow the under surface and be drawn into the crack. (See Figs. 6, 7, 8 and 16.)

15. Where possible, locate edges and joints above the highest probable water level.

Edges of the waterproofing, either at parapets or where it joins the webs of through girders, should be at least as high as the base of rail, and preferably higher than the top of rail. Joints in the floor should be located so that the grades slope away from the joint.

Reinforcement.

16. Reinforcement of the structure should be suitably disposed, and ample in strength to prevent cracks or distortion which would injure the waterproofing. (See Figs. 6, 8, 9, 10, 13, 15 and 16.)

Reinforcement should be protected against destructive agencies such as electrolysis, brine, etc.

17. Cloths, felts or fibers should be capable of holding the waterproofing pitch where placed and should be durable, strong and flexible.

18. Wire mesh or sheet metal reinforcement for the membrane should be of durable material, flexible where necessary, and intimately bonded or introduced so that the waterproofing and reinforcement act together. (See Figs. 7 and 15.)

19. Necessary breaks in the surface of waterproofing or flashing, such as for drain pipes, or at construction or expansion joints, should be reinforced with extra flashing material. (See Figs. 7 and 15.)

Flashing.

20. Metal flashing shall be of material which is non-corrosive, and shall be insulated or protected against electrolytic action at points of contact with steel members of the structure. (See Figs. 5, 7, 8, 13 and 15.)

21. Flashing should be of material which can be applied readily, and should retain the position in which it is placed when subjected to actual conditions of service and temperature.

22. Flashing should be firmly attached in its proper position, so that it cannot easily be displaced or removed. (See Figs. 13 and 15.)

23. The edges of waterproofing and flashing should be protected against drip, percolation and capillary action. (See Figs. 5, 6, 7, 8, 9, 10, 11, 13 and 15.)

24. Joints between concrete and other material should be grooved and filled with an elastic expansion joint cement. (See Figs. 1 and 9.)

Protection.

25. Waterproofing and flashing should be protected, *as soon as possible after installation,* against mechanical injury, excessive temperature, chemical action, and deterioration caused by exposure to light and air.

26. The protecting covering should be dense, hard, durable and easy to apply.

It is recommended to use on flat surfaces either:

(a) Brick laid in cement mortar or served with hot pitch.
(b) Plain or reinforced cement mortar.
(c) Plain or reinforced concrete.
(b) Bituminous mastic.

For surfaces with considerable slope, mastic is not satisfactory, being difficult to apply and also to retain in place.

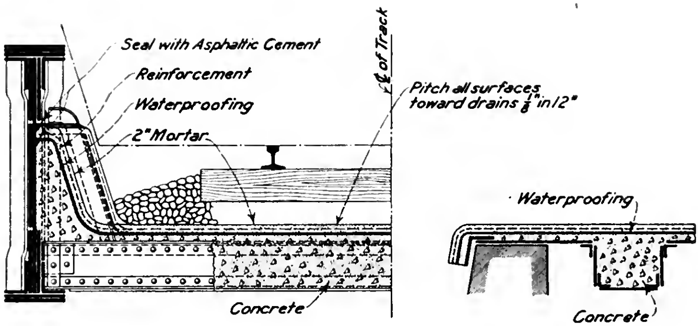


FIG. 1

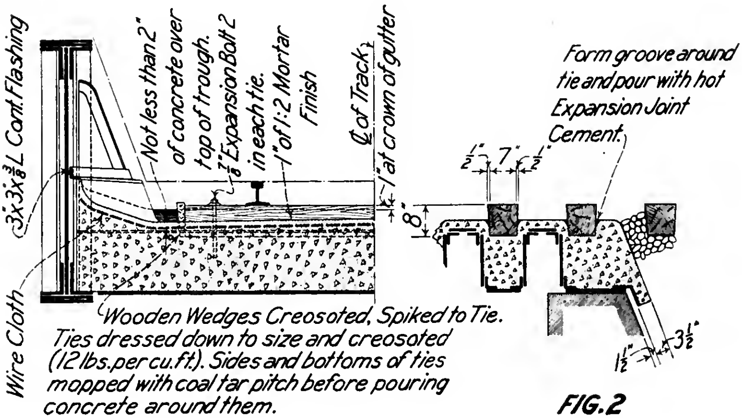


FIG. 2

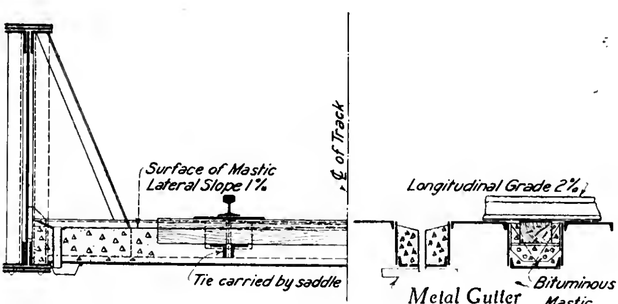


FIG. 3

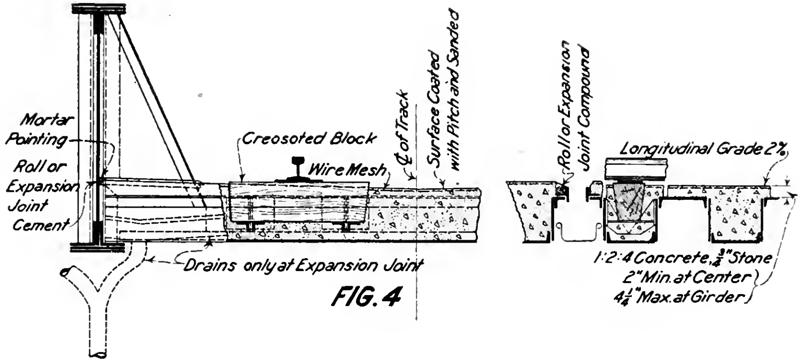


FIG. 4

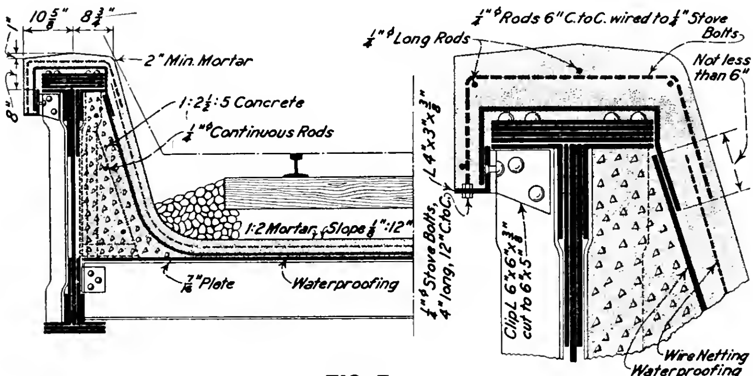


FIG. 5

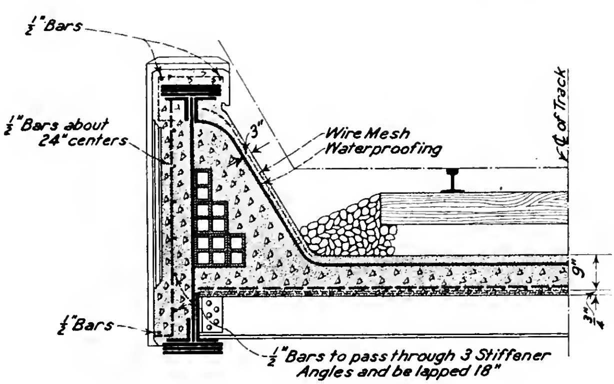
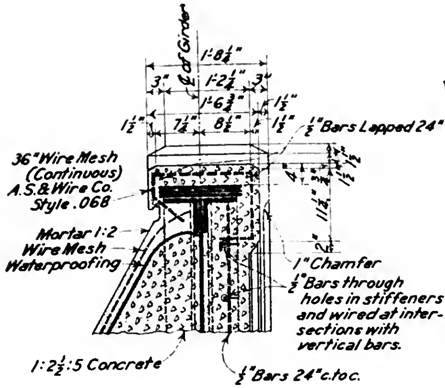


FIG. 6



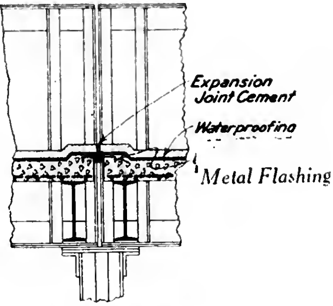


FIG. 7

DETAIL OVER COLUMN BENT

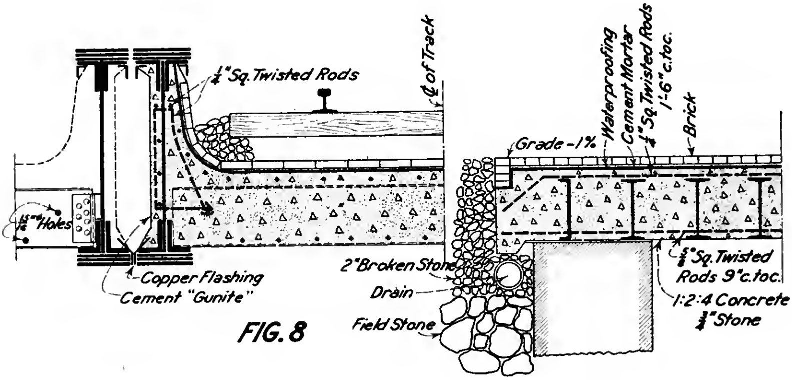


FIG. 8

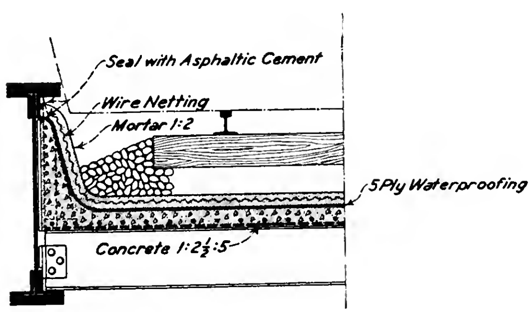


FIG. 9

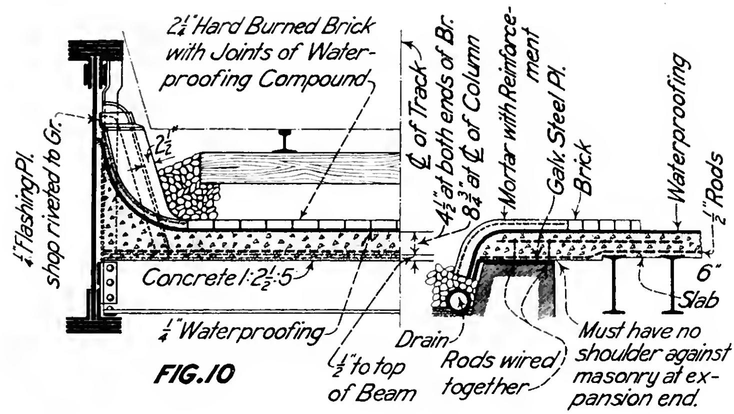


FIG. 10

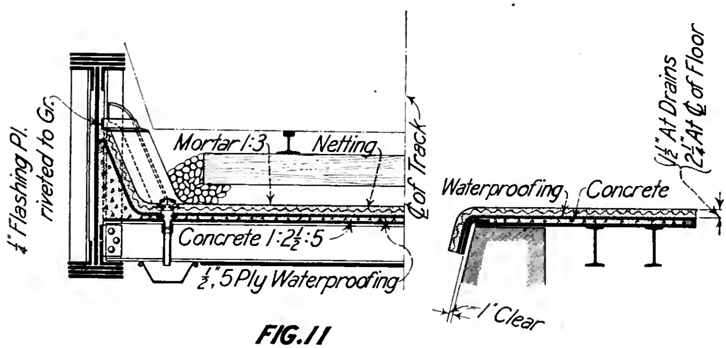
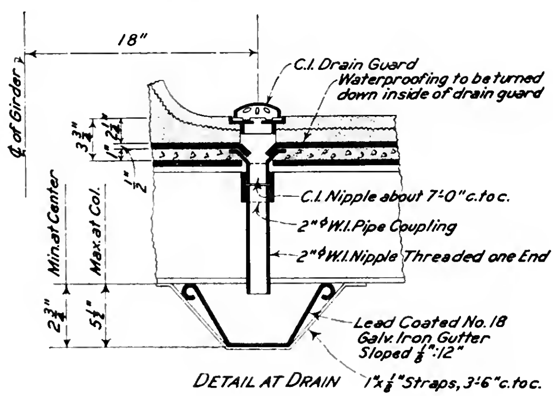


FIG. 11



DETAIL AT DRAIN

FIG. 12

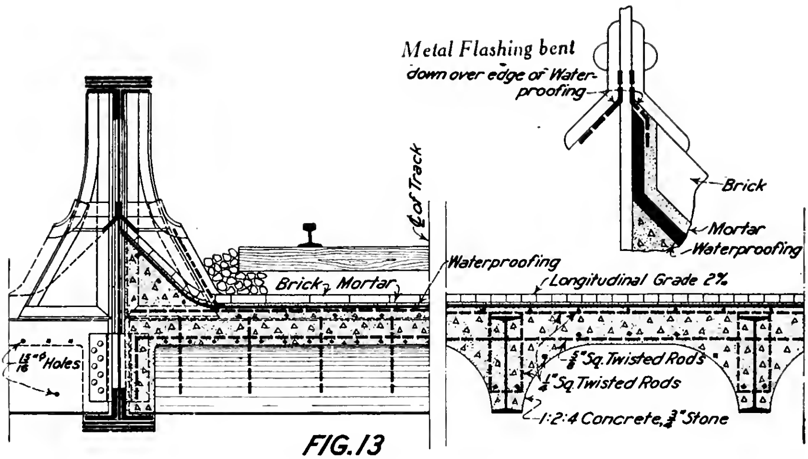

Metal Flashing bent
down over edge of Water-
proofing
Brick
Mortar
Waterproofing
℄ of Track
Waterproofing
Longitudinal Grade 2%
Brick
Mortar
15/16" φ Holes
5/8" Sq. Twisted Rods
1/4" Sq. Twisted Rods
1:2:4 Concrete, 3/4" Stone

FIG. 13

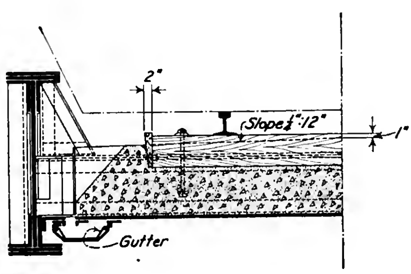

2"
Slope 1/4":12"
1"
Gutter

FIG. 14

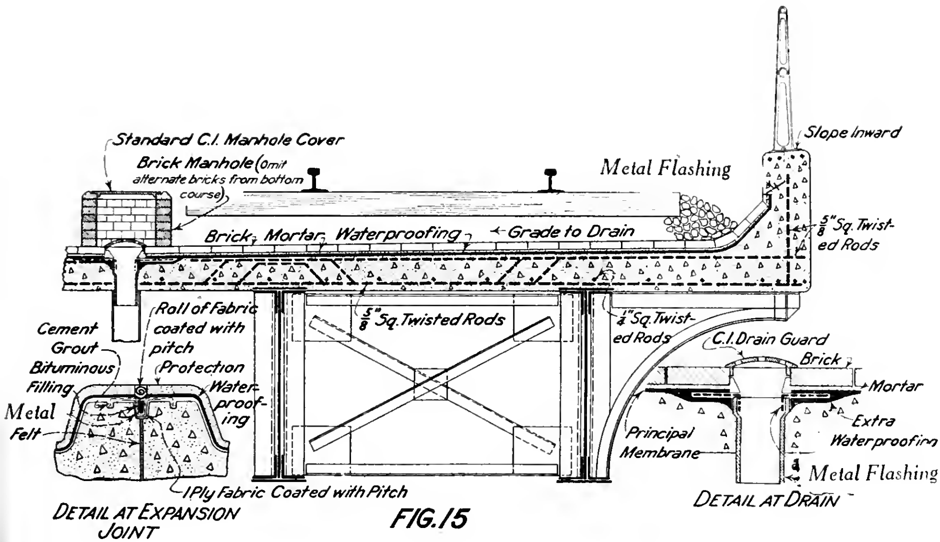

Standard C.I. Manhole Cover
Brick Manhole (omit alternate bricks from bottom course)
Metal Flashing
Slope Inward
Brick, Mortar, Waterproofing
Grade to Drain
5/8" Sq. Twisted Rods
5/8" Sq. Twisted Rods
1/4" Sq. Twisted Rods
C.I. Drain Guard
Brick
Mortar
Extra Waterproofing
Metal Flashing
Principal Membrane
Cement Grout
Bituminous Filling
Metal
Felt
Roll of Fabric coated with pitch
Protection
Waterproofing
1 Ply Fabric Coated with Pitch
DETAIL AT EXPANSION JOINT
DETAIL AT DRAIN

FIG. 15

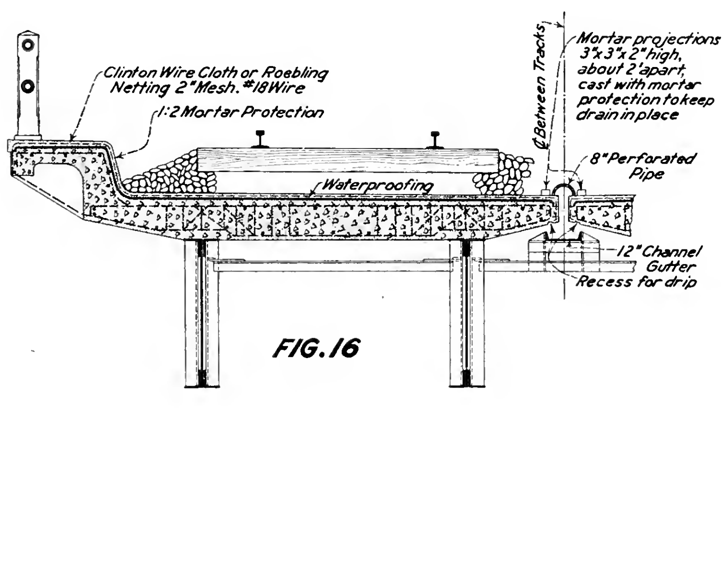

Clinton Wire Cloth or Roebling Netting 2" Mesh. #18 Wire
1:2 Mortar Protection
Waterproofing
℄ Between Tracks
Mortar projections 3"x3"x2" high, about 2' apart, cast with mortar protection to keep drain in place
8" Perforated Pipe
12" Channel Gutter
Recess for drip

FIG. 16

REPORT OF COMMITTEE XIII—ON WATER SERVICE

A. F. DORLEY, *Chairman;*
R. C. BARDWELL,
J. H. DAVIDSON,
G. B. FARLOW,
J. H. GIBBONEY,
E. M. GRIME,
W. C. HARVEY,
R. L. HOLMES,
H. H. JOHNTZ,
C. H. KOYL,
P. M. LABACH,

C. R. KNOWLES, *Vice-Chairman;*
E. G. LANE,
THOMAS LEES,
M. E. MCDONNELL,
W. M. NEPTUNE,
W. A. PARKER,
E. H. OLSON,
A. B. PIERCE,
C. P. RICHARDSON,
F. D. YEATON,

Committee.

To the American Railway Engineering Association:

Your Committee on Water Service presents below its report to the Twenty-second Annual Convention.

The Committee was instructed by the Board of Direction to make a study and report during the year on the following subjects:

(1) Make thorough examination of the subject-matter in the Manual and submit definite recommendations for changes.

(2) Make final report if practicable on the study of regulations of Federal and State Authorities relating to supply of drinking water on trains and premises of railways.

(3) Make final report if practicable on plans and specifications for typical water station layouts, conferring with Committee on Yards and Terminals and Committee on Economics of Railway Operation.

(4) Study and report on extent and effect of incrustation in pipe lines and methods of cleaning.

(5) Study and report on methods of disposing of waste water at water stations and keeping track free from ice.

(6) Study and report on specifications for contracting water service work.

(7) Study and report on the effect of local deposits on pollution of surface or shallow well water supplies.

(8) Study and report on specifications for substructures of wood and steel for water tanks.

Committee Meetings

In addition to the various meetings of the sub-committees, three meetings of the General Committee were held in the offices of the Association at Chicago.

(1) Revision of the Manual

The Committee at this time has no further recommendations to submit as to changes in the subject-matter in the Manual.

(2) Supply of Drinking Water on Trains and Premises of Railroads

A progress report on this subject appears in Appendix A.

(3) Plans and Specifications for Typical Water Station Layouts

A progress report on this subject is submitted in Appendix B.

(4) Extent and Effect of Incrustation in Pipe Lines

A final report on this subject, together with a monograph by C. H. Koyl, is submitted in Appendix C.

(5) Disposal of Water Waste

A final report on this subject appears in Appendix D.

(6) Specifications for Contracting Water Service Work

The Sub-Committee has gathered considerable data on this subject, but it is not as yet in shape for presentation to the Association and desires to report progress.

(7) Effect of Local Deposits on Pollution of Surface or Shallow Well Water Supplies

A preliminary report on this subject is submitted in Appendix E.

(8) Specifications for Substructures of Wood and Steel for Water Tanks

A final report on this subject is submitted in Appendix F for adoption and publication in the Manual.

CONCLUSIONS

Your Committee requests the following action on its report:

(1) That the subject of examination of the subject-matter in the Manual be again referred to the Committee for further study and report.

(2) That the report on progress of drinking water regulations be received as information and that the subject be reassigned to the Committee for further study and report.

(3) That the report on typical water station layouts be received as information.

(4) That the report on extent and effect of incrustation in pipe lines and methods for cleaning be received as information.

(5) That the report on methods of disposing waste water at water stations be received as information.

(6) That the subject of specifications for contracting water service work be reassigned to the Committee for further study and report.

(7) That the progress report on effect of local deposits on the pollution of surface and shallow well water supplies be received as information and the subject be reassigned to the Committee for further study and report.

(8) That report on Specifications for substructures of wood and steel for water tanks be adopted and published in the Manual.

Suggested Subjects for Next Year's Study and Report

(1) Study of subject-matter in the Manual with view to recommendations for changes.

(2) Study of progress of regulations of Federal or State Authorities pertaining to drinking water supplies.

(3) Study and final report on specifications for contracting water service work.

(4) Study and final report on effect of local deposits on pollution of surface and shallow well water supplies.

(5) Study and report on pitting and corrosion of boiler tubes and sheets, taking into consideration the character of the metal used, method of manufacture, construction of boilers and quality of water.

(6) Study and report on specifications for chemicals used in water treatment, presenting specifications for lime, soda ash, sulphate of alumina and anti-foaming compound.

(7) Study and report on use of centrifugal pumps in railway water service.

Respectfully submitted,

THE COMMITTEE ON WATER SERVICE,

A. F. DORLEY, *Chairman.*

Appendix A

STUDY REGULATIONS OF FEDERAL OR STATE AUTHORITIES RELATING TO SUPPLY OF DRINKING WATER ON TRAINS OR PREMISES OF RAILROADS

R. C. BARDWELL, *Chairman*, Sub-Committee.

With a view of expediting the furnishing of water satisfactory for drinking purposes on trains and premises of railroads, the Federal Public Health Service has assigned a number of Sanitary Engineers trained in this connection, to assist the various State Boards of Health in the supervision of drinking water supplies. With the assistance of these men, there has been a marked activity noticeable in the attention given the regulations pertaining to drinking water supplies.

At a meeting held by the Sub-Committee in the office of the Association on June 3 a representative from the office of the Surgeon-General was present and placed before the Committee the following points outlining the position taken by the Public Health Service:

"First, it must be pointed out that the responsibility for furnishing or producing water safe for drinking purposes is a large and serious one, fully comparable with any of the other obligations or responsibilities of the common carriers. The railroads, therefore, must comply fully with accepted modern standards for the production and handling of water for drinking purposes.

"Second, the former and even the present methods of selecting and handling drinking water supplies by the railroads are in need of extensive improvements, which it is now imperative that the fullest consideration be given by the railways.

"Third, it is considered with adequate justification that satisfactory conditions in regard to railway water supplies can only be obtained by the responsible supervision over sanitary factors of the water supplies by a competent and qualified sanitary personnel of the railway organization, varying to be sure with the size of the system. In this connection, it has been noted with some concern that the recently adopted scheme of Water Service Organization contains no provision for the specific responsibility and supervision of the sanitary quality and safety of the drinking water supplies on railroads."

It was brought out in the discussion that the question of a pure drinking water was as much a question of safety as the standard mechanical safety appliances and should be so regarded. The chief objections raised appeared to be in the methods of handling of the water in and to containers on cars. A safe sanitary supply may be readily polluted by improper handling. One of the chief faults has been in lack of protection for the hose connection from hydrant to car reservoir, and it is desired to present the device in use on a large Middle Western System as a sample method for taking care of this feature (Figs. 1 and 2).

It is the recommendation of the Committee that the detailed supervision of drinking water supplies on railroads should be under the authority of an officer with competent training in Sanitary Engineering, and such personnel should work in close co-operation with the recommended Water Service Organization as presented at the last convention.

As information of interest, the following quotation is taken from the report of the Executive Committee of the American Railway Association as presented at the November 17th session:

"Request has been received from the Acting Surgeon-General of the Bureau of Public Health Service, Treasury Department, that an order be issued fixing July 1, 1922, as the date when all water containers in cars and stations should be so constructed that ice does not come in contact with the water. The Executive Committee has referred this subject to the Medical and Surgical Section with the request that an effort be made to have the date on which passenger cars must be equipped with water containers so constructed that ice does not come in contact with the water extended to July 1, 1923."

As this feature of Railroad Water Supply is at present in more or less of a development stage, especially with reference to suitable standards for hose connections and hydrants used in filling cars, as well as the improvement and purification of small potable supplies, the progress should be of interest to many members of this Association, and if it is the pleasure of the Association, your Committee will be pleased to keep in touch with the situation and report on the possible and economical means of compliance as practiced and authorized.

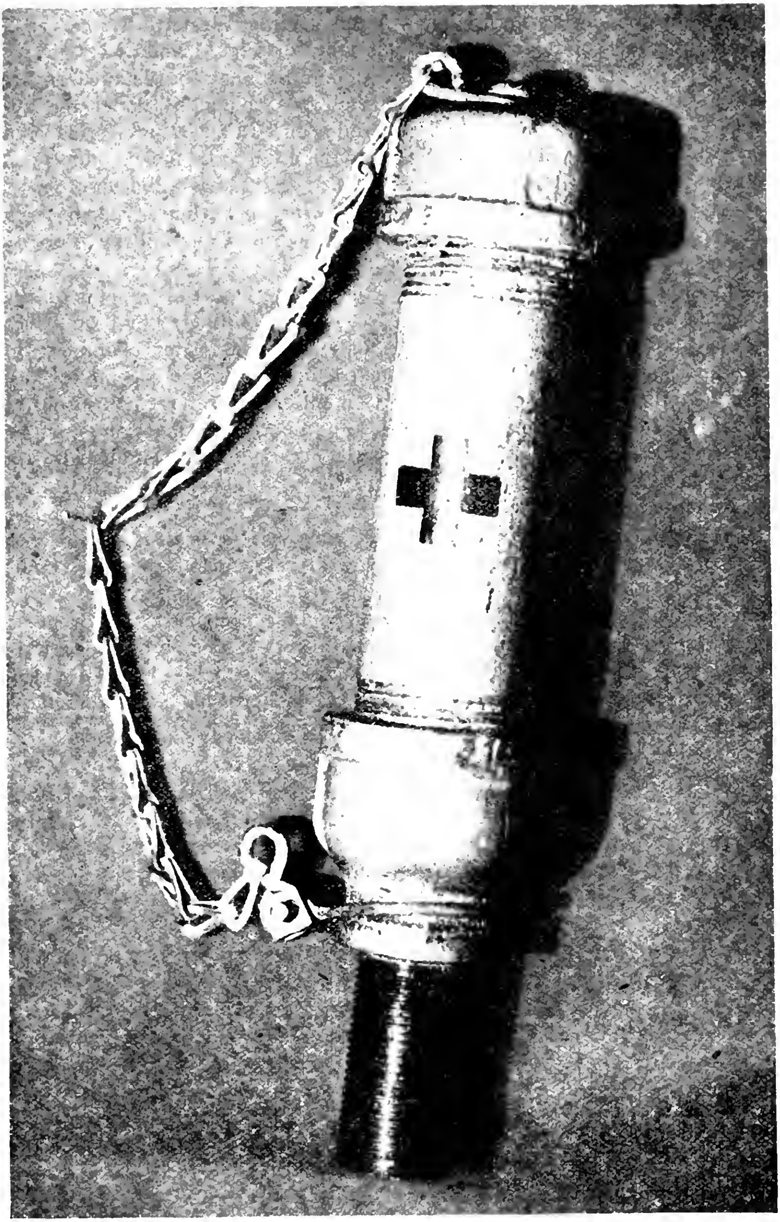


Fig. 1—Device for Protecting Hose Used in Filling Drinking Water Tanks, Illinois Central Railroad (Closed).

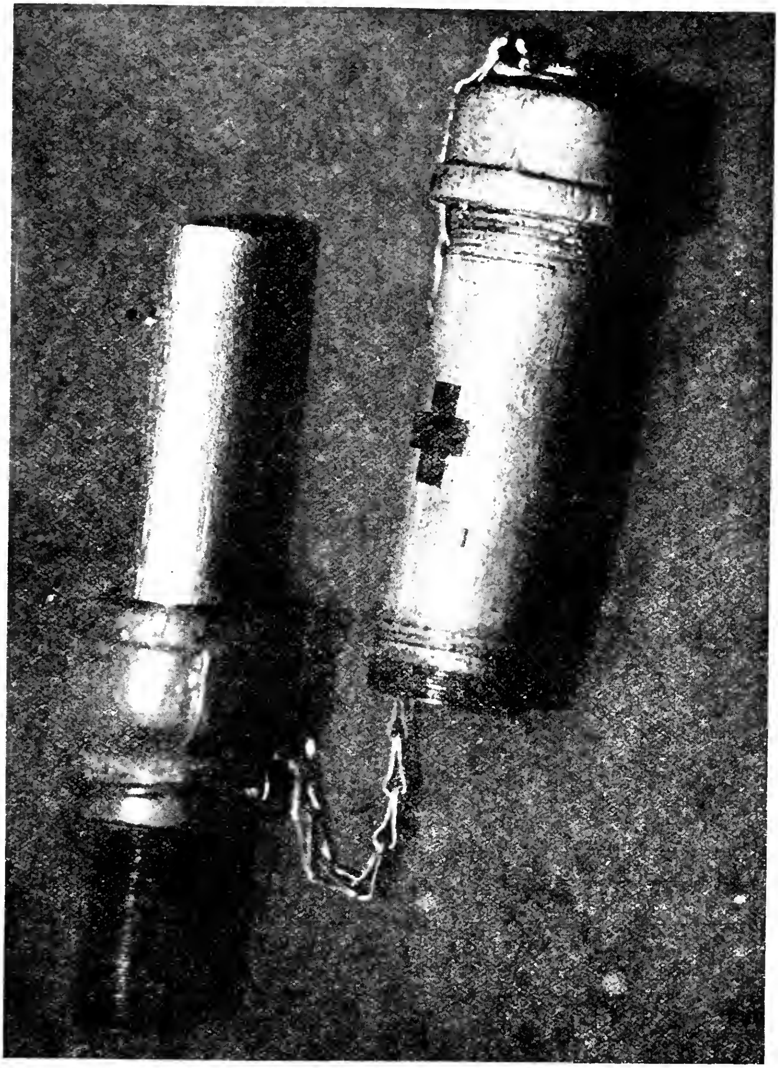


FIG. 2—DEVICE FOR PROTECTING HOSE USED IN FILLING DRINKING WATER TANKS, ILLINOIS CENTRAL RAILROAD (OPEN).

Appendix B

PLANS AND SPECIFICATIONS FOR TYPICAL WATER STATION LAYOUTS

C. R. Knowles, *Chairman,* Sub-Committee.

It is the opinion of the Committee that the subject as assigned has been covered so far as this Committee's jurisdiction extended in the report made to the last convention, it being the opinion that any work which might be done by this Committee other than suggestions given in the last report would lie within the province of the Committee on Yards and Terminals and the newly formed Committee on Shops and Locomotive Terminals. The subject is, therefore, referred to the Secretary of the Association for proper action.

The Water Service Committee will, of course, be glad to coöperate with the committee or committees handling this subject and furnish any assistance possible in the further study of the subject.

Appendix C

EXTENT AND EFFECT OF INCRUSTATION IN PIPE LINES

P. M. LaBach, *Chairman,* Sub-Committee.

The subject assigned is "Nature and Extent of Incrustation in Pipe Lines."

In pursuing the study of the subject the following questionnaire was sent to different railroads in general, covering practically all the United States:

"The Water Service Committee of the American Railway Engineering Association has been assigned the question of nature and extent of incrustation in pipe lines.

"If you have had trouble of this nature, will you please answer, insofar as possible, the questions in the following list. If you have never had any trouble, please state that fact also.

"Incrustation from raw water.

Nature—Physical appearance and chemical analysis?
Extent—Physical measurements and time required to produce?
Cause—Analysis of raw water if available?

"Method of cleaning.

In place? On removal of pipe?

"Results obtained from cleaning.

Former pressure—at pumps—when working?
New pressure—at pump—when working?
Former capacity in gallons per minute?
New capacity in gallons per minute?

"Incrustation from treated water.

Nature—Physical appearance and chemical analysis?
Extent—Physical measurements and time required to produce?
Cause—Analysis of raw water if available?

"Method of cleaning.

In place? On removal of pipe?

"Results obtained from cleaning.

Former pressure—at pump—when working?
New pressure—at pump—when working?
Former capacity in gallons per minute?
New capacity in gallons per minute?

Replies were received which show that stoppage of pipe lines by foreign materials is to be found in all territories. Some replies indicate that certain railroads do not know of its existence, but municipalities in the same area report finding the trouble and contracting for its removal. One road reports a 4 in. line in Maryland as practically showing no diminution in diameter after forty years' service. This was ascertained on renewal.

(I) General Causes and Characteristics

(a) Corrosin, tubercles or roughening of interior surface.
(b) Mud or other deposits of suspended matter.
(c) Snails and similar growths.
(d) Iron, manganese and aluminium in water.
(e) Water treatment.
(f) Application of heat.

(a) A large proportion of stoppages is due to this cause alone. Where pipe is well coated, before laying, trouble of this nature is not generally to be expected in ordinary water for a number of years. While in itself it may not result in serious trouble, it usually forms the foundation for other deposits by roughening the interior of the pipe. The amount of deposit depends entirely on local conditions.

(b) Mud or suspended matter (other than found as a result of water treatment) seldom forms a deposit unless the foundation has been already laid by (a). The amount found depends largely upon the nature of the water and the velocity of the flow.

(c) Snails and similar growths are frequently found in suction lines, but little information is to be found on the subject.

(d) Iron, manganese or aluminium promote the growth of various forms of Crenothrix in pipes or reservoirs. When these substances are absent apparently no difficulty is found from this source.

In addition to Crenothrix there is a large variety of bacteriological growth with long scientific names, but familiarly known as pipe moss, pipe sponge, etc. It is claimed that these organisms will not thrive unless the water is acid. Anything tending to make the water alkaline will reduce or cure the trouble. Filtration may or may not assist. To be of value the filter must be of a nature to remove the bacteria or its food, or both. Many filters fail to remove bacteria, although they may lessen the difficulty.

The usual sequence is for the pipe to roughen through corrosion. Then mud or slime is deposited which forms a culture bed for a variety of growths.

(e) Incrustation due to water treatment is commonly found in treating plants of various types. This deposit is greatest when the water is undertreated or raw and treated water are mixed in the pipe lines. There is also difficulty due to water being used before the reactions are complete. There is no evidence that filters will entirely eliminate the trouble as the reaction frequently takes place after the chemicals pass the filter. That a good filter will help there is no question.

This deposit is usually found in annular rings of various degrees of hardness. (See Figs. 3 and 4.)

Fig. 3—10-Inch C. I. Pipe Before and After Cleaning.

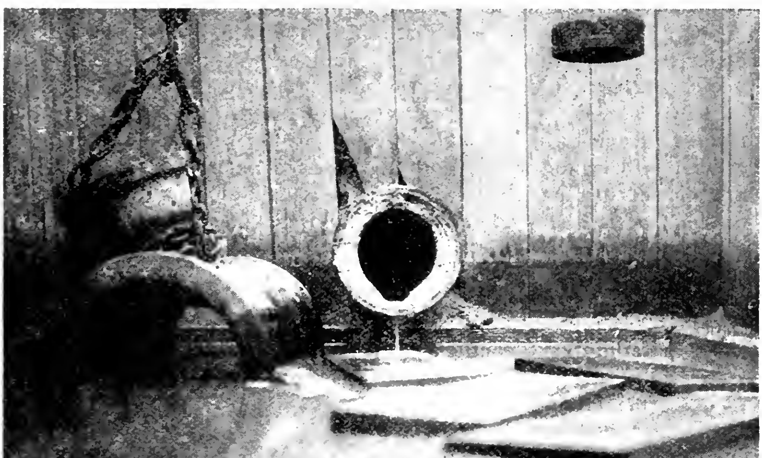


Fig. 4—10-Inch C. I. Pipe Showing Characteristic Shape of Incrustation.

(f) The application of heat will deposit a scale largely composed of the carbonates of lime and magnesia. In treated water the changes in temperature will also cause a deposit. When the temperature rises in passing from the treating tank any excess of lime or magnesia will deposit. The reverse is true of soda. As any excess is generally carbonate of lime, the latter is usually the main source of deposit.

(II) Operating Costs Affected

(g) Carrying capacity of pipe.
(h) Useful life.
(k) Depreciation.

(g) A pipe line in good condition should carry at a given pressure within 5 per cent. of the amount of water given by a set of Hazen or Weston tables. Or it may be stated that for a given amount of water per month the friction should not be more than 5 per cent. greater than for a new pipe.

When stoppage exists it may result in either of the following conditions: The pump may be run to handle as much water as formerly; or the speed may be cut down. In bad cases the speed is decreased, as the pump and pipe pressure would be excessive.

In computing the cost of incrustation the comparison can be based on the water horse power hour. Calculate this for the existing plant by the use of pressure gages. Make the same calculation for new pipe plus 5 per cent. The difference in fuel cost will show the saving, unless overtime wages enter into the subject.

(h) The useful life of a cast iron pipe may be several hundred years under the best conditions. These conditions are seldom found in practice and practically do not exist in industrial plants. The shortest length of life reported is four years at an intermittent treating plant. The longest is unknown, although 40 years is not unusual. There is not enough information available to set a period on useful life. Pipe lines are allowed to remain in place long after their economic useful life has ceased to exist, but nothing is done until the supply of water is inadequate.

(k) There is not enough information available to compute depreciation of pipe lines in industrial plants.

(III) Method of Cleaning

(l) By hand.
(m) Mechanical.
(n) Chemical.

(l) The cleaning of pipe by hand can only be done when the deposit is comparatively soft. It is sometimes possible in short pipes under special circumstances to clean them in place by using a scraper of some sort, but mechanical means are usually found more effective.

(m) Mechanical means are most frequently used. The pipe line may be removed and revolving cutting tool fixed on a shaft pushed through the section of pipe. This has been found to answer the purpose with an air motor and a special cutting tool on a 13-foot shaft. Flue cleaners have also been used for the same purpose.

The latest method is to clean the pipe in place. This is done by opening the pipe line in two places and running a cable between them. This cable is used to drag a cutting tool behind it. One railroad has used a flue cleaner successfully. However, most of the work has been done by contract. There is only one company in this field. They own the patents for tools and devices used in this class of work and have no competition.

In so far as our reports show the first water main cleaned was on the Illinois Central in 1867. It was 10,000 4-in. pipe laid in 1855. The incrustation was clay mud scale. The pipe was taken up and relaid. The relief was only temporary and the pipe was relaid with 8-in.

From that time to the present many lines have been cleaned or relaid without any record being made of it.

What may be accomplished by cleaning, irrespective of the method, is given in the following cases:

8-inch main, 11,575 feet long, cleaned September, 1909. Pressure required before cleaning 140 lb. for 400 gals. per minute. After cleaning 49 lb. was required to deliver 450 gallons.

6-inch main 7200 feet long. Former pressure at pumps 84 lb. New pressure 65 lb. Former capacity 180 gallons per minute; new capacity 220 gallons per minute.

(n) Valves, etc., around treating plants or where treated water is used are usually cleaned by the use of hydrochloric acid. The pipe lines can be cleaned by the same process, but the cost would generally be prohibitive unless the chemicals are recovered. This method is used at times, but the Committee has not sufficient information as to its practicability.

(IV) Prevention

(o) Flushing is generally nothing more than a mechanical method. It may be used if the local conditions are proper. It will prevent the formation of chemical deposits but rarely. Raw water used to flush lines which may carry uncombined chemicals will only aggravate the trouble.

(p) Aeration before pumping will aid where the water contains iron and produces the effect noted in (d). Adding to the aeration in intermittent treating plants is a preventative when the treatment is too short for completed reactions. The same may be said of any type of agitation.

(q) The prevention of chemical reactions in the pipe lines will, as a rule, stop all incrustation. By the nature of the subject this is not possible. It may be said that the better and more complete the treatment the less the trouble will be. No method has been devised which will eliminate temperature changes and their resultant effect.

(V) *The specifications for cleaning by contract* usually include a stipulation that the pipe line will be restored to within 5 per cent. of the normal friction loss as taken from a standard set of tables. This seems to have been attained when the contractor agreed to operate without injury to the coating in the inside of the pipe.

Any further stipulations would not be general and would depend upon what else, beside actual cleaning, the contractor agreed to do.

(VI) Conclusions

Pipe cleaning will pay when the water horse power hour cost per year is reduced sufficiently to pay 7 per cent. interest on the amount needed for the improvement.

Pipe line cleaning will pay if there is a shortage when the cost of cleaning is less than the cost of an additional pipe line needed for adequate service.

AFTER-PRECIPITATION FROM TREATED WATER—ITS CAUSE AND PREVENTION

By C. H. Koyl, Engineer Water Service, Chicago, Milwaukee & St. Paul Railway

In the early days of water softening in this country—from 1898—it was noticed that after water had been through the softening process, completed by passing through some simple kind of filter like a packed 12-in. of wood excelsior or a thin bed of sand from which it issued brilliantly clear, there was a deposition of flakes of carbonate of lime found on standing.

After studying this for some time it became evident that the chemical reactions had not been completed in the softening plant—that the last molecules of calcium-oxide (C_aO) had not found the last molecules of carbon di-oxide (CO_2); and since chemical reaction is almost instantaneous when once the atoms or molecules are within combining distance—consider any explosion—it was evident that the lime (to mention only one reagent) had not been thoroughly mixed with the water.

I then made a series of tests to determine the amount of mechanical mixing necessary to effect a softening down to 3 grains per gallon, at which point the reactions in ordinary water are nearly complete, and found it to vary from 25 minutes in clean well water at 60 deg. Fahr. to 50 minutes in river water at 45 deg. Fahr. Thereafter I built a reaction (mixing) tank as part of every "continuous" water softening plant.

In those days the "intermittent" plants, whose tanks were filled with water, treated with the proper amounts of lime and soda, well stirred for 20 minutes and then settled for three hours, were doing excellent work. But "continuous" plants had solutions of lime and soda in proper proportion continuously added to the incoming stream of raw water and the combination run around a few baffle boards for mixing purposes, and the softened water from these plants all deposited flakes of calcium carbonate on standing; and if the water was passed through a sand filter or through a pipe while the deposition was taking place (so that the particles of calcium carbonate were so small and young as to merit the term "nascent") then these molecules or small particles attached themselves to the sand grains or the pipe walls, and the sand grains were said to "grow" and the pipe to be incrusted, or, in very bad railroad parlance, to be corroded.

The addition of a 50-minute mixing chamber as a preliminary to the settling chamber of the "continuous" water softening plant did away with this "after precipitation" and I never saw enough of it from one of these plants to be noticeable. It was remarked, however, that if the water was undertreated in lime after disposition took place in spite of the 50-

minute mixing, for undertreated water requires much longer mixing than that.

It was still noted too that when the best of treated water was fed to locomotive boilers through injectors there was a sufficient deposition in the injector and branch pipe and on the check valve to interfere with the operation of the injector; and while this was not a serious matter in warm weather when the temperature of the injector does not exceed 212 deg. Fahr. unless the check valve leaks, it became very serious in cold weather in the north country, where in winter injectors are kept hot by steam from the boiler.

In the winter 1915-16 there was a treating plant at every water station on the Great Northern Railway on the line from Devils Lake, N. D., to Shelby, Mont., a distance of nearly 700 miles, all near the Canadian border; and while boiler leaking was unknown there was so much trouble from clogging of the injectors that its prevention became a serious study.

The material deposited in the injectors was calcium carbonate. It came from the water at a temperature not far above 212 deg. Fahr. At this temperature the content of calcium carbonate can be reduced to about 2 grains per gallon, but calcium sulphate, if it were present, would not be affected. Therefore, I decided to try to convert at least part of the 3 grains of calcium carbonate in the cold water into calcium sulphate by adding 3 grains per gallon of ferrous sulphate to the water before it left the mixing tank of the treating plant. This would leave in the water a small amount of ferrous carbonate which would give the injector no trouble.

The first test was made at Minot, N. D., because the switch engines in the yard had been the subject of continuous complaint. The water was treated as above for one month and then a switch engine was taken to the roundhouse and its injector, branch pipe and check valve dismantled and examined in the presence of all the local motive power men. The inside of the injector and all its connections was as clean as the day they were made.

Immediately thereafter the treatment with ferrous sulphate began to be extended to all treating plants on the line and the results have been uniformly good. On the road, so far as water is concerned, the winter handling of locomotives is as simple as the summer's.

The use of ferrous sulphate as outline above, as well as the use of all other chemicals employed in treatment of water, should be under the supervision of a competent person who understands the reactions involved.

CLEANING WATER MAIN AT BELLE PLAINE, IOWA

By F. D. Yeaton, Assistant Engineer, Chicago, Milwaukee & St. Paul Railway

The high cost of cast-iron pipe, together with the cost of laying it, should make the subject of cleaning water mains unusually attractive at the present time. Municipalities throughout this country have done considerable water pipe cleaning work; but the railroads, in general, have not done a large amount of pipe cleaning.

Recently, I had the opportunity of inspecting the cleaning of a cast-iron pipe line at Belle Plaine, Iowa. The pipe line is 6 inches in diameter by 8000 feet in length and is used for delivering water, obtained from a river, to a railroad engine terminal. The carrying capacity of the pipe line had been reduced about 10 per cent., amounting to approximately 50,000 gallons per day, due to a rough hard scale, $\frac{3}{16}$-inch thick, that had formed on the exterior of the pipe.

The pumping plant and the lime soda ash treating plant are located at the river. My investigation brought out the fact that the river at certain seasons of the year was muddy; that the introduction of chemicals was not closely supervised; that the capacity of the treating plant was insufficient during the maximum consumption, necessitating pumping direct from the river into the pipe line.

The pipe line was cleaned in 1000-foot sections. The method used for cleaning the pipe line was as follows:

1. The pipe was uncovered at two places, 1000 feet apart.

2. The water was shut off and a 3-foot section of pipe was removed at each place.

3. A cable carrier and special riser pipe was inserted at the opening nearest to the pump. (See Figs. 6 and 7.)

4. A 45-degree elbow and short length of pipe were connected to the pipe line in the opening farthest from the pump. (See Fig. 5.)

5. The water pressure was then turned on forcing the carrier, to which was attached a $\frac{3}{16}$-inch steel cable, through the 1000-foot section of pipe.

6. A $\frac{3}{8}$-inch steel cable was then attached to the $\frac{3}{16}$-inch cable by means of a small winch, operated by hand, was pulled through pipe.

7. The water pressure was closed off again and the riser removed. The scraping or cleaning machine was attached to the $\frac{3}{8}$-inch cable and inserted into the pipe. (See Fig. 6.)

8. The pipe opening was then closed by means of a short piece of pipe, and sleeve and joints were caulked.

9. The water pressure was again turned on and the cleaning machine pulled through the pipe by means of the $\frac{3}{8}$-inch cable and hand winch, operated by four men.

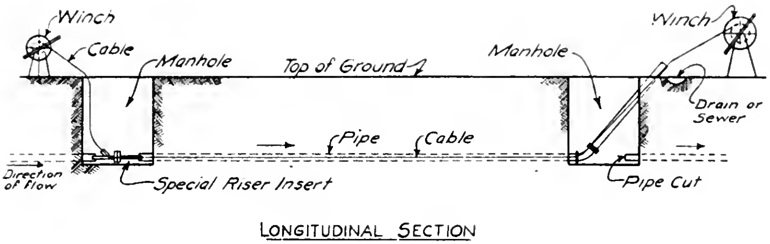


FIG. 5.

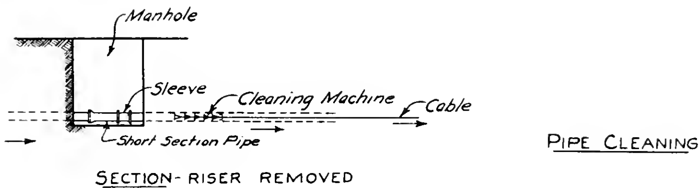


FIG. 6.

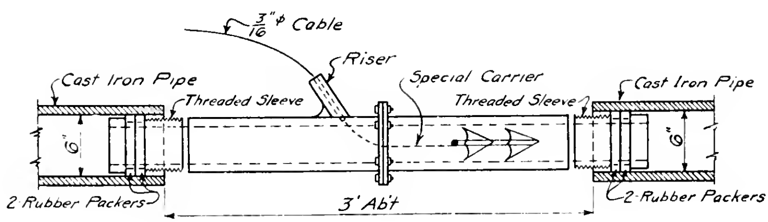


FIG. 7.

The equipment was furnished by a contractor.

The principal parts of the equipment used for cleaning the pipe line were:

1500 feet of 3/16-inch diameter steel cable;
1500 feet of 3/8-inch diameter steel cable;
1 device, called a "Carrier;"
1 device, called a "Cleaning Machine;"
1 special riser device;
2 standard diaphragm pumps;
2 winches.

The supervisor was furnished by the contractor and the necessary force by the railroad company. The force employed consisted of:

1 foreman;
1 caulker;
1 carpenter (to sheet and brace pit).
8 laborers (to dig and operate winches).

A rough estimate of the cost of the work, including transportation, labor, superintendence, equipment, etc., was $200 per day, and the length of straight pipe cleaned per day was 1000 feet, or an average cost of 20 cents per linear foot. This is exceedingly low when viewed from the standpoint of the cost of a new 6-inch pipe line.

The cleaning machinery will operate through a 45-degree elbow, and it is reported that it has gone around a long 90-degree bend. It requires a pressure of about 30 lb. per square inch to force the special cable carrier through the pipe. The cleaning machine was operated at a speed of 5 to 10 feet per minute. The rate at which the pipe cleaning can be done depends, of course, upon the thickness and hardness of the scale to be removed, as well as upon local conditions.

Fig. 8—Cleaning Machine.

Fig. 9—Winch for Pulling Cable in Place.

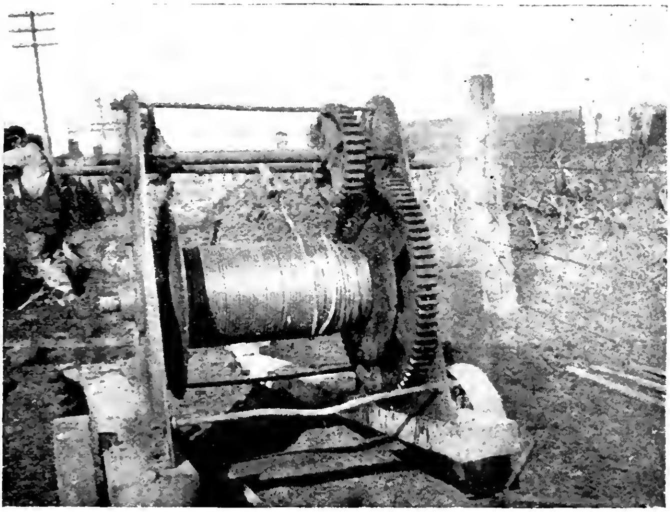


Fig. 10—Large Winch for Pulling Cable and Machine (Four Men to Operate).

Fig. 11—Special Riser Device.

Fig. 12—Winch and Trench Pump in Position.

Appendix D

METHODS OF DISPOSING OF WASTE WATER AT WATER STATIONS AND KEEPING TRACK FREE OF ICE

E. M. GRIME, *Chairman*, Sub-Committee

General

(1) Water is commonly supplied to locomotives at water stations by means of a spout from the supply tank or by a water column and the amount of water wasted depends very largely upon the care exercised by the fireman when taking water. The most common cause of waste is flooding of the locomotive tender allowing considerable water to be spilled as soon as the locomotive moves. Spouts which are not adjustable to high and low tenders and improper spotting of locomotives are other causes of considerable waste.

Effects

(2) The effect of wasting large quantities of water is to soften up the roadbed in the immediate vicinity and this in the colder climates causes bad heaving conditions. The accumulation of ice in the winter season also becomes so serious in many cases that section men must be delegated to keep it removed at a cost varying anywhere from $10.00 to $50.00 per month, depending upon the number of locomotives served.

Methods of Prevention

(3) It is impracticable to have a very wide range of movement for water tank spouts and so it is imperative that locomotives be carefully spotted at points where water is received direct from a tank spout. Also on divisions where both high and low locomotive tenders are in use, it is desirable to have the manholes on the low tenders raised up to the same height as that of the high tenders.

Water columns are of two general types—those having rigid or nearly rigid spouts allowing of but limited movement in a vertical direction and those with spout of the telescopic type, adjustable over a vertical range of 5 feet or more. Where the rigid spout is used a sleeve, hanging by chains from the end of the spout, serves in a measure to make it adjustable for high and low tenders, but it does not entirely eliminate waste. The telescopic type of water column has now been made standard on some railroads and where it is in use there is very little water waste.

At water tanks there is frequently more or less waste due to firemen raising the spout before the water has entirely cleared from it or due to slight leakage from the tank valve. The maintenance of tank valves is a matter which must receive close attention from the water service department, especially in the winter season.

Typical Plans for Disposal

4. While water waste is almost entirely unnecessary, it unfortunately is a prolific source of trouble especially on railroads located in the colder sections of this country and various plans for quickly getting rid of wasted water have been tried with more or less success. One of the best plans for taking care of the situation at a water tank is to ballast the track in the immediate vicinity for a distance of ten feet each way from the spout with a heavy layer of crushed rock and provide a catch basin with grating cover directly under the end of the outlet pipe with an inlet at the level of the subgrade.

For the northern latitudes, such catch basins should have a sewer connection at least eight feet below the surface so the water will be rapidly carried off before it has an opportunity to freeze. A catch basin of this type is giving excellent service in North Dakota.

Where a steam pumping plant is located not too far away from the tank, a steam pipe connection into the catch basin will be a big help in keeping the drainage channel clear and the expense will be nominal. Catch basins may also be used to advantage near water columns. Where there is no danger from frost, some saving may be made by building the catch basin as a part of the water column pit. In cold climates the catch basin drain should not connect direct with the standpipe pit as cold air entering through the drain is liable to cause freezing at the standpipe.

Appendix E

EFFECT OF LOCAL DEPOSITS ON POLLUTION OF SURFACE OR SHALLOW WELL WATER SUPPLIES

R. L. Holmes, *Chairman,* Sub-Committee

General

1. (a) Water obtained from rivers, lakes, wells and other sources of supply usually contain a considerable quantity of foreign matter in suspension and solution, not only as inert mineral substances, but also in the form of living organisms and waste products or organic origin.

From an hygienic standpoint, the use in common for sewage disposal and domestic water supply of lakes or rivers upon which are located a succession of cities and manufacturing plants, is dangerous.

On some rivers, like the Delaware, Ohio, Missouri, and Mississippi, and on some lakes, this succession is particularly impressive, and when the water has been used in its raw or unpurified state, sickness and death have resulted and thousands of lives have been lost.

(b) Recent observations and experiments have proven that water in its raw state from small streams, lakes and reservoirs may be rendered unfit for locomotives or industrial use by reason of surface pollution, the effect of sewage, mine, drainage, coal storage, industrial waste and decayed vegetation on locomotive and industrial water supplies is very detrimental.

Effect upon Surface Supply

2. (a) Coal Mines and Storage.—Cases are known where coal mine drainage modifies or completely changes the character of streams. The most objectionable property of water containing mine drainage is its corrosiveness. The iron sulphates and acid will actively attack metals. Ferric sulphate (a common constituent of mine drainage) once admitted into a boiler will induce serious pitting conditions. The ferric sulphate will dissolve sufficient iron to reduce itself to the ferrous condition, and being oxidized by the air admitted with fresh water will again attack the boiler, and by continuous repetitions of this process will accomplish its early ruin. Brass piping or acid proof bronze is not immune.

The storing of coal on reservoir sheds should never be permitted. Reservoir water has been made unusable by this practice.

(b) Cinders.—It is a fact that water station attendants waste their cinders in places most convenient to them and usually they are deposited adjacent to the water supply. Cinder deposits should not be permitted near a surface water supply nor upon the water shed of surface reservoirs. Sulphates in large quantities are found in cinder deposits and are a source of contamination.

(c) Oil Wells.—Waste water from oil wells have been found to be highly mineralized and has been known to render surface reservoir water unfit for both boiler and domestic uses. This source of pollution should be guarded against by carrying the injurious waters to another shed or beyond the catchment area of the reservoir.

(d) Sewage and Industrial Waste.—Surface reservoirs should not be located where they will be subject to the flow of sewage or industrial waste, especially those of relatively small capacities. Water in small reservoirs has been known to have increased three hundred per cent in total solids, consisting of sulphates, chlorides and organic matter, by reason of sewage and industrial waste.

(e) Mud and Cultivation.—The Committee thus far is unable to determine the effect of mud upon a surface supply, except that it materially reduces the capacity of the reservoir, primarily caused by permitting cultivation too near the flood line.

Water from an extensively cultivated catchment area is more or less turbid and for this reason is at times objectionable.

Turbidity and suspended mineral matter may be greatly reduced by using rapid sand filters, allowing about 3 GPM per square foot filter area.

Effect on Shallow Wells

3. (a) Storage Coal.—Storing coal near or in a position where the drainage therefrom will flow near a shallow well supply should not be permitted. The effect is similar in a greater or less extent to that mentioned in Article 2, paragraph (a).

(b) Cinder Deposits.—See Article 2, paragraph (b). Cinder deposits adjacent to or near a shallow well supply will in time give serious trouble. The ground under and adjacent to cinder piles will become saturated with objectionable chemicals, which through seepage will render the water in its raw state unfit for locomotive or industrial use.

Typical Instances

4. The Committee has secured considerable data of great value, but is not in position to make their report final and recommends that the work be continued through the ensuing year.

Appendix F

SPECIFICATIONS FOR SUBSTRUCTURES OF WOOD AND STEEL FOR WATER TANKS

C. R. KNOWLES, *Chairman*, Sub-Committee.

Number of Posts.

There has been but little change in the type of construction of substructure or towers for wooden tanks having a capacity of 50,000 gallons or more, the common practice on American railroads being a 12-post structure of 12x12 timbers, braced according to height.

Steel frames for wooden tanks, and in a great many instances for flat-bottom steel tanks, have also been of the 12-post type. This Association found in 1910 in answers to inquiry sent out that of the roads reporting, 82 per cent of the 50,000-gallon tanks were supported on 12-post towers, 10 per cent on 16 to 26-post towers and 8 per cent on 4-post towers. Of the 100,000-gallon tanks 100 per cent had 12-post towers, with one exception of a 4-post tower. The general practice of constructing 12-post towers is explained in the fact that it is possible to secure a better distribution of the load with a 12-post structure and to support every part of the tank bottom without an elaborate floor system. It also permits of a good distribution of the foundation load and represents the most economical type of construction.

Height of Sub-Structure.

The Water Service Committee, in reporting on specifications for wood and steel water tanks, Volume 11, Part 2, page 1148, have the following to say in regard to fixing a standard height from base of rail to bottom of tub:

"The question of height of tank, floor for tanks having substructure, was considered, and the height of 20 ft. from base of rail to bottom of tub was used in all cases. This for the following reasons, assuming that the following conditions would obtain in an ordinary water station:

"Discharge main, 1,000 ft. 14-in. cast iron pipe; 12-in. water column; discharge required at column, 2,500 gallons per minute.

"Referring to the report of the Committee on friction in pipe lines and water columns, we find that the head lost would be as follows for the assumed conditions:

Feet head lost at entrance to 14-in. pipe in the tank and velocity of issuing stream for 2,500 gallons per minute	1.30
Feet head lost in 1,000 ft. 14-in. cast iron pipe at 2,500 gallons per minute	7.00
Feet head lost in two 14-in. elbows, long radius	.30
Feet head lost in 12-in. water column	4.20
Total feet lost	12.80

"The tub should at all times have at least 4.8 ft. of water in the same, to allow for emergencies. This head in tub deducted from 24.8 ft. leaves 20 ft., which the tub should be raised above the top of rail."

This question is more elaborately treated in the report under the head of "Friction Factors."

Many existing water service installations have in service pipe lines and water columns smaller than the sizes given above and a standard height of 20 ft. from base of rail to bottom of tub would not be practical in all cases and plans are submitted for three different heights of substructure, namely, 16, 20 and 30 feet elevation.

Bracing.

While the general practice followed in construction of posts and floor system appears to be fairly uniform the practice as to bracing is divided between plank bracing and strut bracing. The superiority of the strut type of bracing is recognized, but many roads have adopted the plank bracing on account of the lower cost. It is apparent to the Committee that it would be impossible to prepare plans and specifications for a single type of bracing that would be acceptable to the Association as a whole. Therefore, plans are submitted for both the plank and strut types.

Plank bracing represents the earlier type of tank construction and consists of planks usually 3 in. by 10 in. placed diagonally across the posts, being either nailed or bolted to place and usually consists of double bracing on posts at right angles to track and single bracing on posts parallel to track.

The strut type of bracing consists of one or more sets of double braces (according to height) between all posts and while more expensive is undoubtedly the most substantial type of bracing that could be used.

The earlier type of construction of steel or iron towers consisted largely of bolted or riveterd round columns and in some cases box columns. This was followed by the so-called star post or a post built up from angles. The objection to a post of this type is that it provides spaces in which moisture may collect and causes deterioration through corrosion which cannot be prevented. The best and most economical type of construction appears to be with post constructed of 6 in. by 6 in. by ½ in. angle for the 50,000-gallon tank and 8 in. by 8 in. by ½ in. angle for the 100,000 gallon tank. Three in. by 3 in. by ¼ in. bracing would be sufficient with a post of this kind, but on account of providing for possible corrosion it is considered advisable to use a 3 in. by 3 in. by ⅜ in. angle for bracing. The floor system consists of 10-in. 25-lb. I-beams for tying in the different bents, joists constructed of 7 in. 15-lb. I-beams and caps of 12-in. 31½-lb. I-beams.

It is customary to include foundation bolts for steel towers, although they are seldom used on wooden towers. It would appear that there is little necessity for use of anchor bolts on tank towers 20 ft. or less in height. The best example of the stability of unanchored tank towers is illustrated by the fact that three unanchored standard 20 ft. by 30 ft.

wooden tanks located on the Louisiana Division of the Illinois Central, one of which was supported by a 20-ft. steel tower, one by a 20-ft. wooden tower (with strut bracing) and one by a 28-ft. wooden tower (strut bracing), withstood the hurricane of September 29, 1915, with no more damage than the unroofing of one of the tanks. According to Weather Bureau reports there was a sustained wind velocity during this hurricane of over 80 miles per hour and velocities up to 120 and 130 miles per hour during the hardest gusts. Both 20-ft. towers were directly in the path of the storm, while the 28-ft. tower, while not in the path of the storm, was exposed to extremely high winds and was the tank which was unroofed.

It is the practice on some railroads to use steel floor joists instead of timber on wooden substructures, while a number of other roads advocate the use of second-hand steel rails for joists.

The advantage claimed for the steel joists is that they will have a life equal to that of the tub, while untreated timber joists would have to be renewed at least once during the life of the tub. While this is perhaps true the same thing is true of all other parts of an untreated wooden substructure.

As a general thing it seems that the practice of using steel rails or I-beams for floor joists prevails only where such material is available at approximately the same cost as timber joists. If it is desired to use steel joists they may be readily applied to the substructure submitted in place of the 4 by 14 floor joists.

SPECIFICATIONS STEEL SUB-STRUCTURES FOR WATER TANK—50,000 AND 100,000 GALLONS CAPACITY

General.

1. The structure will consist of a twelve (12) post steel tower, complete in all details, as shown on attached plan, for supporting a wooden water tank of the specified size and capacity at the required elevation. The intent of the plans and specifications is to include all material required between the top of foundation and the bottom of tank.

Material.

2. Except as may be herein noted all metal in the structure will be made in accordance with specifications of the Association as given in Part Second, "Iron and Steel Structures," Manual of Recommended Practice (pages 494 to 499, 1915 edition).

Workmanship.

3. Except as may be herein noted workmanship on the structure will be performed in accordance with the requirements of the Association as given in Part Second, "Iron and Steel Structures," Manual of Recommended Practice (pages 499 to 503, 1915 edition).

Painting.

4. Steel work before leaving the shop shall be thoroughly cleaned and given one good coat of red lead ground in linseed oil or such paint as may be specified by the engineer. Except as herein noted, cleaning and painting shall be done in accordance with specifications of the Association as given in Part Second, "Iron and Steel Substructures," Manual of Recommended Practice (pages 503 and 504, 1915 edition).

SPECIFICATIONS TIMBER SUB-STRUCTURES FOR WATER TANK—50,000 AND 100,000 GALLONS CAPACITY

General.

1. The structure will consist of a twelve (12) post timber tank tower complete in all details, as shown on attached plan, for supporting a wooden water tank of the specified size and capacity at the required elevation. The intent of the plans and specifications is to include all material required between the top of foundation and the bottom of tank.

Timber.

2. The timber shall be cypress, pine, fir, redwood, or such other timber as may be specified by the engineer, S. 4 S. and conforming to the specifications of this Association for No. 1 railroad bridge timber, as given in "Wooden Bridges and Trestles," Manual of Recommended Practice (pages 231 to 235, 1915 edition).

Workmanship.

3. All workmanship shall be in accordance with "Specifications for Workmanship for Pile and Frame Trestles to Be Built Under Contract," Manual of Recommended Practice (pages 238 to 241, 1915 edition).

Metal Details.

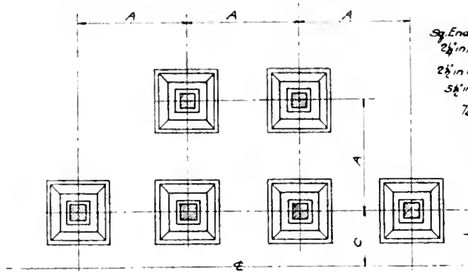
4. All metal details shall conform to the specifications of the Association as given in "Specifications for Metal Details Used in Wooden Bridges and Trestles," Manual of Recommended Practice (pages 236 to 238, 1915 edition).

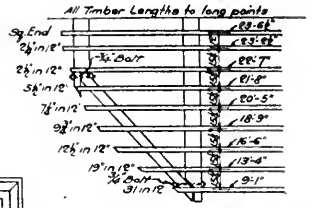
Painting.

5. All exposed woodwork shall be painted with one priming and two finishing coats of such paints and colors as may be specified. by the engineer.

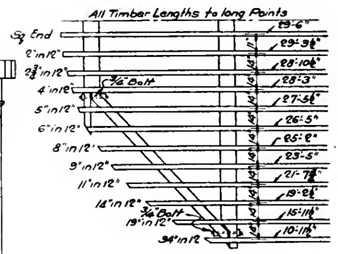
Treating.

6. Where treated timber is used timber shall be treated with creosote oil in accordance with the requirements of Committee on Wood Preservation, Manual of Recommended Practice (pages 539 to 559, 1915 edition).

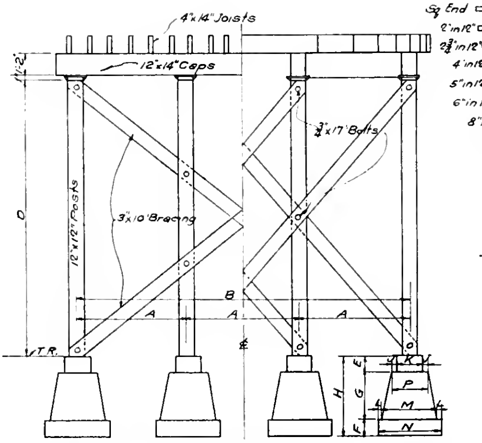




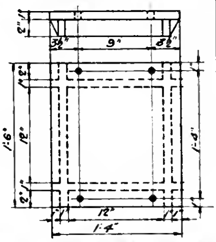
—FLOOR SYSTEM - 16'x24' TANK—



—FLOOR SYSTEM - 20'x30' TANK—



—SECTION PARALLEL— —SECTION AT—
—TO TRACK— —RIGHT ANGLE TO TRACK—



—DETAIL OF POST CASTING—

TABLE OF DIMENSIONS & SIZES				
Mark Or Description	SIZE OF TANK			
	16'x24'		20'x30'	
	16' Tower	20' Tower	16' Tower	20' Tower
A	6'-11"	6'-11"	8'-6"	8'-6"
B	20'-9"	20'-9"	26'-6"	25'-6
C	3'-5½"	3'-5½"	4'-3"	4'-3"
D	13'-5"	17'-5"	13'-5"	17'-5
E	1'-0"	1'-0"	1'-0"	1'-0"
F	1'-0"	1'-0"	1'-6"	1'-6"
G	3'-0"	3'-0"	3'-6"	3'-6"
H	5'-0"	5'-0"	6'-0"	6'-0"
J	0'-5"	0'-5"	0'-5"	0'-5"
K	1'-8"	1'-8"	1'-8"	1'-8"
L	0'-3"	0'-3"	0'-3"	0'-3"
M	3'-6"	3'-6"	4'-6"	4'-6"
N	4'-0"	4'-0"	5'-0"	5'-0"
P	2'-6"	2'-6"	2'-6"	2'-6"
Posts	12"x12"	12"x12"	12"x12"	12"x12"
Braces	3"x10"	3"x10"	3"x10"	3"x10"
Bolts	¾"x17"	¾"x17"	¾"x17"	¾"x17"

Note:—
The footing detail as given represents an average condition
Measurement "N" will be governed by soil conditions but in no case to exceed 3000#/□'

STD. TIMBER 12 POST WATER TANK TOWER
DIAGONAL PLANK BRACING
FOR 16'x24' & 20'x30' TANKS
16'-0" & 20'-0" HEIGHTS

Scale - None Sept 16, 1920

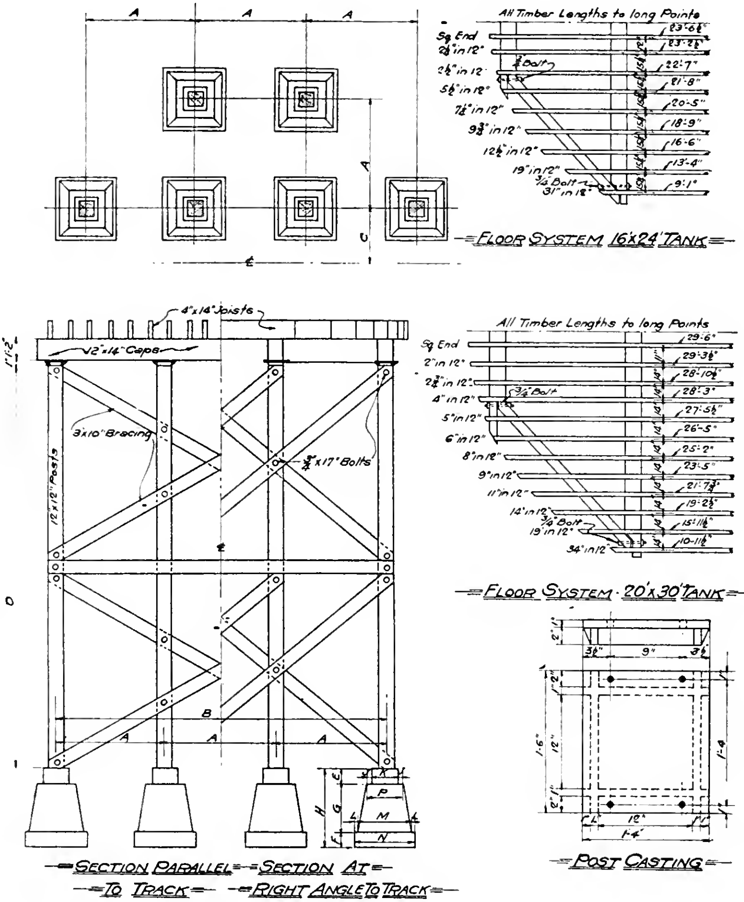
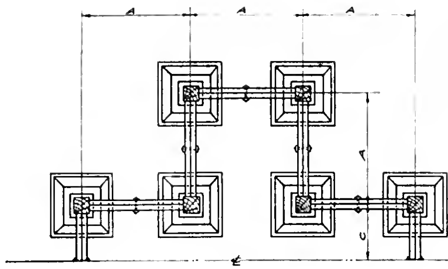


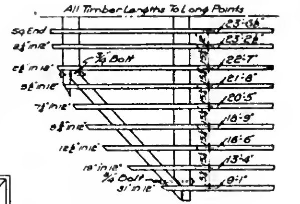
TABLE OF DIMENSIONS		
Mark or Description	30'-0" TOWER	
	SIZE OF TANK	
	16'x24'	20'x30'
A	6'-11"	8'-6"
B	20'-9"	25'-6"
C	3'-5½"	4'-3"
D	27'-5"	27'-5"
E	1'-0"	1'-0"
F	1'-0"	1'-6"
G	3'-0"	3'-6"
H	5'-0"	6'-0"
J	0'-5"	0'-5"
K	1'-8"	1'-8"
L	0'-3"	0'-3"
M	3'-6"	4'-6"
N	4'-0	5'-0"
P	2'-6"	2'-6"
Posts	12"x12"	12"x12"
Braces	3"x10"	3"x10"
Bolts	¾"x17"	¾"x17

NOTE:-
The footing detail as given represents an average condition.
Measurement "N" will be governed to soil conditions but in no case to exceed 3000#/□"

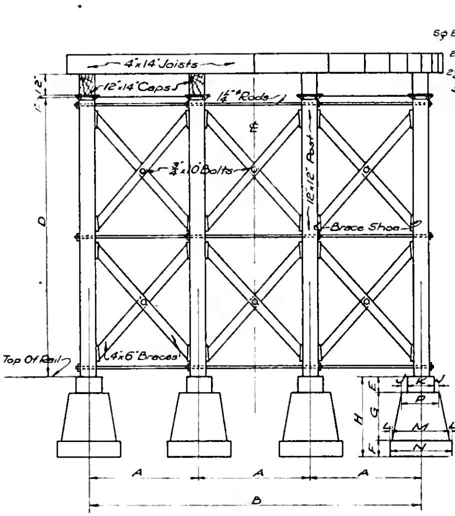
=STD TIMBER 12 POST WATER TANK TOWER=
=DIAGONAL PLANK BRACING=
=FOR 16'x24' & 20'x30' TANKS=
=30'-0" HIGH=

Scale - None Sept. 17, 1920

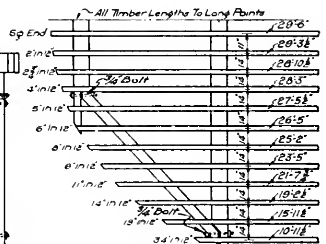




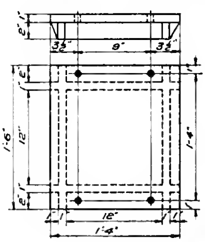
—FLOOR SYSTEM - 16'x24' TANK—



—HALF SECTION— —HALF ELEVATION—



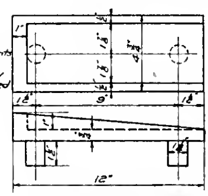
—FLOOR SYSTEM-20'x30' TANK—



—DETAIL OF POST CASTING—

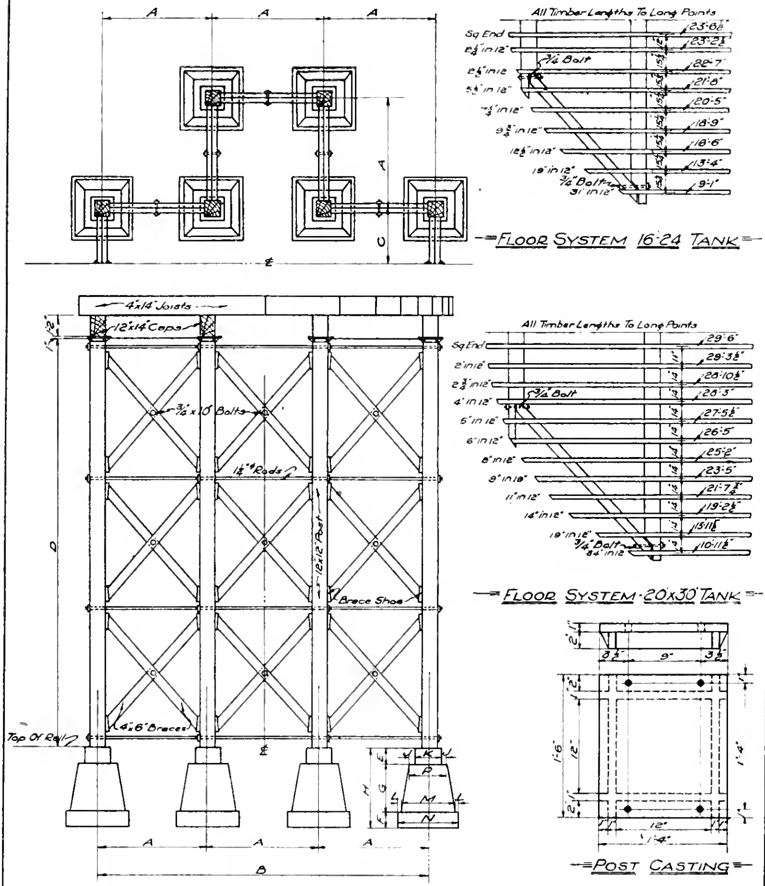
TABLE OF DIMENSIONS & SIZES				
Mark Or Description	SIZE OF TANK			
	16'x24'		20'x30'	
	16' Tower	20' Tower	16' Tower	20' Tower
A	6'-11"	6'-11"	8'-6"	8'-6"
B	20'-9"	20'-9"	25'-6"	25'-6"
C	3'-5½"	3'-5½"	4'-3"	4'-3"
D	13'-5"	17'-5"	13'-5"	17'-5"
E	1'-0"	1'-0"	1'-0"	1'-0"
F	1'-0"	1'-0"	1'-6"	1'-6"
G	3'-0"	3'-0"	3'-6"	3'-6"
H	5'-0"	5'-0"	6'-0"	6'-0"
J	0'-5"	0'-5"	0'-5"	0'-5"
K	1'-6"	1'-6"	1'-8"	1'-8"
L	0'-3"	0'-3"	0'-3"	0'-3"
M	3'-6"	3'-6"	4'-6"	4'-6"
N	4'-0"	4'-0"	5'-0"	5'-0"
P	2'-6"	2'-6"	2'-6"	2'-6"
Posts	12"x12"	12"x12"	12"x12"	12"x12"
Braces	4"x6"	4"x6"	4"x6"	4"x6"
Bolts	¾"x10"	¾"x10"	¾"x10"	¾"x10"
Rods	1¼"øx8'-4"	1¼"øx8'-4"	1¼"øx9'-11"	1¼"øx9'-11"

NOTE:-
The footing detail as given represents an average condition.
Measurement 'N' will be governed by soil conditions but in no case to exceed 3000#/□'

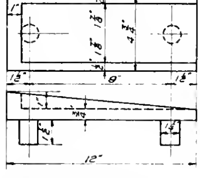


—BRACE SHOE—

—STD TIMBER 12 POST WATER TANK TOWER
DIAGONAL STRUT BRACING.
—FOR 16'x24' & 20'x30' TANKS—
—16'-0" & 20'-0" HEIGHTS—
—Scale None— —Sept 16 1920—



HALF SECTION — HALF ELEVATION



BRACE SHOE

TABLE OF DIMENSIONS		
Mark Or Description	30'-0" Tower	
	Size Of Tank	
	16'x24'	20'x30'
A	6'-11"	8'-6"
B	20'-9"	25'-6"
C	3'-5½"	4'-3"
D	27'-5"	27'-5"
E	1'-0"	1'-0"
F	1'-0"	1'-6"
G	3'-0"	3'-6"
H	5'-0"	6'-0"
J	0'-5"	0'-5"
K	1'-8"	1'-8"
L	0'-3"	0'-3"
M	3'-6"	4'-6"
N	4'-0"	5'-0"
P	2'-6"	2'-6"
Posts	12"x12"	12"x12"
Braces	4"x6"	4"x6"
Bolts	¾"x10"	¾"x10"
Rods	1¼"x8'-4"	1¼"x9'-4"

NOTE

The footing detail as given represents an average condition.

Measurement "N" will be governed by soil condition but in no case to exceed 3000#/□'

STD TIMBER, 12 POST WATER TANK TOWER
DIAGONAL STRUT BRACING
FOR 16x24 & 20x30 TANKS
30'-0" HIGH

Scale None — Sept 17, 1920.

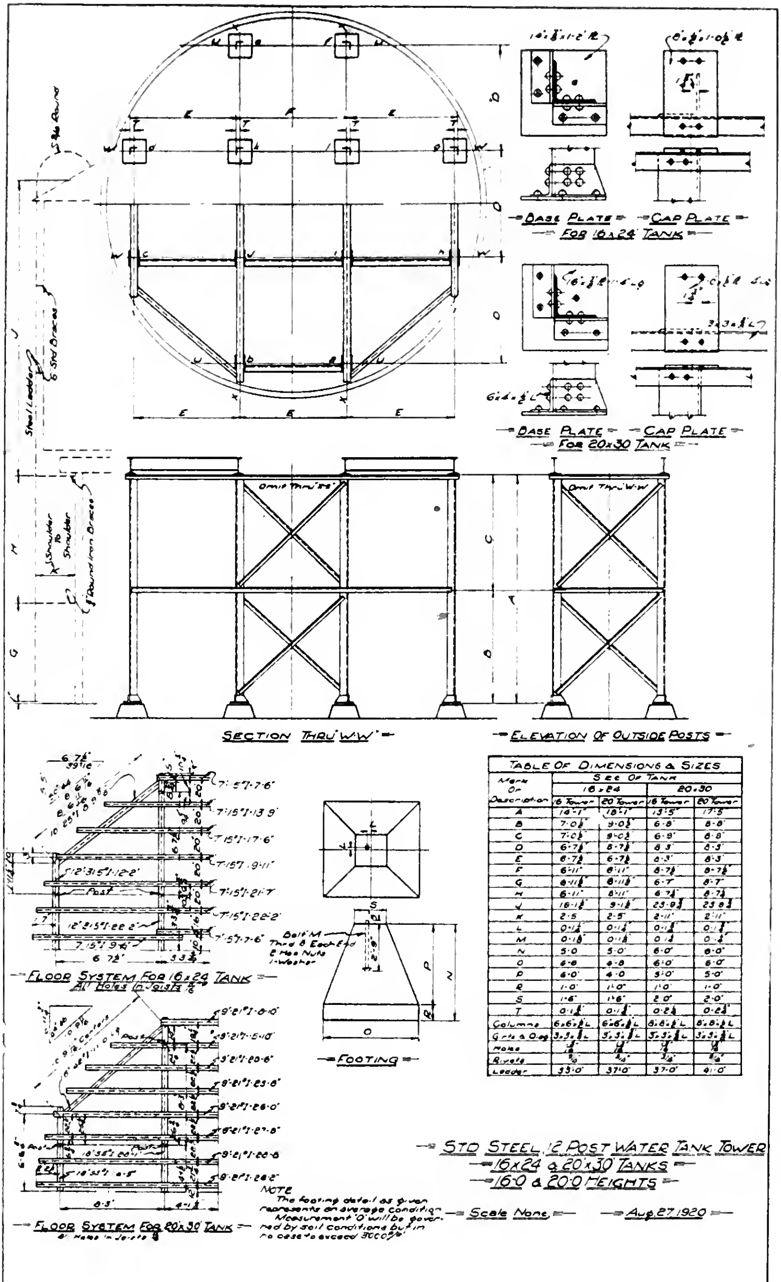
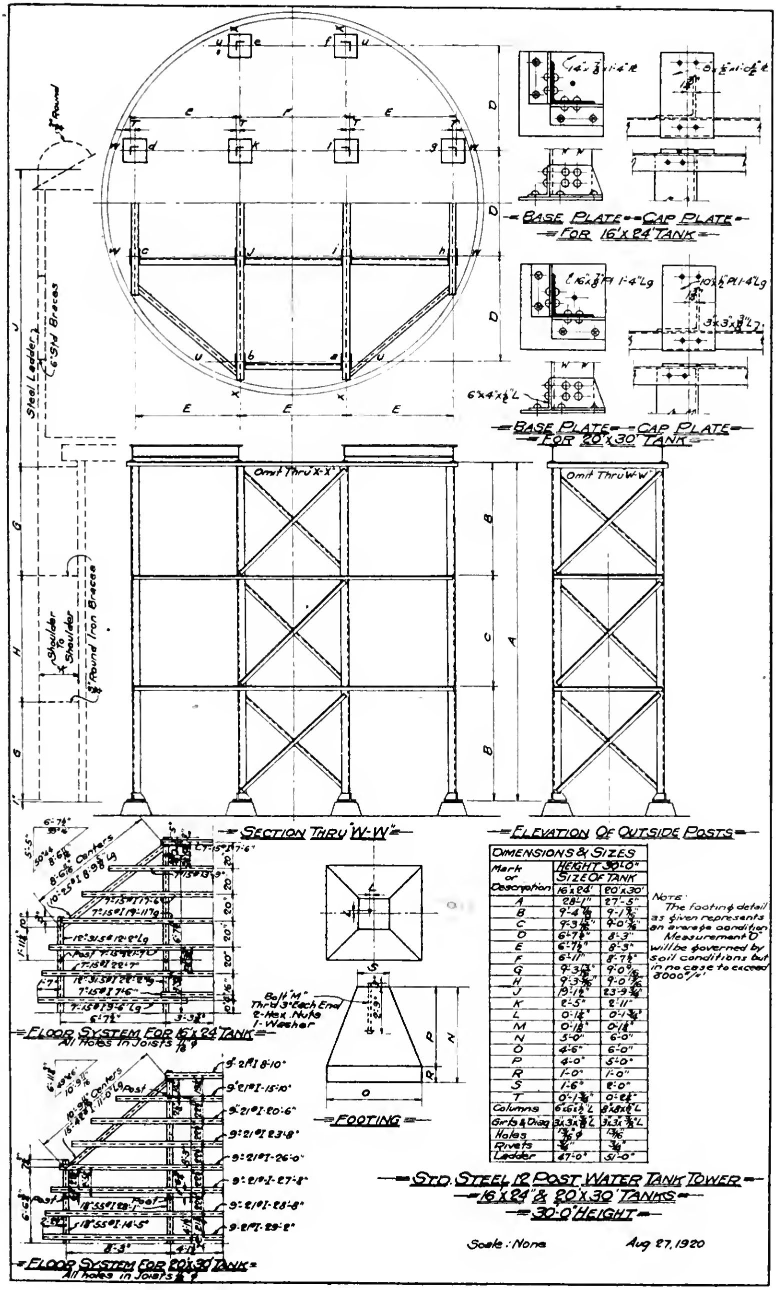


Table of Dimensions & Sizes

Mark or Description	Size of Tank 16x24: 16 Tower	Size of Tank 16x24: 20 Tower	Size of Tank 20x30: 16 Tower	Size of Tank 20x30: 20 Tower
A	14-1"	18-1"	13-5"	17-5"
B	7-0½"	9-0½"	6-8"	8-8"
C	7-0½"	9-0½"	6-9"	8-8"
D	6-7½"	6-7½"	8-3"	8-3"
E	6-7½"	6-7½"	8-3"	8-3"
F	6-11"	8-11"	8-7½"	8-7½"
G	8-11½"	8-11½"	6-7"	8-7"
H	6-11"	8-11"	6-7½"	8-7½"
J	18-1½"	9-1½"	23-9¾"	23-9¾"
K	2-5	2-5"	2-11"	2-11"
L	0-1¼"	0-1¼"	0-1¾"	0-1¾"
M	0-1⅛"	0-1⅛"	0-1¼"	0-1¼"
N	5-0	5-0"	6-0"	8-0"
O	6-6	6-8	6-0"	6-0"
P	6-0"	4-0	5-0"	5-0"
R	1-0"	1-0"	1-0"	1-0"
S	1-6"	1-6"	2-0"	2-0"
T	0-1½"	0-1½"	0-2½"	0-2½"
Columns	6x6x½ L	6x6x½ L	8x8x½ L	8x8x½ L
Grts & Diag	3x3x⅜ L	3x3x⅜ L	3x3x⅜ L	3x3x⅜ L
Holes	13/16"	13/16"	13/16"	13/16"
Rivets	¾"	¾"	¾"	¾"
Ladder	33-0"	37-0"	37-0"	41-0"



DIMENSIONS & SIZES		
Mark or Description	HEIGHT 30'-0" SIZE OF TANK 16'x24'	20'x30'
A	28'-1"	27'-5"
B	9'-4[illegible]	9'-1[illegible]
C	9'-3[illegible]	9'-0[illegible]
D	6'-7½"	8'-3"
E	6'-7½"	8'-3"
F	6'-11"	8'-7½"
G	9'-3 13/16"	9'-0 9/16"
H	9'-3[illegible]	9'-0[illegible]
J	19'-1½"	23'-9¾"
K	2'-5"	2'-11"
L	0'-1½"	0'-1¾"
M	0'-1½"	0'-1½"
N	5'-0"	6'-0"
O	4'-6"	6'-0"
P	4'-0"	5'-0"
R	1'-0"	1'-0"
S	1'-6"	2'-0"
T	0'-1¾"	0'-2½"
Columns	6"x6"x½" L	8"x8"x½" L
Girts & Diag	3"x3"x⅜" L	3"x3"x⅜" L
Holes	13/16" φ	13/16"
Rivets	¾"	¾"
Ladder	47'-0"	51'-0"

REPORT OF COMMITTEE XVII—WOOD PRESERVATION

C. M. TAYLOR, *Chairman;*
LOWRY SMITH, *Vice-Chairman;*
F. J. ANGIER,
R. S. BELCHER,
E. H. BOWSER,
Z. M. BRIGGS,
W. E. BURKHALTER,
A. S. BUTTERWORTH,
S. D. COOPER,
H. A. DIXON,
C. F. FORD,
W. H. GARDNER, JR.,
C. E. GOSLINE,
E. B. HILLEGASS,
A. B. ILSLEY,
A. S. KENT,
W. H. KIRKBRIDE,
J. F. PINSON,
W. D. SIMPSON,
O. C. STEINMAYER,
DR. H. VON SCHRENK,
J. H. WATERMAN,

Committee.

To the American Railway Engineering Association:

The following subjects were assigned the Committee on Wood Preservation for study and report:

1. Make thorough examination of the subject-matter in Manual, and submit definite recommendations for changes.
2. Report on service test records and extend them to include treated timbers in bridges, docks and wharves. Include also a critical study of the records of service given by the zinc-chloride treatment.
3. Report on the merits of water gas tar as a preservative, taking samples of preservative from timbers which have been in service, in order to determine its quality.
4. Report on preservative treatment for Douglas Fir.
5. Report on indicators for determining the Burnettizing of ties and timbers.
6. Report on availability and use of Sodium Fluoride as a preservative for cross-ties.
7. Recommend treatment to be used in the protection of piles and timbers in water infested by marine borers.
8. Report on comparative value of grades 1, 2 and 3 creosote oil and creosote coal-tar solution as preservative agencies.
9. Report on practicability of making accelerated tests to develop the comparative values of grades 1, 2 and 3 creosote oil and creosote coal-tar solution as preservative agencies.
10. Recommend preservative treatment to be used on piles and timbers in land construction.
11. Recommend proper methods for storing lumber and piling for air-seasoning preliminary to preservative treatment.

Committee Meetings

Meetings of the Committee were held in Chicago, June 17, September 30, and December 16. The names of members in attendance have been given in the minutes of the meetings which have been printed in the Bulletin.

(1) Revision of Manual

No changes this year.

(2) Service Test Records

In Appendix A the Committee submits service test records covering two kinds of work, one on the service of ties in experimental tracks, which are covered by the reports from the Baltimore & Ohio Railroad; St. Louis-San Francisco Railway; Chicago, Indianapolis & Louisville Railway; Santa Fe System, and the Chicago, Rock Island & Pacific Railway; and the second class is shown in report of the Cleveland, Cincinnati, Chicago & St. Louis Railway, showing the total number of ties they have put in track and taken out from the year 1905 until 1919 inclusive.

(3) Water Gas Tar as a Preservative

In Appendix B the Committee reports on the subject of Water Gas Tar as a Preservative.

(4) Preservative Treatment for Douglas Fir

In conjunction with the United States Forest Service, the American Wood-Preservers' Association and the West Coast Lumbermen's Association a very detailed study is now being conducted in connection with the question of the proper methods for the preservative treatment of Douglas Fir, and it is expected that the Committee will be able to have a report on this matter for publication during the year.

(5) Indicators for Determining the Burnettizing of Ties and Timbers

No report.

(6) Sodium Fluoride

The use of Sodium Fluoride as a preservative for cross-ties is covered by the report of Committee as given in Appendix C.

(7) Protection of Piles in Water Infested by Marine Borers

In Appendix D the Committee reports on work on this subject and as a result of its study comes to certain conclusions and recommends certain investigations covering alternate types of protection.

(8) Comparative Values of Grades 1, 2 and 3 Creosote Oil and Creosote Coal-Tar Solution

The Committee feels that the report as given last year covers the situation as well as it is able to put it in writing.

(9) Accelerated Tests of Grades 1, 2 and 3 Creosote Oil and Creosote Coal-Tar Solution

The Committee has not been able to develop any reliable methods for making any such accelerated tests.

Progress Report

The Committee reports progress on subject (10) Recommend Preservative Treatment to Use on Piles and Timbers in Land Construction, and on subject (11) Proper Methods for Storing Lumber and Piling for Air-Seasoning Preliminary to Preservative Treatment.

CONCLUSIONS

1. The Committee recommends that further reports on Indicators for Determining Burnettizing of Ties and Timbers be eliminated, as this matter seems to have been covered fully in previous reports.

2. The Committee recommends that the question of the Comparative Values of Grades 1, 2 and 3 Creosote Oil and Creosote Coal-Tar Solution is one that is not definable in any way so that conclusions can be considered for adoption as recommended practice.

3. The Committee recommends that no further consideration be given to the proposition of trying to develop comparative values of Grades 1, 2 and 3 creosote oil and creosote coal-tar solution.

Recommendations for Future Work

The Committee recommends for future work continuation of subjects (1), (2), (4), (7), (10) and (11).

Respectfully submitted,

THE COMMITTEE ON WOOD PRESERVATION,

C. M. TAYLOR, *Chairman.*

Appendix A

(2) SERVICE TEST RECORDS

S. D. COOPER, *Chairman;* C. F. FORD, A. S. KENT, O. C. STEINMAYER, F. J. ANGIER, Sub-Committee.

In handing this report your Committee would call attention to the reports submitted by the Chicago, Rock Island & Pacific Railway, St. Louis-San Francisco Railway, Baltimore & Ohio Railroad, Santa Fe System, and the Chicago, Indianapolis & Louisville Railway, which are made up from Test Sections, and your Committee would recommend that this manner of making up reports be followed in the future by all railroads submitting reports.

Your Committee feels that in adopting this method much more reliable data is obtained, for the reason that a record of each particular tie in these sections is kept, and, furthermore, a close supervision is kept over these sections enabling those responsible of keeping a close supervision, both in Tie Renewals and Tie Removals.

Your Committee also feels that it is a distinct advantage to keep each class of wood used in these sections separately in reporting, as by so doing, the average life of each kind of wood may be easily determined.

While it is possible that the form used might be improved upon, your Committee would suggest that next year the Committee appointed be instructed to follow up this question with the view of having this form, or one similar, adopted by all roads as standard, which would result, in the opinion of your Committee, in making the reports of more value to all concerned.

On account of there having been no material change in the test records as published and provided by the Forest Products Laboratory, at Madison, and on account of the expense of printing same, your Committee has decided that they will not go to the expense this year, it being understood that the records will be kept up in good shape, and that if there are any material changes by next year, they will be published.

CHICAGO, ROCK ISLAND & PACIFIC RAILWAY

CREOSOTED TIES - LOWRY PROCESS

Location	Kind of Ties	Number.	Year Inserted	Per Cent Ties Removed, all causes to 12/31/19.	Traffic Tons per Year - #
Tiskilwa, Ill.	R.O.	642	1908	11.06	11,000,000
Altoona, Ia.	"	276	"	8.	7,200,000
Princeton, Mo.	"	216	"	18.5	10,500,000
Ely, Ia.	"	1195	"	7.2	8,000,000
Clarksville, Ia.	"	1647	"	.54	5,400,000
West Bend, Ia.	"	149	"	2.7	3,800,000
Fairbury, Nebr.	"	508	"	2.9	3,000,000
Goodland, Kans.	"	88	"	9.	3,100,000
TOTAL		4721		5.4	
Tiskilwa, Ill.	"	1529	1909	6.01	11,000,000
Altoona, Ia.	"	1396	"	1.9	7,200,000
Princeton, Mo.	"	479	"	7.1	10,500,000
Ely, Ia.	"	976	"	47.9	8,000,000
Clarksville, Ia.	"	1592	"	1.25	5,400,000
Fairbury, Nebr.	"	321	"	.3	3,000,000
Goodland, Kans.	"	1118	"	.26	3,100,000
Topeka, Kans.	"	1073		7.0	10,300,000
TOTAL		8484		8.47	
Tiskilwa, Ia.	"	3293	1910	2.8	11,000,000
Altoona, Ia.	"	594	"	2.3	7,200,000
Princeton, Mo.	"	1002	"	3.5	10,500,000
Ely, Ia.	"	2355	"	5.9	8,000,000
Clarksville, Ia.	"	1481	"	.3	5,400,000
Fairbury, Nebr.	"	1749	"	.9	3,000,000
Eldon, Mo.	"	4200	"	.9	3,200,000
Topeka, Kans.	"	522	"	1.16	10,300,000
TOTAL		15196		2.2	
Tiskilwa, Ill.	"	1262	1911	1.11	11,300,000
Altoona, Ia.	"	791	"	2.4	7,200,000
Princeton, Mo.	"	1914	"	.7	10,500,000
Ely, Ia.	"	2256	"	1.8	8,000,000
West Bend, Ia.	"	89	"	0.0	3,800,000
Fairbury, Nebr.	"	52	"	0.0	3,000,000
Goodland, Kans.	"	105	"	0.0	3,100,000
Eldon, Mo.	"	2423	"	1.32	3,200,000
TOTAL		8892		1.33	
Tiskilwa, Ill.	"	211	1912	0.0	11,000,000
Altoona, Ia.	"	770	"	.8	7,200,000
Ely, Ia.	"	459	"	0.0	8,000,000
Princeton, Mo.	"	331	"	17.5	10,500,000
E.Des Moines, Ia.	"	5526	"	.34	4,100,000
Goodland, Kans.	"	72	"	0.0	3,100,000
Eldon, Mo.	"	2423	"	1.3	3,200,000
TOTAL		9792	"	1.18	

CHICAGO, ROCK ISLAND & PACIFIC RAILWAY

CREOSOTED TIES - LOWRY PROCESS

Location	Kind of Ties	Number	Year Inserted	Per Cent Ties Removed, all causes to 12/31/19.	Traffic Tons per Year - #
Tiskilwa, Ill.	R.O.	61	1913	18.0	11,000,000
Altoona, Ia.	"	728	"	41.0	7,200,000
Princeton, Mo.	"	1028	"	28.0	10,500,000
Ely, Ia.	"	1600	"	3.5	8,000,000
Clarksville, Ia.	"	262	"	3.05	5,400,000
Eldon, Mo.	"	1268	"	0.0	3,200,000
Topeka, Kans.	"	676	"	.9	10,300,000
TOTAL		5623		11.9	
Tiskilwa, Ill.	"	1256	1914	0.0	11,000,000
Altoona, Ia.	"	2075	"	3.32	7,200,000
Princeton, Mo.	"	632	"	3.63	10,500,000
Ely, Ia.	"	2038	"	4.85	8,000,000
Eldon, Mo.	"	553	"	3.61	3,200,000
Topeka, Kans.	"	765	"	.9	10,300,000
TOTAL		7319		2.84	
Dalhart, Tex.	Pine	320	1908	4.3	4,300,000
TOTAL		320		4.3	
Ely, Ia.	"	214	1909	6.07	8,000,000
E.Des Moines, Ia.	"	390	"	.8	4,100,000
Goodland, Kans.	"	129	"	2.3	3,100,000
TOTAL		733		2.6	
Ely, Ia.	"	102	1910	63.0	8,000,000
West Bend, Ia.	"	69	"	17.4	5,400,000
E.Des Moines, Ia.	"	155	"	0.0	4,100,000
Fairbury, Nebr.	"	233	"	0.0	3,000,000
Goodland, Kans.	"	737	"	4.3	3,100,000
Topeka, Kans.	"	487	"	13.5	10,300,000
TOTAL	"	1783		9.8	
Tiskilwa, Ill.	"	91	1911	7.7	11,000,000
Clarksville, Ia.	"	1015	"	0.19	5,400,000
West Bend, Ia.	"	821	"	1.82	3,800,000
E.Des Moinee, Ia.	"	56	"	5.3	4,100,000
Fairbury, Nebr.	"	1502	"	1.8	3,000,000
Goodland, Kans.	"	1603	"	0.18	3,100,000
Topeka, Kans.	"	160	"	8.8	10,300,000
TOTAL		5248		1.36	
Ely, Ia.	"	345	1912	0.0	8,000,000
Clarksville, Ia.	"	1045	"	0.0	5,400,000
West Bend, Ia.	"	711	"	0.28	3,800,000
Fairbury, Nebr.	"	1376	"	0.14	3,000,000
Goodland, Kans.	"	536	"	0.0	3,100,000
Topeka, Kans.	"	261	"	0.1	10,300,000
Dalhart, Tex.	"	240	"	0.0	4,300,000
TOTAL		4514		0.17	

CHICAGO, ROCK ISLAND & PACIFIC RAILWAY

CREOSOTED TIES - LOWRY PROCESS

Location	Kind of Ties	Number	Year Inserted	Per Cent Ties Removed, all causes, to 12/31/19.	Traffic Tons per Year - #
Ely, Ia.	Pine	80	1913	1.2	8,000,000
Clarksville, Ia.	"	724	"	0.27	5,400,000
Fairbury, Nebr.	"	1074	"	0.09	3,000,000
Goodland, Kans.	"	2271	"	0.4	3,100,000
Topeka, Kans.	"	374	"	1.07	10,300,000
Dalhart, Tex.	"	141	"	3.5	4,300,000
TOTAL		4664		0.51	
Clarksville, Ia.	"	635	1914	1.1	5,400,000
Fairbury, Nebr.	"	703	"	0.0	3,000,000
Goodland, Kans.	"	2438	"	0.0	3,100,000
Topeka, Kans.	"	602	"	0.5	10,300,000
TOTAL		4378		0.25	
Tiskilwa, Ill.	Gum	80	1908	35.	11,000,000
Ely, Ia.	"	391	"	17.3	8,000,000
Clarksville, Ia.	"	96	"	3.12	5,400,000
West Bend, Ia.	"	887	"	2.9	3,800,000
E. Des Moines, Ia.	"	99	"	4.0	4,100,000
Fairbury, Nebr.	"	114	"	0.9	3,000,000
TOTAL		1667		7.7	
Tiskilwa, Ill.	"	58	1909	5.15	11,000,000
Altoona, Ia.	"	63	"	0.0	7,200,000
Ely, Ia.	"	126	"	18.0	8,000,000
West Bend, Ia.	"	539	"	0.74	3,800,000
E. Des Moines, Ia.	"	624	"	4.1	4,100,000
TOTAL		1410		3.9	
Ely, Ia.	"	159	1910	3.7	8,000,000
West Bend, Ia.	"	279	"	1.08	3,800,000
E. Des Moines, Ia.	"	331	"	3.6	4,100,000
Dalhart, Tex.	"	64	"	3.1	4,300,000
TOTAL		833		2.76	
Altoona, Ia.	"	306	1911	0.9	7,200,000
Princeton, Mo.	"	739	"	6.6	10,500,000
Fairbury, Nebr.	"	71	"	8.4	3,000,000
TOTAL		1116		5.2	
Tiskilwa, Ill.	"	741	1912	0.0	11,000,000
Ely, Ia.	"	1238	"	3.5	8,000,000
E. Des Moines, Ia.	"	1263	"	0.4	4,100,000
TOTAL		3242		1.5	
Tiskilwa, Ill.	"	892	1913	0.33	11,000,000
Ely, Ia.	"	126	"	0.0	8,000,000
Topeka, Kans.	"	545	"	0.0	10,300,000
Dalhart, Tex.	"	141	"	3.5	4,300,000
TOTAL		1704	"	0.46	

CHICAGO, ROCK ISLAND & PACIFIC RAILWAY

CREOSOTED TIES - LOWRY PROCESS

Location	Kind of Ties	Number	Year Inserted	Per Cent Ties Removed, all causes, to 12/31/19.	Traffic Tons per Year - #
Tiskilwa, Ill.	Gum	1415	1914	4.9	11,000,000
Clarksville, Ia.	"	409	"	0.0	5,400,000
Goodland, Kans.	"	357	"	0.0	3,100,000
Eldon, Mo.	"	429	"	0.0	3,200,000
Topeka, Kans.	"	408	"	1.4	10,300,000
TOTAL		3018		0.42	
Altoona, Ia.	Elm	64	1908	0.0	7,200,000
Clarksville, Ia.	"	101	"	.9	5,400,000
West Bend, Ia.	"	238	"	1.68	3,800,000
TOTAL		403		1.24	
Altoona, Ia.	"	64	1909	0.0	7,200,000
E.Des Moines, Ia.	"	188	"	4.7	4,100,000
TOTAL		251		3.5	
Altoona, Ia.	"	148	1911	0.0	7,200,000
Ely, Ia.	"	146	1912	4.8	8,000,000
E.Des Moines, Ia.	"	231	"	0.0	4,100,000
TOTAL		377	"	1.6	
Princeton, Mo.	"	127	1914	3.8	10,500,000

For year 1919 ----

CHICAGO, ROCK ISLAND & PACIFIC RAILWAY

CREOSOTED TIES - REUPING PROCESS

Location	Kind of Ties	Number	Year Inserted	Per Cent Ties Removed, all causes, to 12/3/1919.	Traffic Gross Tons per Yr.(1919
Ola, Ark.	R.O.	741	1909	6.2	4,600,000
Yukon, Okla.	"	672	"	4.31	5,500,000
Heywood, Okla.	"	225	"	28.0	5,500,000
TOTAL		1638		8.4	
Ola, Ark.	"	68	1910	13.23	4,600,000
Heywood, Okla.	"	586	"	4.6	5,500,000
TOTAL		654		5.5	
Heywood, Okla.	"	270	1911	8.52	5,500,000
Okarche, Okla.	"	148	"	0.0	5,000,000
Yukon, Okla.	"	418	"	2.87	5,500,000
McLean, Tex.	"	545	"	1.83	1,720,000
TOTAL		1382		3.32	
Yukon, Okla.	"	373	1912	0.53	5,500,000
McLean, Tex.	"	171	"	11.11	1,720,000
TOTAL		544		3.86	
Heywood, Okla.	"	480	1913	13.33	5,500,000
Okarche, Okla.	"	269	"	0.0	5,000,000
Yukon, Okla.	"	462	"	0.64	5,500,000
TOTAL		1211		5.53	
Ola, Ark.	"	266	1914	0.00	4,600,000
Heywood, Okla.	Pine	2459	1908	27.16	5,500,000
McLean, Tex.	"	3274	"	46.51	1,720,000
Chico, Tex.	"	845	"	28.99	2,140,000
TOTAL		6578		36.88	
Ola, Ark.	"	1056	1909	13.88	4,600,000
Leola, Ark.	"	1324	"	19.86	1,400,000
Heywood, Okla.	"	2187	"	22.45	5,500,000
Okarche, Okla.	"	481	"	2.28	5,000,000
Yukon, Okla.	"	1622	"	16.27	5,500,000
Chico, Tex.	"	2764	"	18.81	2,140,000
TOTAL		9444		17.96	
Ola, Ark.	"	430	1910	7.44	4,600,000
Leola, Ark.	"	1868	"	10.00	1,400,000
Heywood, Okla.	"	677	"	21.09	5,500,000
Okarche, Okla.	"	844	"	1.18	5,000,000
Yukon, Okla.	"	1003	"	3.48	5,500,000
TOTAL		5022		8.92	
Ola, Ark.	"	5116	1911	16.22	4,600,000
Leola, Ark.	"	277	"	2.17	1,400,000
Heywood, Okla.	"	960	"	11.14	5,500,000
Okarche, Okla.	"	1044	"	3.64	5,000,000
Yukon, Okla.	"	1486	"	11.42	5,500,000
Chico, Texas	"	2223	"	8.23	2,140,000
TOTAL		11106		11.42	

CHICAGO, ROCK ISLAND & PACIFIC RAILWAY

CREOSOTED TIES - RUEPING PROCESS

Location	Kind of Ties	Number	Year Inserted	Per Cent Ties Removed, all causes, to 12/3/1919.	Traffic Gross Tons per Yr. (1919).
Dalhart, Tex.	Pine	641	1912	0.0	4,300,000
Ola, Ark.	"	1252	"	1.35	5,000,000
Leola, Ark.	"	1817	"	5.55	1,400,000
Heywood, Okla.	"	1042	"	13.43	5,500,000
Okarche, Okla.	"	1600	"	2.25	5,000,000
Yukon, Okla.	"	1584	"	1.64	5,500,000
Chicao, Tex.	"	1342	"	26.45	2,140,000
TOTAL		9278		7.27	
Dalhart, Tex.	"	1385	1913	0.0	4,300,000
Leola, Ark.	"	1715	"	1.1	1,400,000
Heywood, Okla.	"	950	"	11.16	5,500,000
Okarche, Okla.	"	945	"	10.8	5,000,000
Yukon, Okla.	"	1868	"	1.07	5,500,000
Chico, Tex.	"	1431	"	6.77	2,140,000
TOTAL		8294		3.92	
Ola, Ark.	"	97	1914	0.0	5,000,000
Leola, Ark.	"	368	"	4.89	1,400,000
Heywood, Okla.	"	984	"	2.54	5,500,000
Okarche, Okla.	"	708	"	0.56	5,000,000
Yukon, Okla.	"	1927	"	2.02	5,500,000
McLean, Tex.	"	328	"	0.3	1,720,000
Chico, Tex.	"	891	"	2.13	2,140,000
TOTAL		5303		2.0	
McLean, Tex.	Gum	338	1908	23.9	1,720,000
Ola, Ark.	"	82	1909	15.85	5,000,000
Leola, Ark.	"	385	"	12.72	1,400,000
Heywood, Okla.	"	564	"	21.27	5,500,000
Okarche, Okla.	"	77	"	0.0	5,000,000
Yukon, Okla.	"	571	"	5.78	5,500,000
TOTAL		1679		12.86	
Leola, Ark.		80	1910	15.0	1,400,000
Okarche, Okla.	"	73	"	0.	5,000,000
TOTAL		153		7.84	
Ola, Ark.	"	65	1911	9.23	4,600,000
Okarche, Okla.	"	151	"	3.31	5,000,000
TOTAL		216		5.09	
Okarche, Okla.	"	203	1912	0.0	5,000,000
Leola, Ark.	"	382	1914	0.52	1,400,000
Heywood, Okla.	"	567	"	11.9	5,500,000
TOTAL		949		7.37	

CHICAGO, ROCK ISLAND & PACIFIC RAILWAY

ZINC TREATED TIES

Location	Kind of Ties	Number	Year Inserted	Per Cent Ties Removed, all Causes, to 12/3/1919.	Traffic Gross Tons per Yr. (1919).
Ola, Ark.	R.O.	50	1914	0.0	4,600,000
Yukon, Okla.	"	117	"	19.6	5,500,000
TOTAL		167		14.36	
Dalhart, Tex.	Pine	1820	1914	1.09	4,300,000
Heywood, Okla.	"	292	"	22.36	5,500,000
Okarche, Okla.	"	883	"	1.35	5,000,000
Chico, Tex.	"	596	"	18.62	2,140,000
TOTAL		3596		5.28	

STATEMENT SHOWING STATUS OF TEST TIES
IN TEST SECTIONS ON ST.L-S. F. RY.
AT CLOSE OF CALENDAR YEAR 1919

Location of Test Track	Kind of Wood	Kind of Treat-ment	Year in Track	Orig. No. in Track	Percent Remov-ed	Tonnage
Sulligent, Ala.	W.O.	Unt.	1914	944	77.4%	3,630,000
Memphis, Tenn.	"	"	1914	831	23.2%	3,180,000
Diggins, Mo.	"	"	1914	1342	17.2%	3,940,000
Eureka, Mo.	"	"	1914	1081	12.1%	6,920,000
Afton, Okla.	"	"	1914	252	6.3%	6,490,000
Poteau, Okla.	"	"	1914	142	27.0%	1,030,000
Woodville,"	"	"	1914	655	15.4%	2,270,000
Valley Center,Ks.	"	"	1914	408	7.7%	420,000
Bonita, Kans.	"	"	1914	861	13.7%	7,540,000
Sulligent, Ala.	"	"	1915	373	67.8%	3,630,000
Memphis, Tenn.	"	"	1915	968	11.3%	3,180,000
Diggins, Mo.	"	"	1915	473	6.4%	3,940,000
Eureka, Mo.	"	"	1915	613	16.0%	6,920,000
Afton, Okla.	"	"	1915	193	11.4%	6,390,000
Poteau, Okla.	"	"	1915	250	0	1,030,000
Woodville, "	"	"	1915	599	5.5%	2,270,000
Valley Center,Ks.	"	"	1915	348	1.1%	420,000
Bonita, Kans.	"	"	1915	601	8.0%	7,540,000
St.Clair, Mo.	R.O.	R'p'g	1906	752	24.1%	6,920,000
St.Clair, Mo.	Gum	"	19 06	321	12.5%	6,920,000
Diggins, Mo.	R.O.	Lowry	1908	103	5.0%	3,940,000
Eureka, Mo.	"	"	1908	136	1.5%	6,920,000
Afton, Okla.	"	"	1908	293	.3%	6,490,000
Poteau, Okla.	"	"	1908	90	0	1,030,000
Valley Center,Ks.	"	"	1908	190	0	420,000
Bonita, Kans.	"	"	1908	329	44.4%	7,540,000
Diggins, Mo.	"	"	1909	476	6.8%	3,940,000
Eureka, Mo.	"	"	1909	394	2.0%	6,920,000
Afton, Okla.	"	"	1909	1312	1.7%	6,390,000
Woodville,Okla.	"	"	1909	94	0	2,270,000
Valley Center,Ks	"	"	1909	268	0	420,000
Bonita, Kans.	"	"	1909	532	18.3%	7,540,000
Diggins, Mo.	"	"	1910	219	6.0%	3,940,000
Eureka, Mo.	"	"	1910	135	0	6,920,000
Poteau, Okla.	"	"	1910	74	1.3%	1,030,000

STATEMENT SHOWING STATUS OF TEST TIES
IN TEST SECTIONS ON ST.L- S.F.RY.
AT CLOSE OF CALENDAR YEAR 1919

Location of Test Track	Kind of Wood	Kind of Treat-ment	Year in Track	Orig. No. in Track	Percent Remov-ed	Tonnage
Valley Center, Ks.	R.O.	Lowry	1910	68	0	420,000
Eureka, Mo.	Gum	"	1908	198	8.5%	6,920,000
Afton, Okla.	"	"	1908	107	3.8%	6,490,000
Woodville, Okla.	"	"	1908	56	0	2,270,000
Valley Center, Ks.	"	"	1908	398	.8%	420,000
Bonita, Kans.	"	"	1908	224	14.7%	7,540,000
Eureka, Mo.	"	"	1909	155	.6%	6,920,000
Afton, Okla.	"	"	1909	199	3.0%	6,490,000
Afton, Okla.	Pine	"	1908	63	11.1%	6,490,000
Poteau, Okla.	"	"	1908	69	1.7%	1,030,000
Woodville, Okla.	"	"	1908	298	19.8%	2,270,000
Afton, Okla.	"	"	1909	120	10.3%	6,490,000
Poteau, Okla.	"	"	1909	154	3.9%	1,030,000
Woodville, Okla.	"	"	1909	648	6.1%	2,270,000
Woodville Okla,	"	"	1910	71	4.3%	2,270,000
Eureka, Mo.	Elm	"	1909	90	0	6,920,000

RECORD OF TESTS ON BALTIMORE AND OHIO RAILROAD COMPANY
(Corrected to October, 1920)

Location	Kind of Wood	Treatment	No. of Ties Orig. Insert.	Year	No. Orig. Ties Left in Track. Test.	% Ties Removed All Causes to Date.	Tonnage Traffic per Annum x
Windsor, O.	Ash	Zn&Coal T.Creo.	3	1911	3		29,251
Windsor, O.	Beech	Coal. Tar Creo.	27	1911	27		29,251
Windsor, O.	Beech	Zn&Coal T.Creo.	571	1911	571	6	29,251
N.Dayton,O.	Beech	Untreated	50	1919	50		57,912
N.Dayton,O.	Beech	W. Gas Tar	101	1919	101		57,912
Boyds, Md.	Beech	ZN&W.C.T.Creo.	64	1915	64		11,738
Boyds, Md.	Beech	ZN&W.C.T.Creo.& Coal Tar Creo.	54	1915	54		11,738
Barnesville,Md.	Beech	Zn&W.G.Tar	5	1919	5		5,371
Barnesville,Md.	R.Bir.	Zn&W.G.Tar	45	1919	45		5,371
N.Dayton,O.	Cherry	Untreated	27	1919	27		57,912
N.Dayton,O.	Cherry	Zn&W.G.Tar	32	1919	32		57,912
N.Dayton,O.	Chest.	Untreated	50	1919	50		57,912
N.Dayton,O.	Chest.	Zn&W.G.Tar	95	1919	95		57,912
Windsor, O.	Elm	Zn&Coal T.Creo.	51	1911	51		29,251
Windsor, O.	Elm	Coal T. Creo.	37	1911	37		29,251
Windsor, O.	Elm	Tbr. Asphalt	12	1911	12		29,251
N.Dayton, O.	Elm	Untreated	25	1919	25		57,912
N.Dayton, O.	Elm	Zn&W.G.Tar	34	1919	34		57,912
N.Dayton, O.	D.Fir	Untreated	105	1919	105		57,912
N.Dayton, O.	D.Fir	Zn&W.G.Tar	155	1919	155		57,912
Barnesville,Md.	D.Fir	Untreated	105	1919	105		5,371
Barnesville,Md.	D.Fir	Zn&W.G.Tar	105	1919	105		5,371
Windsor, O.	Gum	Zn&Coal T. Creo.	125	1911	125	8	29,251
Windsor, O.	Gum	Coal T. Creo.	118	1911	118	7	29,251
Windsor, O.	Gum	Tbr. Asphalt	3	1911	3		29,251
Boyds, Md.	Gum	Zn&W.G.T.Creo.	2	1915	2		11,738
Boyds, Md.	Gum	Zn&W.G.T.Creo. & Coal Tar Creosote	2	1915	2		11,738
Windsor, O.	Hky.	Zn&Coal T. Creo.	1	1911	1		29,251
Barnesville,Md.	Hky.	Zn&W.G.Tar	4	1919	4		5,371
Windsor, O.	H.Mple.	Zn&Coal T. Creo.	475	1911	475	9	29,251
Windsor, O.	H.Mple.	Tbr. Asphalt	2	1911	2		29,251
Windsor, O.	H.Mple.	Coal Tar Creo.	67	1911	67		29,251
Boyds, Md.	H.Mple.	Zn&W.G.Tar	6	1915	6		11,738
Boyds, Md.	H.Mple.	Zn&W.C.T.Creo.& Coal Tar Creo.	6	1915	6		11,738
Barnesville,Md.	H.Mple.	Zn&W.G.Tar	49	1919	49		5,371
Barnesville,Md.	S.Mple.	Zn&W.G.Tar	55	1919	55		5,371
Staten Is.,N.Y.	Bl.Oak	Untreated	25	1915	25	92	539,639

x - In 1,000 Tons.

Record of Tests on Baltimore & Ohio Railroad Company

Corrected to October, 1920

Location	Kind of Wood	Treatment	No. of Ties Orig. Insert.	Year	No. Orig. Ties Left in Track. Test.	% Ties Removed All Causes to Date.	Tonnage Traffic per Annum
Staten Is., N.Y.	Bl.Oak	Zn&C.T.Creo.	105	1915	105		539,639
Staten Is., N.Y.	Cst."	Untreated	25	1915	25		539,639
Staten Is., N.Y.	Cst."	Zn&C.T.Creo.	105	1915	105		539,639
Windsor, O.	Rd.Oak	Zn&C.T.Creo.	1118	1911	1118	2	29,251,000
Windsor, O.	Rd.Oak	Coal Tar Creo.	872	1911	872	0.3	29,251,000
Windsor, O.	Rd.Oak	Tbr. Asphalt	984	1911	969	43.5	29,251,000
Boyds, Md.	Rd.Oak	Zn&W.G.T.Creo.	451	1915	451		11,738,000
Boyds, Md.	Rd.Oak	Zn&W.G.Tar	133	1915	133		11,738,000
Staten Is., N.Y.	Rd.Oak	Untreated	25	1915	25	84	539,639
Staten Is., N.Y.	Rd.Oak	Zn&C.T.Creo.	105	1915	105		539,639
N.Dayton, O.	Rd.Oak	Untreated	48	1919	48		57,912,000
N.Dayton, O.	Rd.Oak	Zn&W.G.Tar	103	1919	103		57,912,000
Hamden, O.	Rd.Oak	Untreated	25	1917	25		32,176,000
Hamden, O.	Rd.Oak	Zn&W.G.Tar	100	1917	100		32,176,000
LaPaz Jct., Ind.	Rd.Oak	Zn&C.T.Creo.	988	1917	988		3,189,000
Green Spring, W. Va.	Rd.Oak	Zn&C.T.Creo.	10	1914	10		600,000
Green Spring,"	Rd.Oak	C.T.Creo., 10#	10	1914	10		600,000
Green Spring,"	Rd.Oak	C.T.Creo., 6#	10	1914	10		600,000
Green Spring,"	Rd.Oak	Zn&W.G.T.Creo.	10	1914	10		600,000
Green Spring,"	Rd.Oak	Zn&W.G.T.Creo.& Coal Tar Creo.	10	1914	10		600,000
Green Spring,"	Rd.Oak	Untreated	10	1914	10	100	600,000
Her'g Run, Md.	Rd.Oak	C.T.Creo., 4#	300	1914	300		14,517,000
Her'g Run, Md.	Rd.Oak	C.T.Creo., 10#	300	1914	300		14,517,000
Her'g Run, Md.	Rd.Oak	Sodium Fluoride	300	1914	300	33	14,517,000
Her'g Run, Md.	Rd.Oak	Untreated	298	1914	289	66	14,517,000
Her'g Run, Md.	Rd.Oak	W.G.Tar, 5#	150	1914	150		14,517,000
Her'g Run, Md.	Rd.Oak	W.G.Tar, 6#	150	1914	150		14,517,000
Her'g Run, Md.	Rd.Oak	W.G.Tar, 7#	150	1914	149	.6	14,517,000
Her'g Run, Md.	Rd.Oak	W.G.Tar, 11#	362	1914	359	.8	14,517,000
Her'g Run, Md.	Rd.Oak	ZnCl, 0.35#	300	1914	172	42	14,517,000
Her'g Run, Md.	Rd.Oak	ZnCl, 0.63#	300	1914	213	29	14,517,000
Her'g Run, Md.	Rd.Oak	Zinc - Creo.	600	1914	600	1.33	14,517,000
Her'g Run, Md.	Rd.Oak	Zn-W.G.T. Coal Tar Creo.	300	1914	300	.33	14,517,000
Windsor, O.	W. Oak	Untreated	761	1911	761	55	29,251,000
Boyds, Md.	W. Oak	Untreated	4	1915	4		11,738,000
Staten Is., N.Y.	W. Oak	Untreated	25	1915	25		539,639

RECORD OF TESTS ON BALTIMORE AND OHIO RAILROAD COMPANY
(Corrected to October, 1920)

Location	Kind of Wood	Treatment	No. of Ties Orig. Insert.	Year	No. Orig. Ties Left in Track. Test.	% Ties Removed All Causes to Date	Tonnage Traffic per Annum
Staten Is., N.Y.	W.Oak	Zn&C.T.Creo.	104	1915	104		539,639
Hamden, O.	W.Oak	Untreated	25	1917	25		32,176,000
Hamden, O.	W.Oak	Zn&W.G.Tar	100	1917	100		32,176,000
N.Dayton, O.	W.Oak	Untreated	99	1919	99		57,912,000
N.Dayton, O.	W.Oak	Zn & W.G.Tar	96	1919	96		57,912,000
Hamden, O.	(Water .Oak	Untreated	25	1917	25		32,176,000
Hamden, O.	" Oak	Zn & W.G.Tar	100	1917	100		32,176,000
N.Dayton, O.	(LL Ht.Pine	Untreated	50	1919	50		57,912,000
Windsor, O.	Pine	Coal Tar Creo.	1	1911	1		29,251,000
N.Dayton, O.	(Sap "	Zn & W.G.Tar	92	1919	92		57,912,000
Barnesville, Md.	(LL Ht."	Untreated	50	1919	50		5,371,000
Barnesville, Md.	(Sap "	Zn & W.G.Tar	52	1919	52		5,371,000
Barnesville, Md.	Syc'e	Zn & W.G.Tar	50	1919	50		5,371,000
Windsor, O.	B.Wal.	Coal Tar Creo.	1	1911	1		29,251,000
Windsor, O.	W.Wal.	Zn & C.T.Creo.	1	1911	1		29,251,000

STATEMENT SHOWING VARIOUS SPECIAL TESTS

SANTA FE SYSTEM

Station or Line	Kind of Wood	Treatment	Location M.P. & Feet		to M.P. & Feet	
Marceline, Mo.	Hn.Pine	Reuping	348	- 2506	348	- 2838
Sutton, Kans.	"	"	436	- 2600		
Ponca City, Okla.	"	"	286	- 4754		
Bliss, Okla.	Sn."	"	297	- 245		
Perry, Okla.	Hn."	"	323	- 5274		
Perry, Okla.	Sn."	"	323	- 5274		
Garnett, Kans.	"	"	86	- 435		
Argonia, Kans.	"	"	264	- 1580		
Hutchinson Cutoff	Sn. Gum	"	219	- 0		
" Main Ln.	"	"	219	- 1150		
Plevna, Kans.	"	"	240	- 3696		
"	Sn.R.O.	"	240	- 3696		
Ottawa Cutoff	Hn.Pine	"	80	- 0	87	- 3155
Smithshire, Ill.	Sn.Beech	"	201	- 2640		
Marceline, Mo.	"	"	349	- 1320		
Tecumseh, Kans.	"	"	47	- 4980		
Newton, Kans.	"	"	181	- 2640		
"	Hn.Pine	"	183	- 2640		
"	Sn. "	"	183	- 2640		
"	Hn.R.O.	"	183	- 2640		
"	Sn. Gum	"	183	- 2640		
Hutchinson Cutoff	Hn.Pine	"	247	- 1608	268	- 0
"	Sn. "	"	247	- 1608		
"	Hn. Gum	"	247	- 1608		
"	Hn.Ohia	Unt'd	257	- 0	258	- 0
"	Sn. "	"	257	- 0	258	- 0
"	Hn.Pine	Reuping	290	- 0	294	- 1320
Newton, Kans.	Hn.Pine	Burnett	179	- 264	184	- 3036
"	"	"	179	- 264	184	- 3036
"	Sn.Pine	"	179	- 264	184	- 3036
Walton, Kans.	Hn.Pine	Reuping	173	- 0	178	- 1320
Newton, Kans.	Sn.Pine	Burnett	179	- 264	184	- 3036
Walton, Kans.	Sn.Pine	Reuping	173	- 0	178	- 1320
Walton, Kans.	Hn. Oak	"	173	- 0	178	- 1320
Turner-Holliday	Hn.Pine	Burnett	7	- 0	13	- 0
"	Sn.Pine	"	7	- 0	12	-
"	Hn.Pine	Reuping	7	- 0	13	- 0
"	Sn.Pine	"	7	- 0	9	- 0
"	Hn. Oak	"	7	- 0	10	- 0
Clements, Kans.	Hn.Pine	"	600			

STATEMENT SHOWING VARIOUS SPECIAL TESTS

SANTA FE SYSTEM

Station or Line	Number Originally Inserted	Date Inserted	Now in Track	Number Removed Rotten 1915	1916	1917	1918	1919	1920
Marceline, Mo.	304	1905	134	8					
Sutton, Kans.	44	1905	0						
Ponca City, Okla.	190	1904	181						
Bliss, Okla.	275	1904	237					1	5
Perry, Okla.	27	1904	27						
	366	1904	359				3		
Garnett, Kans.	384	1905	300	26	12	22			
Argonia, Kans.	372	1905	330		4	20			
Hutchinson Cutoff	390	1907	375		4	1			
" Main Ln.	230	1907	214						
Plevna, Kans.	262	1907	245						
"	52	1907	41						
Ottawa Cutoff	24238	1906	23881						
Smithshire, Ill.	384	1912	379						
Marceline, Mo.	99	1912	99						
Tecumseh, Kans.	160	1912	160						
Newton, Kans.	151	1912	151						
"	149	1913	149						
"	151	1913	151						
"	150	1913	149						
"	150	1913	150						
Hutchinson Cutoff	41021	1910	40823						
"	9436	1910	9206						
"	14497	1910	14495						
"	132	1910	132						
"	108	1910	106						
"	13600	1910	13592						
Newton, Kans.	6357	1904	14	2257	219	540	1904		
"	9251	1905	1780	2246	572	434	140	3092	
"	2517	1904	124	1054	349	86	175	117	
Walton, Kans.	10994	1917	10994						
Newton, Kans.	40	1905	2		16	6	13		
Walton, Kans.	1394	1917	1394						
Walton, Kans.	4395	1917	4395						
Turner-Holliday	4640	1918	4640						
"	686	1918	686						
"	8794	1918	8712						
"	456	1918	456						
"	2864	1918	2864						
Clements, Kans.	165	1904	156						

STATEMENT SHOWING VARIOUS SPECIAL TESTS

SANTA FE SYSTEM

Station or Line	Number Removed									
	Mechanical Wear						Exp. Purposes			
	1915	1916	1917	1918	1919	1920	1915	1917	1919	1920
Marceline, Mo.	12	6	15		27	10	2			
Sutton, Kans.	4		1	17		22				
Ponca City, Okla.	6						2	1		
Bliss, Okla.	6	5	2		8					
Perry, Okla.										
				3					1	
Garnett, Kans.			12			10	2			
Argonia, Kans.	56	4	98							
Hutchinson Cutoff		6								
" Main Ln.					16					
Plevna, Kans		3	1							
"			1							
Ottawa Cutoff			16							
Smithshire, Ill.										
Marceline, Mo.										
Tecumseh, Kans.										
Newton, Kans.										
"										
"										
"										
"										
Hutchinson Cutoff		6	32		4					
"			9							
"										
"										
"										
Newton, Kans.						1423				
"	601					136				
"						612				
Walton, Kans.										
Newton, Kans.						3				
Walton, Kans.										
Walton, Kans.										
Turner-Holliday										
"										
"										
"										
"										
Clements, Kans.		5								

STATEMENT SHOWING VARIOUS SPECIAL TESTS

SANTA FE SYSTEM

Station or Line	Number Removed Other Causes 1915	1917	1918	1919	1920	Total	Last Inspection Made	Kind of Ballast
Marceline, Mo.	90					170	9-23-20	Gravel
Sutton, Kans.						44	9-30-20	Slag
Ponca City, Okla.						9	9-29-20	Rock
Bliss, Okla.					11	38	9-29-20	"
Perry, Okla.						0	9-30-20	"
"						7	9-30-20	"
Garnett, Kans.						84	10- 6-20	"
Argonia, Kans.		60				242	10- 1-20	"
Hutchinson Cutoff					4	15	9-22-20	"
" Main Ln.						16	9-22-20	Cinder
Plevna, Kans.					13	17	9-22-20	Rock
"					10	11	9-22-20	"
Ottawa Cutoff	7	8	8		315	357	9-28-20	"
Smithshire, Ill.				1	4	5	9-24-20	Gravel
Marceline, Mo.						0	9-23-20	"
Tecumseh, Kans.						0	9-22-20	Rock
Newton, Kans.						0	9-28-20	"
"						0	9-28-20	"
"						0	9-28-20	"
"					1	1	9-28-20	"
"						0	9-28-20	"
Hutchinson Cutoff	75	(X)8	X 72		1	198	9-23-20	"
"				221		230	9-23-20	"
"					2	2	9-23-20	"
"						0	9-23-20	"
"			2			2	9-25-20	"
"			6		2	8	9-27-20	"
Newton, Kans.						6343	9-28-20	"
"			50			7471	9-28-20	"
"						2393	9-28-20	"
Walton, Kans.						0	9-29-20	"
Newton, Kans.						38	9-28-20	Screening
Walton, Kans.						0	9-29-20	"
Walton, Kans.						0	9-29-20	"
Turner-Holliday						0	10- 4-20	Cinder
"						0	10-4 -20	Rock
"					81	82	10- 4-20	"
"						0	10- 4-20	"
"						0	10- 4-20	"
Clements, Kans.						9	10- 5-20	"

X 70 Removed account changing switch
(X) 8 Burned.

STATEMENT SHOWING VARIOUS SPECIAL TESTS

SANTA FE SYSTEM

Station or Line	Wgt. of Rail	Size of Tie Plate	Ties per Mile	Kind of Spike	Tons Traff. per Annum.	Seasoning.	Int. Ins.	Vac. Time
Marceline, Mo.	85	6x8-7½x9	3200	Cut	10,369,895	Air		
Sutton, Kans.	85	6x8-7½x9	"	"	6,499,249	"		
Ponca City, Okla.	90	7½x9	"	"	2,550,296	"		
Bliss, Okla.	90	"	"	"	2,550,296	"		
Perry, Okla.	90	"	"	"	2,550,296	"		
"	90	"	"	"	2,550,296	"		
Garnett, Kans.	90	"	"	"	4,821,390	"		
Argonia, Kans.	90	"	"	"	5,131,506	"		
Hutchinson Cutoff	90	"	"	"	4,904,161	"		
" Main Ln.	85	"	"	"	3,003,686	"		
Plevna, Kans.	90	"	"	"	4,904,161	"		
"	90	"	"	"	4,904,161	"		
Ottawa Cutoff	90	6x8-7½x9	"	"	14,327,691	"		
Smithshire, Ill.	90	7½x9	"	"	10,172,186	"		
Marceline, Mo.	90	"	"	"	10,369,895	"		
Tecumseh, Kans.	90	"	"	"	6,902,490	"		
Newton, Kans.	90	6x8-7½x9	"	"	15,034,755	"		
"	85	7½x9	"	"	15,034,755	"		
"	85	"	"	"	15,034,755	"		
"	85	"	"	"	15,034,755	"		
"	85	"	"	"	15,034,755	"		
Hutchinson Cutoff	90	"	"	Screw	4,904,161	"		
"	90	"	"	"	4,904,161	"		
"	90	"	"	"	4,904,161	"		
"	90	"	"	"	4,904,161	"		
"	90	"	"	"	4,904,161	"		
"	90	"	"	"	4,904,161	"		
Newton, Kans.	85	"	"	Cut	15,034,755	"	24	45"
"	85	"	"	"	15,034,755	"	24	45"
"	85	"	"	"	15,034,755	"	24	45"
Walton, Kans.	85	"	"	"	15,034,755	"	24	45"
Newton, Kans.	90	"	"	Cut &	15,034,755	"		
Walton, Kans.	90	"	"	Screw	15,034,755	"		
Walton, Kans.	90	"	"	"	15,034,755	"		
Turner-Holliday	85	"	"	Cut	47,966,366	"	22	30"
"	85	"	"	"	47,966,356	"	23	30"
"	85	"	"	"	47,966,356	"		
" v	85	"	"	"	47,966,356	"		
"	85	"	"	"	47,966,356	"		
Clements, Kans.	90	"	"	"	15,034,755	"		

STATEMENT SHOWING VARIOUS SPECIAL TESTS

SANTA FE SYSTEM

Station or Line	Steam Lbs.	Steam Time	Air Lbs.	Air Time	Pressure. Lbs.	Pressure. Time	Temp. Re-tort	Fin.Vac. Ins.	Fin.Vac. Time	Lbs. Creo.	Absp. Zn Cl.
Marceline, Mo.			60	45	104	1'45"	120°F			4.56	
Sutton, Kans.			60	45	104	1'45"	120			4.56	
Ponca City, Okla.			60	45	104	1'45"	120			4.56	
Bliss, Okla.			65	50	104	2'15"	122			3.93	
Perry, Okla.			60	45	104	1'45"	120			4.56	
"			65	50	104	2'15"	122			3.93	
Garnett, Kans.			65	50	104	2'15"	122			3.93	
Argonia, Kans.			65	50	104	2'15"	122			3.93	
Hutchinson Cutoff			100	30	200	2'30"	186	23	1'30"	5.00	
" Main Ln.			100	30	200	2'30"	186	23	1'30"	5.00	
Plevna, Kans.			100	30	200	2'30"	186	23	1'30"	5.00	
"			100	30	200	2'30"	186	23	1'30"	5.00	
Ottawa Cutoff			75	30	150	1'45"	172	22	1'15"	5.00	
Smithshire, Ill.			50	25	175	3'00"	168	29	1'30"	3.72	
Marceline, Mo.			50	25	175	3'00"	168	29	1'30"	3.72	
Tecumseh, Kans.			50	25	175	3'00"	168	29	1'30"	3.72	
Newton, Kans.			50	25	175	3'00"	168	29	1'30"	3.72	
"			85	25	175	1'45"	190	23	1'30"	5.00	
"			95	25	175	1'45"	190	23	1'30"	5.00	
"			40	25	200	3'30"	190	23	1'30"	5.00	
"			60	25	175	2'45"	195	23	1'30"	5.00	
Hutchinson Cutoff			85	25	175	1'45"	194	22	1'30"	5.00	
"			65	25	175	1'45"	194	22	1'30"	5.00	
"			100	30	175	3'00"	194	23	2'00"	5.00	
"											
"											
"			85	25	175	1'45"	194	22	1'30"	5.00	
Newton, Kans.	20	3'30"			100	2'00"	200				.58
"	20	3'30"			100	2'00"	200				.58
"	20	3'30"			100	2'00"	200				.52
Walton, Kans.	20	3'30"			100	2'00"	200				.52
Newton, Kans.			75	25	175	1'45"	150	25	1'30"	5.00	
Walton, Kans.			90	25	175	1'45"	180	25	1'30"	5.00	
Walton, Kans.			30	25	175	3'00"	180	25	1'30"	4.07	
Turner-Holliday	20	2'30"			175	3'30"	150				.56
"	20	2'30"			175	3'30"	150				.51
"					175	1'45"	150	25	1'30"		
"					175	1'45"	180	25	1'30"		
"					175	3'00"	180	25	1'30"		
Clements, Kans.			60	45	104	1'45"	120				

CHICAGO, INDIANAPOLIS & LOUISVILLE RAILROAD

MONON ROUTE

Species	Where Grown	Form Hewed or Sawed	Di-men-sions	Where Set	Date Set	Tan-gent	% Grade	No. of Ties Set.	Sea'd or Un-sea'd	Prep't'n Spacing in Track
W. Oak	Ind.	Hewed	6x8x8	Mile 117.9 to 117.1	June 1914	"	5	131	Se'd	20"
R. Oak	"	Sawed	"	"	"	"	"	199	"	"
R. Oak	"	Hewed	"	"	"	"	"	198	"	"
Beech	"	Hewed	"	"	"	"	"	198	"	"
Beech	"	Sawed	"	"	"	"	"	198	"	"
Elm	"	H & S	"	"	"	"	"	200	"	"
Sc.Pine Niger "	"	Hewed	"	"	"	"	"	196	"	"
Black Walnut	"	Hewod	"	"	"	"	"	4	"	"
Cherry	"	Hewed	"	"	"	"	"	6	"	"
Sassa-fras	"	Hewed	"	"	"	"	"	15	"	"
Mul-berry	"	Hewed	"	"	"	"	"	2	"	"

CHICAGO, INDIANAPOLIS & LOUISVILLE RAILROAD

MONON ROUTE

Pre-serva-tive	Pro-cess	Aver. Absp. per Cu.Ft.	Aver. Absp. per Tie.	Tie Plate: Kind, Size.	Bal-last	Wgt. of Rail	Spikes, Cut or Screw.	Traf. Tons per Year	% Re-mov. ed.	Pres. Con-di-tion	Date In-spect-ed
Creo-sote	Low-ry	5.3	22.2	Econ-omy 7"	Grav-el	90	Cut	5697567	0	Good	Sept., 1920.
"	"	7.7	20.6	"	"	"	"	"	0	"	"
"	"	7.7	20.6	"	"	"	"	"	0	"	"
"	"	113	30.1	"	"	"	"	"	0	"	"
"	"	7.	18.7	"	"	"	"	"	0	"	"
"	"	8.7	23.3	"	"	"	"	"	0	"	"
"	"	9.2	24.5	"	'	"	"	"	0	"	"
"	"	4.6	12.4	"	"	"	"	"	0	"	"
"	"	7.3	19.4	"	"	"	"	"	0	"	"
"	"	3.1	9.4	"	"	"	"	"	0	"	"
"	"	1.3	3.5	"	"	"	"	"	0	"	"

The Cleveland, Cincinnati, Chicago & St. Louis Railway Company commenced using creosoted ties in their tracks during the year 1905 treated with an average of 7.78 lb. of oil per cubic foot by the Lowry Process. The statement shows 8,816,652 creosoted ties had been inserted in tracks and 308,996, or 3.5 per cent., removed for all causes at the end of the year 1919. The timber used was principally Ta group mixed with a small percentage of Tc and Td groups. The increase in percentage of 1906, 1907, 1908 and 1909 ties removed may be attributed to the close method of stacking ties in the storage yard during those years. During 1910 and subsequent years ties have been stacked one by ten with 3 to 4 ft. alleys between stacks. The total number of ties inserted in tracks treated and untreated in 1905 was 1,300,661, total number inserted in 1909 was 840,362, a reduction of 460,299 ties, or 35.39 per cent., by using treated ties. There were 369 ties inserted per mile in 1905 and 201 ties per mile in 1919, a reduction of 168 ties per mile. Of the ties inserted in 1905, 31.24 per cent. were treated and 68.75 per cent. were untreated. Of the ties inserted in 1919, 76.96 per cent. were treated and 23.04 per cent. untreated. During the fifteen years mentioned the treated tie territory was increased and the untreated tie territory decreased. The mileage in 1919 was 15.57 per cent. more than in 1905.

C.C.C. & St.L. RY. CO. (INC. P. & E.)

STATEMENT OF CREOSOTED TIES APPLIED AND REMOVED - 1905 TO 1919, INC.

RECAPITULATION

Yr. Put in Track	No. Put in Track	Removed Account Decay Main	Side	Total	Per Cent Taken Out
1905	406304	16556	3430	19986	4.92
1906	496660	65879	6686	72565	14.61
1907	393988	34906	3414	38320	9.72
1908	463811	20791	3499	24290	5.24
1909	506051	11891	1602	13493	2.66
1910	860379	8106	2309	10415	1.21
1911	558206	4735	508	5243	.93
1912	724399	1320	546	1866	.26
1913	672269	246	85	331	.05
1914	721274	165	108	273	.04
1915	763783	53	21	74	.01
1916	567825	71	29	100	.02
1917	507803	4	-	4	-
1918	527038	-	-	-	-
1919	646772	-	4	4	-
No Nails		24153	14483	38636	-
TOTAL.	8816652	188876	36724	225600	2.56

C. C. C. & ST. L. RY. CO. (INC. P. & E.)

STATEMENT OF CREOSOTED TIES APPLIED AND REMOVED - 1905 TO 1919 INC.

RECAPITULATION

Yr. Put in Track	No. Put in Track	Main	Side	Total	Percent Taken Out	Total Number Ties Removed	Per Cent Taken Out, All Causes.
1905	406394	5747	1235	6982	1.72	26968	6.64
1906	496660	10044	1202	11246	2.26	83811	16.87
1907	393988	8696	1264	9960	2.53	48280	12.24
1908	463811	8647	1243	9890	2.13	34180	7.37
1909	506051	7962	1881	9843	1.94	23336	4.60
1910	860379	8461	2152	10613	1.23	21028	2.44
1911	558206	5012	1403	6415	1.15	11658	2.08
1912	724399	3155	1668	4821	.66	6687	.92
1913	672269	1182	1361	2543	.37	2874	.42
1914	721274	1629	1117	2746	.38	3019	.42
1915	763783	682	1186	1868	.24	1942	.25
1916	567825	498	529	1027	.18	1127	.20
1917	507803	159	329	488	.09	492	.09
1918	527038	41	211	252	.04	252	.04
1919	646772	7	25	32	-	36	-
No Nails	-	3101	1569	4670	-	43306	-
TOTAL	8816652	65023	18373	83396	.94	308996	3.50

Appendix B

(3) MERITS OF WATER-GAS-TAR AS A PRESERVATIVE

F. J. Angier, *Chairman;* Z. M. Briggs, C. E. Gosline, Sub-Committee.

Your Committee has endeavored to get some additional information other than that contained in previous reports on the use of water-gas-tar as a preservative of cross-ties.

The report of the Committee in 1917 contains an account of the ties treated by the United Gas Improvement Company of Philadelphia and placed in the track of the Public Service Company of New Jersey. They were treated in 1911 with the full-cell treatment of 10 lb. per cubic foot. The manner in which these ties were treated, together with the analysis of the oil used and their location, was given in detail in that report. On December 1, 1919, the ties were again inspected and were apparently in excellent condition, none having been removed on account of decay. They are mostly Florida Pine 6x8 in. by 8 ft. and have now given approximately 9 years' life.

In November, 1914, the Baltimore & Ohio Railroad placed 600 Red Oak ties in a test track at Herring Run, Md. They were treated by the United Gas Improvement Company at Philadelphia with water-gas-tar. The details of the treatment and the analysis of the oil are as follows:

Red Oak Ties Plaoed in Track November 1914 at Herring Run, Md., Baltimore & Ohio Railroad, treated with Watar-Gas-Tar.

	Items			
Treatment	No.6	No.66	No.7	No.77
Preliminary Steaming	-	-	2 hrs.10 min.	
Max. Pressure	-	-	27#	
Preliminary Vacuum	-	-	2 hrs.55 min.	3 hrs.40 min.
Max. Inches.	-	-	16	21
Pressure Poriod	4 hrs.	4 hrs.	9 hrs.15 min.	16 hrs.15 min.
Max. Temp.	182°	180°	185°	190°
" Pressure	60 lbs.	60 lbs.	70 lbs.	67 lbs.
Final Vacuum	1 hr.13 min.	1 hr.15 min.	1 hr.20 min.	1 hr.
Max. Inches	20	20	13	16
Number of ties in test.	150	150	150	150
Ties Numbered	1501-1650	1651-1800	1801-1950	1951-2100
Average pounds absorption por cubic foot.	5.16	6.12	7.09	10.90

An inspection of these ties was made on September 16, 1920, with the result that after six years no signs of decay were found, while 63 per cent. of the untreated Red Oak ties placed in the same track have been removed account of decay. Two of the ties were taken out of this track for test. Each tie was sawed in two and one-half of each sent to

Analysis made by Forest Products Laboratory

	Items No. 6-66-7	Items No. 77
Specific Gravity 38°/15°	1.061	1.041
Distilling below 205°C.	5.8	3.9
205° to 235°C.	5.8	8.9
235° to 245°C.	3.3	4.8
245° to 275°C.	18.4	15.8
275° to 315°C.	16.4	16.8
315° to 330°C.	6.0	6.9
Residue	43.9	42.9
Loss	.4	.1
Color	Black	Black
Odor	Pungent	Pungent
Character	Liquid	Liquid
Remarks	No Moisture	5.6% Moisture

the Baltimore & Ohio laboratory at Baltimore; half of one tie to the laboratory of the Port Reading Creosoting Plant, at Port Reading, N. J., and half of one tie to the laboratory of the United Gas Improvement Company at Philadelphia. The oil was extracted and analyzed with the following results:

	Items 6-66-7 Tie No. 1805 B. & O. Analysis	*Item 77 Tie No. 1960 B. & O. Analysis*
Specific gravity, 38°/15° C.	1.085	1.108
Distilling below 205° C.	.6	4.2
205° to 235° C.	2.6	...
235° to 245° C.	2.8	3.1
245° to 275° C.	7.4	4.1
275° to 315° C.	7.4	14.7
315° to 330° C.	9.7	10.6
Residue	69.1	63.2
Loss	.4	.1

Memorandum of Inspection of Public Service Ties Treated with Water-Gas-Tar

Date Inspection Made: Friday, November 12, 1920.
Present: Mr. F. J. Angier, of the Baltimore & Ohio Railroad Co.
Mr. H. S. Valentine, of the Eppinger & Russell Co.
Mr. W. H. Fulweiler, of the United Gas Improvement Co.
Object: This is the annual inspection of these ties for report to the A.R.E.A.
Sections Inspected:
Section No. 7: Pensauken Line. 44th and Elm Streets to Pensauken Junction 1,912 ties.
Section No. 7: Riverton Line. Pensauken Junction to No. 4 Turnout. 1,912 ties.
Section No. 6: Woodbury Line. Crown Point Road to Southern Curve. 1,911 ties.
Section No. 3: Mantua Line. Toll Gate to Mantua. 1,911 ties.
Section No. 4: Mantua Line. Toll Gate to Mantua. 1,912 ties.
Section No. 1: Blackwood Line. Rivers crossing to Woodbury City Line. 1,911 ties.

The ties appeared to be in good condition, although the Committee noticed that in several sections rails had been respiked and the old spike holes were not plugged. No treated ties have been removed except those for the purpose of test.

The instructions to your Committee were to confine this investigation strictly to cross-ties treated with water-gas-tar, therefore, the treatment of other material was not considered. In view of the good results so far obtained in the treatment of cross-ties with water-gas-tar, it is suggested that other railroads install test tracks, and keep a careful record of the comparative life of cross-ties treated with water-gas-tar alone, or combined with coal-tar-creosote, zinc chloride, or other preservatives.

Appendix C

(6) AVAILABILITY AND USE OF SODIUM FLUORIDE AS A PRESERVATIVE FOR CROSS-TIES

O. C. STEINMAYER, *Chairman;* R. S. BELCHER, Z. M. BRIGGS,
Sub-Committee.

Use

Sodium fluoride has been used only in very small amounts for the preservation of ties, and that only for experimental purposes.

Availability

Comparatively very little sodium fluoride is available for the preservation of ties at this time. Lack of a demand and an immediate shortage of high-grade fluor spar has deterred manufacturers in increasing their facilities for its preparation. Its recovery as a by-product from the manufacture of phosphate fertilizer is not being carried out because of the high initial outlay in plant construction under present conditions of labor and material shortages.

Tests on the toxicity of sodium fluoride as made by the Forest Products Laboratory, Madison, Wisconsin, indicate it to be about double that of zinc chloride. Service tests on ties treated with this salt have not been carried on over a period sufficiently long to determine if this same ratio holds true in practice. Until this information is at hand, it appears to the Committee that no railroad going into the extensive use of sodium fluoride for the treatment of ties would be warranted at this time, in using an amount much less than is customary when treating with zinc chloride, i. e., ½-lb. per cubic foot of wood. Under the circumstances, the comparative prices of zinc chloride and sodium fluoride will determine whether or not the former will be supplanted by the latter, wholly or in part.

Recent developments indicate that there is a possibility that sodium fluoride will be obtainable at a price very nearly that of zinc chloride. This situation, therefore, causes the Committee to suggest that any railroad maintaining experimental tracks should arrange to install a sufficient number of ties treated with sodium fluoride to obtain test records from which definite conclusions may be drawn.

Appendix D

(7) PROTECTION OF PILES IN WATER INFESTED BY MARINE BORERS

A. B. ILSLEY, *Chairman;* E. H. BOWSER, W. H. KIRKBRIDE, J. F. PINSON, H. VON SCHRENK, E. B. HILLEGASS, LOWRY SMITH, W. D. SIMPSON, Sub-Committee.

1. It is a matter of general observation that the attacks of marine borers on exposed piling are of late more extensive and severe than formerly. This fact, together with the increasing scarcity and cost of timber and high cost of replacement, has made the matter of protection against the attacks of marine borers very important.

These pests have always been with us, but as protection against them is a painstaking and expensive operation it has generally not received the attention it deserves.

2. There are many varieties of borers present in the coast waters bordering the United States, but as far as protecting against them is concerned there are only two that need be considered, viz., the mollusk, represented by the various species of Teredo, and the crustacean, represented by the Limnoria and to some extent the Sphaeroma. Protection that is effective against these is also effective against any others so far encountered.

The borers breed faster and their attack is more severe in warm than in cold water, in clean water than dirty water, and in salty than brackish water. The action of Limnoria is affected by the velocity of the current so that each location presents a problem in protection by itself, and a method that is effective in one location may be ineffective in another.

The Teredo and Limnoria are active to some extent on the Atlantic Coast north of Cape Cod. Further south their inactivity increases and in the Gulf and all along the Pacific Coast their action is very severe.

The activity of these borers is as a rule affected by the same conditions; however, their simultaneous presence is not always the rule nor is their activity necessarily the same, although found in the same location; as an example, the Teredo is active in Norfolk harbor but there are very few, if any, Limnoria. The range of action of the Teredo is from a point above low water mark to a depth of 25 to 30 feet, or to mud line. The attack of the Limnoria is most severe between high and low water but extends down to about the same depth as that of the Teredo. In Charleston harbor where Limnoria is particularly active, there are creosoted piles which are badly eaten at low water mark, but which have been attacked only to a slight extent in patches below low water. Untreated piles in these waters are quickly attacked by the Limnoria at all depths to the mud line.

3. Creosoting has been relied upon to a great extent for protection against the attacks of marine borers and experience has shown that where properly carried out, from the selection of the timber to the driving in the structure, creosoting will generally stop the Teredo at points on the Atlantic Coast north of Florida but that at points on the Gulf and Pacific Coasts where the Teredo is more active creosote treatment is often inadequate.

On the Atlantic and Gulf Coasts the piling treated for marine use is usually Pine and on the Pacific Coast Douglas Fir. The piling should be free from knots or other imperfections that will interfere with the creosoting. The inner bark should be completely removed and as much creosote oil should be injected as the wood is capable of taking up. After treatment the piles should be handled in such a manner as to avoid tearing the wood or abrazing it in any way that will weaken or break through the treated area, and they should not be cut or bored below high water mark, the idea being to present to the Teredo a perfect and impervious armor of creosoted material without holes or weak spots. When such protection can be obtained it is probable that it will successfully prevent the embryonic Teredo from getting a start. However, if there are weak spots in the armor the borers will find them and when once started they have sufficient vitality to continue boring on into the creosoted wood no matter how thorough the treatment.

As it is impossible to secure perfect material, perfect treatment and perfect handling the creosoting process as ordinarily applied can be considered as effective only in greatly retarding the action of the Teredo. At points on the Gulf and Pacific Coasts where it is most active users of piles have sometimes found it inadequate and have usually applied additional mechanical protection.

Creosote so far has not been found to stop the attacks of Limnoria. On the most carefully treated specimens of pile south of Norfolk on the Atlantic Coast, the Gulf Coast and on the Pacific Coast their action is noticed after three to six years, probably as soon as the creosote has lost some of its toxic properties through leaching, and when once started their action progresses rapidly.

In view of this experience, at points on the South Atlantic, Gulf and Pacific Coasts, where the borers are very active, it is the practice of many who desire to insure a greater permanence of protection to piles in important structures to apply mechanical protection to the piles in addition to creosoting and it is the purpose of this report to describe the most generally used of these methods.

Piles that receive mechanical protection are creosoted in addition in order to prevent decay above the water and also retard the attacks of borers until repairs can be made in case the mechanical protection becomes damaged.

4. Some of the methods of mechanical protection against Marine Borers are as follows:

(A) Cast Iron Cases

These cases which are shown in Fig. 1 have been used at points on the Gulf for many years. The cast sections are made in halves so that they can be placed in position after the piles have been driven and capped. As the castings are bolted together the casing is lowered to the mud line and forced down into the mud. The space between the case and pile is usually filled with sand and capped with cement mortar to prevent the

Fig. 1—Cast Iron Protection on Louisville & Nashville Railroad.

sand being washed out by the waves. This protection is entirely efficient as long as the jacket remains intact. Cast iron corrodes very slowly in sea water and if made thick enough will resist corrosion a great many years. Some of these cases at points on the Gulf have been in position about thirty years. Care must be observed that the cases go far enough into the mud so that the piles will not be uncovered by the washing away of the mud, or by dredging operation. In this event the sand escapes and the entire pile is exposed to a current of sea water and then to attack by the borers.

It is stated that the borers will not live behind these cases even though the sand filling be omitted, but it is assumed that they must be closed at the bottom tightly enough to cut off the food supply of the borer.

At present prices of cast iron these cases are almost prohibitive in cost.

(B) Vitrified Pipe Cases

In locations not exposed to wave action and the pounding of drift vitrified pipe can be substituted for cast iron. It does not corrode, but is easily broken.

The pipe sections are preferably in one piece and placed over the pile before it is capped. The sections are cemented together, lowered to the bottom and forced into the mud. The space between the case and the pile is filled with sand and capped with cement mortar.

This protection has been much used along the Gulf and Pacific Coast, where full length protection is necessary, and is entirely efficient as long as it remains intact. Any defects in the case below the water will be shown by the escaping sand and any broken pipe sections can be easily replaced. It is the custom in maintaining these cases to make inspections and repairs about once a year. The borers will not have gained sufficient headway in creosoted timber in that length of time to cause trouble.

Fig. 2—Vitrified Pipe Casings.

For protecting piles after they have been capped, or for making renewals, the pipe sections are made in halves and are joined together with some form of lock or copper wire, or treated wooden plugs.

Fig. 2 shows piles protected by vitrified pipe cases. These sections are in halves and are wired together with No. 5 copper wire. The joints in the case were coated with pitch and the space about the pile filled with sand and capped with cement.

(C) Reinforced Concrete Cases

Cases less fragile than vitrified pipe and less expensive than cast iron can be made of reinforced concrete. See Fig. 3.

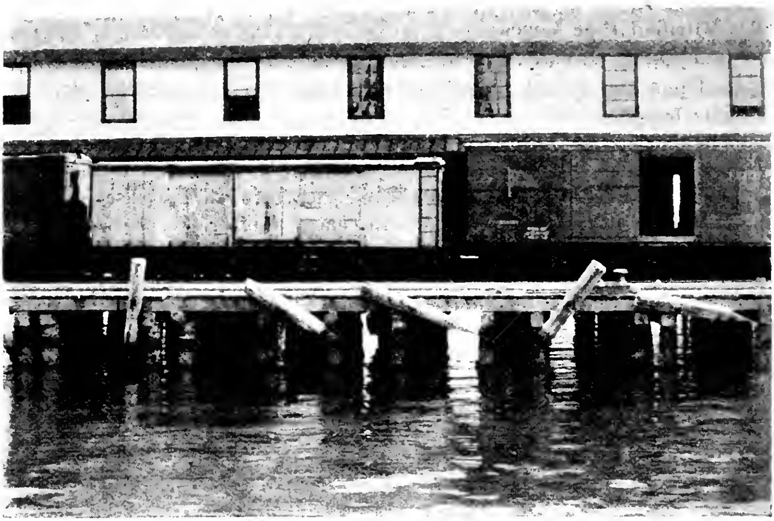


Fig. 3—Concrete Casings.

The sections can be made in one piece for placing before the pile is capped, or in halves for placing afterward. One of the designs provides for a lock by leaving some of the reinforcing wires projecting so that they can be twisted together and covered with cement mortar after the halves have been joined. For these cases the concrete casing over the reinforcement is rather thin, and there is some question whether the reinforcement will corrode and the cases go to pieces under the action of sea water. Service tests are needed to develop this point.

Methods A, B and C afford full length protection, which can be placed at any time after the piles have been driven.

(D) Concrete Jackets Cast in Place

Considerable protection work has been done of late in Charleston, S. C., waters by casting concrete jackets in place about the piles. In these waters the Teredo is less active than at points on the Gulf, and is successfully controlled by careful creosoting. The Limnoria is very active and will finally cut off creosoted piles at about low water mark. It does not seem to work progressively on treated piles at depth greater than two feet below low water mark, although piles that have been pulled show traces of attack in isolated patches all the way to the mud line.

Under these conditions, protection for a length of about ten feet, extending from about three feet below low water to about two feet above high water, is efficient. Some of these jackets are plain concrete and some are reinforced.

The reinforced jackets have been applied as follows:

Six-penny nails were driven into the piles in rings, the nails being about 6 inches apart, and the rings about 18 inches apart. They were left projecting about 3 inches and extended the length of the jacket. The reinforcement was No. 10 gage iron wire and was twisted around the nails. It was placed in two directions, both along and around the pile, and located about 1½ inches from the pile. The form was of ⅛-inch wood veneering placed around the piles, resting against the heads of the nails and bound with wire. This veneering came in lengths of about four feet and when one length was filled with concrete another was added and the jacket carried to the top. The form stretched sufficiently to allow the mortar in most cases to cover the heads of the nails. 1-2-4 concrete was used with ¾-inch stone. No great difficulty was found in placing the concrete. Most of the jackets were on piles exposed to the mud at low water, and the jackets were carried down to and into the mud. Where the water was deep the forms were carried about 3 feet below low water and bagging placed about the bottom to keep the mortar from running out. This feature is very important, for unless the bottom of the form is carefully stopped, the mortar will leak out and a failure will result.

A lot of these jackets were placed in 1915 and have not shown any sign of failure, except in a few cases the concrete has broken away at the bottom—due possibly to a leaky stop at the bottom of the form. They have been carefully watched for signs of corrosion in the reinforcement, but no corrosion has been evident. The work of protecting piles in deep water should be performed in warm weather, as it is necessary for the workman to be working in the water much of the time.

Casting the concrete jacket in place has the advantage of restoring in a measure the strength of the pile, even though its section may have been reduced materially.

When it is necessary to work around bracing attached to the piles the advantage of the use of the veneering for the form is considerable, as it can be easily cut to fit the obstructions. Where there is much pounding from drift or bending in the piles, or if it is desired to strengthen as well as to protect them, the jackets should probably be reinforced, but it is certain that if the reinforcement can be omitted the work can be done much cheaper and generally better concrete will be obtained.

On a protecting job now going on in Charleston jackets of plain concrete are being used. These are about 3 inches thick and the concrete is 1-2-4 mix with fine aggregate. The forms are No. 24 gage galvanized iron, the sheet being wide enough to form a complete section. The two edges are nailed to wooden strips about 2½ inches square, one of which has a tongue and the other a groove. The sheets are placed around the pile and the wooden strips clamped together. A tight, smooth concrete form is obtained. These forms are made in different sizes and lengths to fit the different sized piles and different depths of water. By using forms made in this way concrete jackets have been carried as much as 12 feet below low water, and it was evident when examined by a diver that good results had been obtained. The general experience is, however, that it is not safe to trust to concrete that is deposited in more than 3 or 4 feet of water.

When it is possible to pump out the form good concrete can be placed at greater depths.

(E) Gunite

In 1919, near Seattle, Washington, a large number of piles were coated with Gunite. Your Committee has this work under observation, but it is too soon to report on the success of this particular job.

If the Gunite coating proves durable it possesses certain advantages, as it can be quickly applied and should be comparatively cheap.

(F) Nails

The oldest method of protection of which we have knowledge is studding the exposed surface with nail heads. This was practiced by the Romans to protect against the Teredo and the method has been used in European waters for centuries.

Its virtue does not seem to lie entirely in covering the exposed surface with nail heads, but is still effective when not more than one-fourth the surface is covered by the heads.

Several plain piles studded with nails were driven about 2½ years ago in Charleston harbor. The nails have heads about ¼ inch in diameter and are driven ½ inch to ¾ inch apart. The piles are entirely free from attacks by borers, whereas a plain pile without the nails driven at the same time has been reduced at low water line by the action of the Limnoria from about 10 inches to about 5 inches in diameter.

Some tests of these nails have been made by the New York Dock Department, but it seems that elsewhere this method has not received the attention and study it deserves, and your Committee suggests that the Association arrange to have some service tests made. It is anticipated, however, that the work of applying the protection would be found rather expensive.

(G) Sheet Metal

Sheets of copper and zinc have been used with success in many places for protection against marine borers. This protection is entirely efficient as long as it remains intact. However, full length protection must be applied before the pile is driven and it is likely to be broken in handling. Copper is not affected by salt water, but zinc soon corrodes. It is stated that some of the brands of rust-resisting sheet iron will withstand the action of sea water for several years, and it is possible that that material could be used to advantage under some conditions rather than copper, which is too expensive.

(H) Coatings of Tar, Asphalt, Etc.

Many attempts have been made to provide a durable protection by applying coatings of tar or asphalt either alone or combined with some fabrics. These coatings are efficient as long as they can be kept intact, but they are likely to be broken by handling, or by the pounding of drift, and they have in general proved unreliable.

(I) Bark

Bark left on piles will protect against Marine Borers, therefore, when plain piles are used in infested waters their life can generally be strengthened by leaving the bark on.

Fig. 3 shows untreated fender piles that have been destroyed by borers. At this particular dock piles with bark will resist the Teredo for about one year, while piles without bark are destroyed within one to three months.

Conclusions

(a) That when piles are used in important structures, in infested waters where the best known protection is desired, they should receive in addition to a thorough treatment with creosote oil some form of mechanical protection best adapted to the conditions.

(b) That generally at points on the Gulf and Pacific Coasts creosoted piles should have full length mechanical protection, like A, B or C, to assure protection against Limnoria as well as Teredo.

(c) That generally at points on the Atlantic Coast creosote treatment will stop the Teredo, but that mechanical protection like D is necessary to resist the Limnoria.

Recommendations for Next Year's Work

(a) That Gunite protection be observed further.

(b) Make tests with Gunite applied to piles before driving.

(c) Make tests with Teredo nails.

(d) Make tests with rust-resisting sheet iron.

(e) Develop whether piles that are to have full length mechanical protection may have a lighter treatment of creosote.

(f) Make service tests of reinforced concrete cases.

REPORT OF COMMITTEE VII—ON WOODEN BRIDGES AND TRESTLES

W. H. Hoyt, *Chairman;*
H. Austill,
F. C. Baluss,
C. H. Blackman,
M. J. Connerton,
H. J. Hansen,
H. T. Hazen,
C. S. Heritage,
E. M. Lewis,
A. O. Ridgway, *Vice-Chairman;*
J. B. Maddock,
L. A. Murr,
D. W. Smith,
L. L. Sparrow,
G. C. Tuthill,
A. M. Van Auken,
S. L. Wonson,
Committee.

To the American Railway Engineering Association:

The following subjects were assigned for consideration of Committee VII during the past year:

1. Make thorough examination of the subject-matter in the Manual, and submit definite recommendations for changes.

2. Continue study and report on general specifications and classification and grading rules for timber and lumber for railroad purposes.

3. Report on specifications for timber to be treated with a preservative substance, conferring with Committee on Wood Preservation.

4. Make detail study of various types of wooden trestles with a view to recommending two or three standards adaptable for general railway use.

Committee VII has held but one meeting during the past year and this was called at the Association Rooms in Chicago, Saturday, October 30th, 1920. At this meeting reports of the various sub-committees were submitted and details of the work considered, plans for Annual Report made and future work of the Committee given consideration.

Four sub-committees reported to the main Committee as follows:

Sub-Committee No. 1, A. O. Ridgway, Chairman, reported on "Revision of Manual" as follows:

Revision of Manual

Definitions.

(Present Text)

Shim.—A small piece of wood or metal placed between two members of a structure to bring them to a desired elevation.

(Revision)

Shim.—A small piece of wood or metal placed between two members of a structure to bring them to a desired relative elevation.

Use of Guard Rails and Guard Timbers for Wooden Bridges and Trestles.

(Revision)

Eliminate hyphen between the words "guard" and "rail" wherever used in this section.

(Present Text)

(2) It is recommended that the guard timber and the inner guard-rail, when used, shall be so spaced in reference to the track rail that the rear truck will strike the inner guard-rail without striking the guard timber. The inner guard-rail should not be higher or more than one inch lower than the running rail.

(Revision)

(2) It is recommended that the guard timber and the inner guard rail, when used, shall be so spaced in reference to the track rail that the derail truck will strike the inner guard rail without striking the guard timber. The inner guard rail should not be higher or more than one inch lower than the running rail.

Use of Lag Screws in Trestle Construction.

(Revision)

Substitute figures for letters in designation of paragraphs throughout the section.

(Present Text)

(d) Use of lag screws renders unnecessary the dapping of guard timbers, and therefore decreases cost of trestles without impairing quality.

(Revision)

4. Use of lag screws renders unnecessary the dapping of guard timbers, and therefore decreases cost of trestles without impairing quality.

(Present Text)

(f) For proper application of lag screws, holes in guard timbers should be bored with auger bits $\frac{1}{16}$ in. less in diameter and holes in ties ¼ in. less in diameter than the normal size of lag screws used.

(Revision)

6. For proper application of lag screws, holes in guard timbers should be bored with ouger bits $\frac{1}{16}$ in. less in diameter and holes in ties ¼ in. less in diameter than the nominal size of lag screws used.

Specifications for Workmanship for Pile and Frame Trestles to Be Built Under Contract.

(Present Text)

2. The work to be done under these specifications covers the driving, framing and erection of a..................track wooden trestle about ....feet long and an average................feet in height.

(Revision)

2. The work to be done under these specifications covers the construction of a................track wooden trestle about................ feet long and an average of................feet high.

(Present Text)

20. Sway bracing shall be properly framed and securely fastened to piles or posts. When necessary, filling pieces shall be used between the braces and the piles of a bent on account of the variation in size of piles, and securely fastened and faced to obtain a bearing against all piles.

(Revision)

20. Sash and sway bracing shall be properly framed and securely fastened to piles or posts. When necessary, filling pieces shall be used between the braces and the piles of a bent on account of the variation in size of piles, and securely fastened and faced to obtain a bearing against all piles.

(Present Text)

22. Girts shall be properly framed and securely fastened to caps, sub-sills, posts or piles, as the plans may require.

(Revision)

22. Girts shall be properly framed and securely fastened to caps, sub-sills, intermediate sills, posts or piles, as the plans may require.

(Present Text)

23. Stringers shall be sized to a uniform height at supports. The edges with most sap shall be placed downward.

(Revision)

23. Stringers shall be sized to a uniform depth at supports. The edges with most sap shall be placed downward.

(Present Text)

26. Timber guard rails shall be framed as called for on the plans, laid to line and to a uniform top surface. They shall be firmly fastened to the ties as required.

(Revision)

26. Guard timbers shall be framed as called for on the plans, laid to line and to a uniform top surface. They shall be firmly fastened to the ties as required.

Your Committee recommends the adoption of foregoing recommendations in regard to Revision of Manual.

Sub-Committee (2), W. H. Hoyt, Chairman, was allotted the second subject, covering "Specifications and Classification and Grading Rules for Timber and Lumber for Railroad Purposes." Report of this subcommittee is given in Appendix B.

During the past year Sub-Committee (2) has continued its study of specifications and classification of timber. Much correspondence has been carried on with the National Association of Lumber Manufacturers; with the Forest Products Laboratory at Madison, and various other interested parties. A study has been made of the specifications submitted this year by the American Society for Testing Materials, and our report embodies the best features of all the information obtainable. Your Committee recommends the adoption and the publication in the Manual of its report as submitted in Appendix A.

Sub-Committee (3), C. S. Heritage, Chairman, submitted its report on "Specifications for timber to be treated with a preservative substance" and the same has been included in the "Specifications and Classification and Grading Rules" as given in Appendix A. The adoption of Appendix A will also adopt report of Sub-Committee (3).

Sub-Committee (4), A. M. Van Auken, Chairman, was allotted the work suggested under item 4, viz., "Make detail study of various types of wooden trestles with a view to recommending two or three standard types adaptable for general railway use."

This sub-committee commenced work on June 7th and requests were sent out calling for plans of trestles in use on various roads. Communications were also sent to many Bridge Engineers seeking their views, and to various individuals and concerns in a position to give advice concerning available supplies of suitable timber, in response to which a large number of blueprints and many helpful letters were received.

Two meetings of this sub-committee were held, the first at Nashville, Tenn., on July 31st and the second at Chicago, Ill., on October 29th, 1920. A detailed report of the work of this sub-committee is submitted as a progress report in Appendix B.

Recommendations for Next Year's Work

This Committee recommends for next year's work the following subjects:

1. Revision of Manual.
2. Make detailed study of various types of wooden trestles with a view to recommending two or three standards adaptable for general railway use. Include study of multiple story frame trestles and ballast deck trestles.
3. Make study and report best method of fire-proofing wooden bridges and trestles.

Respectfully submitted,

THE COMMITTEE ON WOODEN BRIDGES AND TRESTLES,

W. H. HOYT, *Chairman.*

Appendix A

STUDY OF VARIOUS TYPES OF WOODEN TRESTLES WITH A VIEW TO RECOMMENDING TWO OR THREE STANDARDS ADAPTABLE FOR GENERAL RAILWAY USE

The question was raised early in our work, as to the available supplies of timber suitable for trestles and we submit information from the Forestry Bureau and National Lumber Manufacturers Association:

Forestry Bureau places supply of old timber, not once cut over, as follows:

Southern Yellow Pine	139 Billion ft. B.M.
Douglas Fir	560 Billion ft. B.M.

The National Lumber Manufacturers Association reports as follows:

Douglas Fir	595 Billion ft. B.M.
Southern Yellow Pine	258 Billion ft. B.M.
Oak	157 Billion ft. B.M.
Cypress	23 Billion ft. B.M.

Advices from Southern mills are that there will be no difficulty in securing sixteen inch timber as long as yellow pine is sawed commercially, and that prices will continue to be fixed by the market price of commercial lumber into which it can be sawed.

The sub-committee was unable to agree upon loading classification of trestles and the matter was referred to the main committee which approved the following:

Light loading	Cooper's E-45
Medium loading	Cooper's E-55
Heavy loading	Cooper's E-65

Another question leading to much discussion was that of allowable stress. The stresses shown in the table in the Manual were excellent when adopted, but with the more concise definitions of timber and the increased knowledge of its strength, it should be possible to improve it. The table on page 362 of Bulletin No. 225 is a move in this direction.

Two tables accompany this report. The first gives most of the data concerning the plans submitted to us by the different Railroad Companies. The second, prepared for the Committee by Mr. W. E. Hawley, Assistant Engineer, Duluth, Missabe & Northern Railway, is an analysis of these designs. We wish to call attention to these designs, which are in use and apparently carrying traffic safely, and yet how far they are from complying with the stresses given in the table on page 362 of Bulletin 225, especially in regard to horizontal shear.

Railroad	Pile Bent				Frame Bent										Dump Bent			Open Deck						Ballast Deck									Remarks
	Piles	Caps	Brace		Posts		Caps	Sill	Brace		Long Brace		Mud Sills		Piles	Caps	Dirt Pl	Panel	Stringers		Ties	Guards		Piles	Caps	Panel	Stringers		Floor	Guard	Piles	Post	
	No	Size	Size	How Fastened	No	Size	Size	Size	Size	How Fast'd	Size	How Fast'd	No	Size	No	Size	Size	Long	No	Size	Size	Size	Frame	No	Size	Long	No	Size	Size	Timber			
Atchison, Topeka & S Fe	5	12"x14"x14	3"x10"	Bolted	5	12"x12"	12"x14"x14	12"x12"	3"x10"	Bolted					4	12"x14"x14		14	6	7"x16"	6"x8"x9'	7"x8"				14							
	6	12"x14"x14	3"x10"	"	6	12"x12"	12"x14"x14	12"x12	3"x10"		6"x10"	Framed						14	8	7"x16"	6"x8"x9'	7"x8"				14	12 6	8"x14" 10"x10"	None	6"x16"			
																										14	8 6	12"x12" 10"x10	"	7"x16"			
Atlantic Coast Line	4	12x12x12	3"x8"	Bolt & Spike	4	12"x12	12x12x12	12"x12	3"x8"	Bolt & Spike								10'	6	7"x14	7"x8"x10	6"x8	Dapped			10	11	6"x14	3"x9"x14'	8"x8"			Ties are notched over Stringers
	6	12"x12"x14	3"x8"																														
Baltimore & Ohio	4	12"x12"x12"	3"x10"	Bolted	4	12"x12	12"x14"x12	12"x12"	3"x10	Bolted	3"x10"	Bolted	10	12"x12"x4'	4	12"x14"x12"		12'	6	8"x16	8"x8"x9	6"x8	Dapped										
Canadian Northern	6	12"x14"x14"	3"x10	B & S	6	12"x12"	12"x14"x14	12"x12"	3"x10	Spiked	5"x8"	Bolted & Framed						14'-9"	8	10"x18"	8"x8"x12	8"x8"	"										
Canadian Pacific	4	12"x16"x14"	3"x10"	B & S	4	12"x12	12"x16"x14	12"x12"	3"x10"	Bolted								14'-6"															
	5	12"x16"x14	3"x10"	"															6	10"x18"	8"x8"x12'	6"x8	Dapped										
Central of Georgia	4	12"x14"x13	3"x10"	"	4	12"x12"	12"x14"x13	12"x12"	3"x10	B & S	6"x8"	Bolted		12"x12"x5'				12' 6"	6	7½"x15"	8"x8"x10'	6"x8	"			13' 6"	10	7"x16"	3"x8"x14'	6"x8	6		
	5	14"x14"x13"	3"x10"	"														12' 6"	6	8"x16"	8"x8"x10'	6"x8	"										
Central of New Jersey	10	12"x14"x28	3"x10"	"											8	12"x14"		12'	6	8"x16	8"x8"x10	6"x8	"										
Dbl.	10	12"x14"x28	3"x10"	B & S														12'	6	10"x16"	8"x10"x14	6"x8"	Dapp.										Study
Chesapeake & Ohio	4	12"x12"x12"	3"x10"	B & S	4	12"x12	12"x12"x12	12"x12"	3"x10"	B & S	3"x10"	Spiked						12'-6"	4	9"x16"	8"x8"x10'	7"x8	Dapp										
Duluth, Missabe & Northn	6	12"x16"x14													6	12"x14"x14	3"x10"	15'-9"	6	9"x18"	8"x8"x12'	8"x10	"										
Chicago & Northwestern	5	14"x14"x16	4"x10"	B	5	12"x12	14"x14"x14	12"x12"	4"x10"	B	4"x10"	Bolt						16'	6	8"x16	8"x8"x10'	4"x10											
	5	16"x14"x14	4"x10"	B	5	12"x12"	14"x14"x14"	12"x12"	4"x10"	B	4"x10"	Bolt.						13	6	8"x16"	8"x8"x10'	4"x10											
Chi Burlington & Quincy	5	14"x14"x14"	4"x10"	B	4	12"x12"	14"x14"x14"	12"x14"	4"x10"	B	4"x10	Bolt.					8"x16"	14'	8	8"x16"	8"x8"x10'	6"x8"	Dapp.			13'-6"	11	8"x16"	3"x10"x14'	6"x8"	6		
Chicago Great Western	5	12"x14"x12"	3"x10"	B											5	12"x14"	3"x10"	14'	6	8"x16	8"x8"x9	6"x8	"										
	6	12"x14"x16"	3"x10"	B																						13'-6"	2 8	6"x16" 8"x16"	3"x8"x14'	8"x8"	6		
Chicago, Indpls & Louisville	(See below) 5	12"x14"x14	3"x10"	Sp	4	12"x12"	12"x14"x14'	12"x12"	3"x10"	Sp					4	12"x12"x14'		16'	6	8"x16"	7"x8"x9'	6"x8	Dapp.										Corbel
Chi. Milwaukee & St. Paul	5	12"x14"x14	3"x12"	B & S											4	12"x14"x14'		16'	6	8"x16"	6"x8"x10'	6"x8"	"	4		16'	13	8"x16"	4"	8"x10"			
	5	14"x14"x14'	3"x12"	B & S														16'	6	10"x16"	8"x8"x10	6"x8"	"	4		14'	13	8"x16"	4"	8"x10"			
	5	14"x14"x14	3"x12"	B & S	5	12"x12"	12"x14"x14'	12"x12"	3"x12"			3"x12"						16'	6	10"x18"	8"x8"x10'	6"x8"	"	5		15'	4 8"x10" 10 10"x18"	8-8"x10" 12-8"x18"	None	8"x8"			Study
Chi Rock Is. & Pacific	4 5	12"x14"x14"	3"x10"	B														14'	6	7"x16"	8"x8"x9'	4"x8"				14	11	8"x16"	3"x10"x14	6"x8"	6		
	5 6	12"x14"x14"	3"x10"	B														14'	8	7"x16"	8"x8"x9'	4"x8"											
C C C. & St Louis	4	12"x14"x12"	3"x10"	B														12'	6	8"x16"	8"x8"x10	6"x8"											
Denver & Rio Grande	5	14"x14"x14"	3"x12"	S	6	10"x14"	14"x14"x14'	14"x14'	3"x12"	S	6"x12"	B						16'	8	8"x18"	8"x8"x10'	6"x8	D										
Duluth & Iron Range	6	12"x14"x16"	3"x12"	S														11'-6"	6	8"x16"	6"x8"x12'	8"x10"	"										
El Paso & Southwestern	5	14"x14"x14"	3"x10"	B																						14	10	8"x16"	3"x12"x13'	6"x8"	5		
Erie	5	12"x14"x14'	3"x10"	B	4	12"x12	12"x12"x12'	12"x12"	3"x10"	B	3"x10"	B						12'	6	8"x16	8"x8"x9'	5"x8"	D										
Grand Trunk	6	12"x14"x14'	3"x10"	B														12'	6	8"x16"	10"x10"x13'	8"x8"	—										
Grand Trunk Pacific	5	12"x14"x12"	3"x10	B														14'	6	9"x18"	8"x8"x10'	6"x8"											
Great Northern	6	14"x14"x14'	3"x10"	B & S	6	12"x12"	12"x12"x12'	12"x12"	3"x10"	B & S	6"x8"	B						14'	6	10"x18"	8"x8"x10'	6"x8"	D										
Hocking Valley					5	12"x12"	12"x14"x12"	12"x12"	3"x10"	B			12	12"x12"				14	8	8"x16"	6"x8"x9'	6"x8"		5		14	10	"x16"	3"	6"x8"			Study
Illinois Central	6	12"x14"x12	3"x10"	B														14	8	7"x16"	6"x8"x10	6"x8"	D			13	12	7"x16"	3"x8"x14'	6"x8"			

International & Gt Northern	6	12"x14"x14	3"x10"	B												
Kansas City Southern	5	12"x12"x14	4"x10"	.	4	12"x12"	12"x14"x14	12"x12"	4"x10	B	7"x8"	F&B				
Lehigh Valley	4	12"x12"x14	3"x12"	B	4	12"x12"	12"x12"x14	12"x12"	3"x12"	B	3"x12"	B				
Louisville & Nashville	6	14"x16"x13	3"x10"	B&S												
Michigan Central	5	12"x14"x16	3"x10	B												
		12"x14"x14														
Minneapolis & St Louis	5	12"x14"x14	3"x12"	B&S	4	12"x12"	12"x14"x14	12"x12"	3"x12"	B&S	4"x9	S				
	6	12"x14"x14	3"x12"	-												
Missouri, Kansas & Texas	5	12"x14"x14	3"x10"	B							3"x10"	B				
Missouri Pacific	4	14"x14"x14	3"x10"	B	4	12"x12"	12"x12"x14	12"x12"	3"x10"	B	4"x8"	B			5	14"x14"x14
	5	14"x14"x14	3"x10"	B												
	6	14"x14"x14	3"x10"	B												
Mobile & Ohio	4	12"x14"x12	3"x10"	B												
Nashville, Chatt. & St Louis	6	12"x14"x14	4"x9"	B							4"x9"	F&B				
New York Central	4	12"x12"x12	3"x10"	B	4	12"x12"	12"x12"x14	12"x12"	3"x10"	B	3"x10"	B				
	5	12"x14"x14	3"x10"	Sp												
New York, N.H. & H	6	12"x12"x12	3"x10"													
New York, C & St Louis					4	12"x12"	12"x12"x12	12"x12"	4"x10"	B	5"x10"	F&B				
Norfolk & Southern	5	12"x12"x14	3"x10"	S	4	12"x12"	12"x12"x14	12"x12"	3"x10"	S	3"x12"	B			4	12"x12"x12
Norfolk & Western					4	12"x12"	2-6"x12"x12	2-6"x12"	2"x10"	S	3"x12"	B		6"x12		
Northern Pacific	5	14"x14"x14	3"x10"	B	5	12"x12"	12"x12"x14	12"x12"	3"x10"	B	6"x10"	F&B			4	12"x12x14
Pennsylvania					4	12"x12"	12"x12"x13	12"x12"	3"x10"	B	3"x10"	B				
	✓See above															
Chicago Indpls & Louisville	6	14x16"x16	3"x10"	B	6		14x16"x16		3"x10"	B						
Pere Marquette	4	12"x14"x14	3"x10"	B	5	12"x12"	12"x12"x14"	12"x12"	3"x10"	B						
	5	12"x14"x14	3"x10"	.		.	.	.	.	.						
San Antonio & Aransas Pass	4	12"x12"x12	3"x10"	B&S												
St Louis & San Francisco	5	14"x14"x14	3"x10"	B	5	12"x12"	12"x14"x14"	12"x12"	3"x10	B&S	6"x10"	B			4	14"x14"x14"
	6	14"x14"x14	3"x10"	B												
St Louis & Southwestern	5	12"x14"x14	4"x10"	B	5	12"x12"	12"x14"x14	12"x12"	4"x10"	B						
Seaboard Air Line	5	12"x14"x12"	3"x8"	B&S	5	12"x12"	12"x14"x12"	12"x12"	3"x8"	B&S	3"x8"	B				
Southern	4	12"x12"x13	3"x10"	B	4	12"x12"	12"x12"x13	12"x12"	3"x10"	B	3"x10"	B				
Southern Pacific	5	12"x14"x12"	4"x8"	B	5	12"x12"	12"x14"x12	12"x12"	4"x8"	B						
Union Pacific	5	12"x14"x12	4"x8"	B	5	12"x12"	12"x14"x12	12"x12"	4"x8"	B						
Wabash	4	12"x14"x12"														
	6	12"x16"x12	3"x10"	B	6	12"x12"	12"x16"x12	12"x12"	3"x10"	Br	3"x10"	Br		8"x16"x4	4	
Wheeling & Lake Erie	6	12"x14"x14"	3"x10"	B											5	

International & Gt Northern		14	6	7½"x15	7"x9"x9"	7"x9"	D										
Kansas City Southern		14-6"	6	8"x16	7"x8"x10	7"x8"	D			14-6"	11	8"x16"	4"x10"x14				
Lehigh Valley		11	6	8"x16"	8"x8x10	6"x8"	D										8"x10"x4 Corbels
Louisville & Nashville		12	6	8"x16"	8"x8"x10	6"x8"	D			12"	12	6½"x16"	4"x10"x16	6"x8"	6		
Michigan Central		15	10	8"x16"	7"x9"x12	6"x8"				13-6"	11	8"x18"	4"x12"x14	6"x8"	6		
Minneapolis & St Louis		13-9"	6	8"x16"	8"x8"x10	6"x8"	D										
Missouri, Kansas & Texas	4"x12"	14	8	7"x16"	7"x8"x9	6"x8"	D										
Missouri Pacific		13-9"	6	8"x16"	7"x8"x9"	6"x8"	D										
		13-9"	6	8"x16"	7"x8"x9"	6"x8"	D										
		11-9"	6	8"x16"	7"x8"x9"	6"x8"	D										
Mobile & Ohio		12-6"	6	7"x16"	7"x9"x9"	5½"x6½"					8	8"x16"	5"x9"x14	5"x9"	6		
Nashville, Chatt. & St Louis																	
New York Central		12"	6	8"x16"	6"x8"x10	5"x8"	D										
		13'	6	9"x18"	8"x8"x10	8"x8"	D										
New York, N.H. & H		10	6	8"x16"	8"x8"x11	6"x8"	D										
New York, C & St Louis		15	6	9"x18"	7"x8"x9"	6"x8"	D										
Norfolk & Southern	3-3x10	12'-6"	6	8"x16"	7"x8"x9"	7"x8"	D										
Norfolk & Western		12'-6"	6	8"x16"	8"x10"x10	6"x8"	D										Corbel
Northern Pacific		15'	6	9"x18"	8"x8"x12	6"x8"	D										
Pennsylvania		10 12	4 6	10"x18" 8"x16"													12' Span-6 Strs 8"x16" or 6 " 10"x18" 18' Span-6 Strs 10"x16" or Steel
		14	6	10"x16"													
Chicago Indpls & Louisville		16	8	9"x18"	8"x8x10"	6"x8"	D										Corbel
Pere Marquette		14	6	8"x16"	8"x8"x10"	6"x8"	D			13'	2 7	6"x16" 8"x16"	3x12"x12"	6"x8"	6	5	
		14'	2	6"x16"													
San Antonio & Aransas Pass		13"	6	7"x16"	6x8"x8"	6"x8"	D										
St Louis & San Francisco		14'	6	8"x16"	6"x9"x9"	6"x8"	D	5									
		14'	8	8"x16"	6"x8"x9"	6"x8"	D										
St Louis & Southwestern		13-10"	6	7"x16"	7"x8"x10	7"x8"	D	6		13-6"	14	7"x15"	3"x12"	6"x8"			
								5		15-6"	12	7"x15"	3"x12"	6"x8"			
Seaboard Air Line		12-6	8	7x14"	6x8"x9	5"x8"	-			12-6"	25	6x12"	None	4"x6	5		
Southern		13-6"	6	7"x16"	8"x10"x11	8"x8"	D			13-6"	6 13	8"x10" 10"x14"	None	None	6		
Southern Pacific		15	8	8"x17"	8"x8"x9	5"x8"	D			15'	12	8x17"	3"x12"x15	4"x6"	5		
Union Pacific		15	8	8x17"	8x8"x9	5"x8"	D										
Wabash																	
	3-6"x16'	14	8	8"x16"	8"x8"x9"	6"x8"	D										
Wheeling & Lake Erie		14	8	9"x18"	8"x8"x10"	6"x8"	D										

Revised Oct 28th 1920

Comparisons of Stringer Designs for Wooden Trestles

Reference Number of Railway using Stringers	Span: Line No.	Span: Length l (Ft. In.)	Span: l^3	Span: Coefficient of Span for Max. Mom.	Span: Coefficient of Span for Max. Shear	Design of Chord of Stringers: Number of Lines	Design: Nominal Size of Timber (Inches)	Design: Timber Measure (Bd. Ft. per Ft.)	Design: Actual Size of Timber (Inches)	Design: Total Width b (Inches)	Design: Total Area bh (Sq. In.)	Design: Section Modulus $s=\frac{bh^2}{6}$ (In.³)	Design: bh^3 (In.⁴)	Ratios: End Bearing Width to Span Length $\frac{b}{l}$	Ratios: Cross Sect. Area to Span Length $\frac{bh}{l}$	Ratios: Section Modulus to Span Length $\frac{s}{l}$	Ratios: Coefficient for Deflection $\frac{l^3}{bh^3}$	Ratios: Moment Coef. to Sect. Mod.	Ratios: Shear Coef. to Cross Sect.	Bending: Stress per sq. in. from E40	Bending: E50	Bending: E60	Bending: Cooper's Rating at 1200 lb per sq. inch	Longitudinal Shear: Stress per sq. in. from E40	Longitudinal Shear: E50	Longitudinal Shear: E60	Longitudinal Shear: Cooper's Rating at 110 lb per sq. inch	Compression Across Grain: Stress per sq. in. from E40	Compression Across Grain: E50	Compression Across Grain: E60	Compression Across Grain: Cooper's Rating at 310 lb per sq. inch	Line No.
(4)	1	10-0	1000	2.5000	1.5000	3	7 × 14	24 1/2	6 3/4 × 13 1/2	20 1/4	273.38	615.09	49823	2.0250	27.34	61.51	.02007	.00406	.00549	975	1219	1463	47.5	165	206	247	24.5	168	210	252	72.1	1
(57)	2	10-0	1000	2.5000	1.5000	2	10 × 16	26 2/3	9 3/4 × 15 1/2	19 1/2	302.25	780.81	72614	1.9500	30.23	78.08	.01377	.00320	.00496	768	961	1153	60.6	149	186	223	27.2	165	218	262	69.2	2
(52)	3	10-0	1000	2.5000	1.5000	3	8 × 16	32	7 3/4 × 15 1/2	23 1/4	360.38	930.97	86580	2.3250	36.04	93.10	.01155	.00269	.00416	644	806	967	72.5	125	156	187	32.6	146	183	220	82.7	3
(39)	4	11-0	1331	3.2500	1.6363	3	8 × 16	32	7 3/4 × 15 1/2	23 1/4	360.38	930.97	86580	2.1140	32.76	86.33	.01537	.00349	.00454	838	1047	1257	55.5	136	170	204	29.7	160	200	240	75.7	4
(29)	5	11-6	1521	3.6250	1.6956	3	8 × 16	32	7 3/4 × 15 1/2	23 1/4	360.38	930.97	86580	2.0220	31.34	79.23	.01757	.00389	.00471	935	1168	1402	49.6	141	176	212	28.6	166	207	248	72.9	5
(47)	6	11-9	1622	3.8125	1.7234	3	8 × 16	32	7 3/4 × 15 1/2	23 1/4	360.38	930.97	86580	1.9787	30.67	79.23	.01874	.00410	.00478	983	1229	1474	47.2	143	179	215	27.3	144	180	216	86.3	6
ST'D FOR E45 ( )	7	12-0	1728	4.0000	1.7500	3	7 × 16	28	6 3/4 × 15 1/2	20 1/4	313.88	810.84	75408	1.6875	26.16	67.57	.02291	.00493	.00558	1264	1580	1896	38.8	167	209	251	23.7	196	245	284	61.2	7
(50) (52) (31) (27) (6) (12)	8	12-0	1728	4.0000	1.7500	3	8 × 16	32	7 3/4 × 15 1/2	23 1/4	360.38	930.97	86580	1.9375	30.03	77.58	.01996	.00430	.00486	979	1223	1468	44.8	147	182	218	27.6	171	214	256	70.6	8
ST'D FOR E55 ( ) (40)	9	12-0	1728	4.0000	1.7500	3	8 × 16	32	7 3/4 × 15 1/2	23 1/4	360.38	930.97	86580	1.9375	30.03	77.58	.01996	.00430	.00486	979	1223	1468	44.8	147	182	219	27.6	146	182	219	82.9	9
E45 TO E 55 ( )	10	12-0	1728	4.0000	1.7500	4	7 × 16	37 1/3	6 3/4 × 15 1/2	27	418.50	1081.12	100545	2.2500	34.88	90.09	.01719	.00370	.00418	888	1110	1332	52.1	125	157	188	32.1	126	157	189	96.4	10
(13)	11	12-0	1728	4.0000	1.7500	3	10 × 16	40	9 3/4 × 15 1/2	29 1/4	453.40	1171.20	108923	2.4375	37.81	97.60	.01586	.00342	.00386	820	1025	1220	56.1	116	145	174	34.3	136	170	204	88.6	11
ST'D FOR E 65 ( )	12	12-0	1728	4.0000	1.7500	4	8 × 16	42 2/3	7 3/4 × 15 1/2	31.	480.50	1241.29	115440	2.5833	40.04	103.44	.01497	.00322	.00364	775	967	1160	59.9	110	137	164	37.2	110	137	164	110.9	12
(48)	13	12-6	1953	4.3750	1.8000	3	7 × 16	28	6 3/4 × 15 1/2	20 1/4	313.90	810.84	25408	1.6200	25.11	64.87	.02590	.00540	.00573	1295	1619	1942	35.6	172	215	258	23.2	202	252	302	59.7	13
(10)	14	12-6	1953	4.3750	1.8000	3	7 1/2 × 15	28 1/8	7 1/4 × 14 1/2	21 3/4	315.40	762.16	66308	1.7400	25.23	60.97	.02946	.00574	.00570	1378	1722	2066	33.2	171	214	257	23.2	188	235	232	64.1	14
(55) (59)	15	12-6	1953	4.3750	1.8000	3	8 × 16	32	7 3/4 × 15 1/2	23 1/4	360.40	930.97	86580	1.8600	28.83	74.48	.02256	.00470	.00499	1128	1410	1692	40.5	150	187	224	26.9	176	220	264	68.7	15
(11)	16	12-6	1953	4.3750	1.8000	3	8 × 16	32	7 3/4 × 15 1/2	23 1/4	360.40	930.97	86580	1.8600	28.83	74.48	.02256	.00470	.00499	1128	1410	1692	40.5	150	187	224	24.5	150	188	226	80.6	16
(67)	17	12-6	1953	4.3750	1.8000	4	7 × 14	32 2/3	6 3/4 × 13 1/2	27	364.50	820.12	66430	2.1600	29.16	65.61	.02940	.00533	.00494	1280	1600	1920	35.9	148	185	222	27.2	151	189	227	75.9	17
(14)	18	12-6	1953	4.3750	1.8000	2	9 × 16	24	8 3/4 × 15 1/2	17 1/2	271.30	701.73	65168	1.4000	21.70	56.14	.02997	.00623	.00664	1496	1870	2243	30.5	199	249	299	19.6	234	292	351	51.3	18
(62)	19	13-0	2197	4.7500	1.8462	3	7 × 16	28	6 3/4 × 15 1/2	20 1/4	313.90	810.84	75408	1.5577	24.14	62.37	.02913	.00586	.00588	1406	1757	2110	32.8	169	221	265	28.2	207	259	311	58.6	19
(17)	20	13-0	2197	4.7500	1.8462	3	8 × 16	32	7 3/4 × 15 1/2	23 1/4	360.40	930.97	86580	1.7885	27.72	71.61	.02538	.00510	.00512	1225	1530	1836	37.5	154	192	231	26.0	154	192	230	78.1	20
(51)	21	13-0	2197	4.7500	1.8462	3	9 × 18	40 1/2	8 3/4 × 17 1/2	26 1/4	459.40	1339.84	140684	2.0192	35.34	103.06	.01562	.00355	.00402	852	1064	1277	54.5	121	151	181	33.4	160	200	240	79.4	21
(68)	22	13-6	2460	5.1250	1.8888	3	7 × 16	28	6 3/4 × 15 1/2	20 1/4	313.90	810.84	73408	1.5000	23.25	60.06	.03263	.00632	.00602	1517	1896	2275	29.8	181	226	272	21.2	213	266	319	55.9	22
(45) (42)	23	13-9	2600	5.2875	1.9091	3	8 × 16	32	7 3/4 × 15 1/2	23 1/4	360.40	930.97	86580	1.6909	26.21	67.71	.03003	.00568	.00530	1363	1704	2045	33.3	159	199	239	25.0	188	235	282	63.8	23
(65)	24	13-10	2645	5.3725	1.9154	3	7 × 16	28	6 3/4 × 15 1/2	20 1/4	313.90	810.84	75408	1.4642	22.70	58.63	.03508	.00663	.00610	1591	1988	2386	28.6	183	229	275	21.4	217	271	326	55.2	24

(25) (1)	25	14-0	2744	5.5000	1.9286	3	7×16	28	6¾×15½	20¼	313.90	81084	75408	14464	22.42	57.92	.03639	.00678	.00614	1628	2034	2441	280	184	230	276	21.2	219	274	329	54.8	25
(37)	26	14-0	2744	5.5000	1.9286	3	7½×15	28⅛	7¼×14½	21¾	315.40	762.16	66308	1.5536	22.53	54.44	.09138	.00722	.00612	1733	2165	2600	26.1	183	229	275	21.4	204	255	306	58.8	26
(63) (19)	27	14-0	2744	5.5000	1.9286	3	8×16	32	7¾×15½	23¼	360.40	930.97	86580	1.6607	25.74	66.50	.03169	.00508	.00535	1417	1772	2126	32.1	161	201	241	23.7	191	239	287	62.9	27
(44) (36) (26) (2)	28	14-0	2744	5.5000	1.9286	4	7×16	37⅓	6¾×15½	27	418.50	1081.12	100545	19286	29.89	77.22	.02729	.00509	.00461	1221	1526	1830	376	138	173	208	29.2	164	205	246	69.6	28
(57)	29	14-0	2744	5.5000	1.9286	3	10×16	40	9¾×15½	29¼	453.40	1171.20	108923	2.0893	32.38	83.66	.02519	.00470	.00425	1126	1409	1690	403	128	160	192	31.4	152	190	228	79.4	29
(33)	30	14-0	2744	5.5000	1.9286	3	9×18	40½	8¾×17½	26¼	459.40	1339.80	140684	1.8750	32.81	95.70	.01950	.00410	.00420	984	1231	1477	468	126	157	188	31.9	169	211	254	71.0	30
(72) (35)	31	14-0	2744	5.5000	1.9286	4	8×16	42⅔	7¾×15½	31	480.50	1241.30	115440	2.2149	34.32	88.66	.02377	.00443	.00401	1063	1329	1595	43.2	120	151	181	33.7	141	179	217	84.4	31
(18) (64)	32	14-0	2744	5.5000	1.9286	4	8×16	42⅔	7¾×15½	31	480.50	1241.30	115440	2.2143	34.32	88.66	.02377	.00443	.00401	1063	1329	1595	43.2	120	151	181	33.8	122	153	183	99.2	32
(34)	33	14-0	2744	5.5000	1.9286	3	10×18	45	9¾×17½	29¼	511.90	1493.00	156762	2.0893	36.56	106.64	.01750	.00368	.00377	884	1105	1326	522	113	141	170	35.6	127	159	191	93.2	33
(60)	34	14-0	2744	5.5000	1.9286	3 / 1	8×16 / 6×16	48	7¾ / 5¾×15½	29	449.50	1161.20	107992	2.0714	32.11	82.94	.02541	.00474	.00429	1137	1421	1705	403	129	161	193	31.1	153	191	230	78.7	34
(73)	35	14-0	2744	5.5000	1.9286	4	9×18	54	8¾×17½	35	612.50	1786.50	187578	2.5000	43.75	127.60	.01463	.00308	.00315	739	924	1108	628	94	118	142	42.8	127	158	190	95.0	35
(38)	36	14-6	3049	5.8750	1.9655	3	8×16	32	7¾×15½	23¼	360.40	930.97	86580	1.6034	24.85	64.20	.03521	.00631	.00545	1515	1893	2272	30.0	164	205	245	24.2	196	245	293	61.4	36
(8)	37	14-6	3049	5.8750	1.9655	3	10×18	45	9¾×17½	29¼	511.90	1492.97	156762	2.0172	35.30	102.96	.01945	.00394	.00384	944	1181	1417	486	115	144	173	33.5	156	194	233	77.0	37
(7)	38	14-9	3209	6.0625	1.9833	4	10×18	60	9¾×17½	39	682.50	1990.62	209016	2.6441	46.27	134.96	.01535	.00305	.00291	731	914	1096	63.1	87	110	131	46.2	118	147	177	102.0	38
(66) (53)	39	15-0	3375	6.2500	2.0000	3	9×18	40½	8¾×17½	26¼	459.40	1339.84	140684	1.7500	30.63	89.32	.02399	.00466	.00435	1120	1399	1679	41.1	131	163	197	30.7	177	222	266	67.7	39
(70) (69)	40	15-0	3375	6.2500	2.0000	4	8×17	45⅓	7¾×16½	31	511.50	1406.62	139256	2.0666	34.10	93.77	.02424	.00444	.00391	1066	1333	1600	427	117	147	176	33.7	150	188	225	79.8	40
(41)	41	15-0	3375	6.2500	2.0000	5	8×16	53⅓	7¾×15½	38¾	600.60	1551.61	144300	2.5833	40.04	103.44	.02339	.00403	.00333	967	1208	1450	47.3	99	125	150	401	120	150	180	100.4	41
( )	42	15-9	3907	6.8125	2.0952	3 / 1	9×16 / 6×16	44	8¾ / 5¾×15½	32	496.00	1281.30	119164	2.0317	31.49	81.35	.03279	.00532	.00422	1276	1595	1914	354	127	156	190	30.0	150	187	225	79.9	42
(15)	43	15-9	3907	6.8125	2.0952	3 / 1	9×18 / 6×18	49½	8¾×17½	32	560.00	1633.00	171500	2.0317	35.56	103.68	.02278	.00417	.00374	1001	1252	1502	45.7	112	140	168	35.5	150	187	225	79.9	43
( )	44	15-9	3907	6.8125	2.0952	3½ / 1	9×16 / 6×16	50	8¾ / 5¾×15½	36⅜	563.00	1456.50	135456	2.3095	35.80	92.48	.02884	.00468	.00372	1123	1403	1684	40.7	111	140	167	35.5	132	165	198	91.1	44
(22) (21)	45	16-0	4096	7.0000	2.1250	3	8×16	32	7¾×15½	23¼	360.38	930.97	86580	1.4531	22.52	58.19	.04731	.00752	.00590	1565	1956	2347	24.9	176	220	264	22.2	208	260	312	57.5	45
(16)	46	16-0	4096	7.0000	2.1250	3	8×16	32	7¾×15½	23¼	360.38	930.97	86580	1.4531	22.52	58.19	.04731	.00752	.00590	1565	1956	2347	24.9	176	220	264	22.2	167	222	278	67.5	46
(23)	47	16-0	4096	7.0000	2.1250	3	10×16	40	9¾×15½	29¼	453.40	1171.20	108923	1.8281	28.33	73.20	.03760	.00598	.00469	1914	2393	2872	31.5	140	175	210	28.0	141	177	212	85.2	47
(24)	48	16-0	4096	7.0000	2.1250	3	10×18	45	9¾×17½	29¼	511.90	1493.00	156762	1.8281	31.99	93.31	.02613	.00469	.00415	1125	1407	1688	40.6	124	155	186	31.9	141	177	212	85.1	48
(28)	49	16-0	4096	7.0000	2.1250	4	8×18	48	7¾×17½	31	542.50	1582.30	166141	1.9395	33.91	98.89	.02465	.00424	.00392	1062	1327	1593	43.8	117	146	175	3.38	133	167	200	90.2	49
(59)	50	16-0	4096	7.0000	2.1250	4	9×18	54	8¾×17½	35	612.50	1786.50	187578	2.1875	38.28	111.65	.02184	.00392	.00347	940	1176	1411	48.8.	103	129	155	38.5	118	148	177	104.6	50
COLUMN NUMBER	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	32
COLUMN RELATIONS														10÷2	11÷2	12÷2	3÷13	4÷12	5÷11											Nov 17, 1928		

The accompanying table of comparisons of stringer designs for wooden trestles was made from the data furnished by the table compiled from the answers to the questionnaire sent to the various railroads by sub-committee No. 4 of Committee on Wooden Bridges and Trestles. These designs display American railway practice quite completely. No data was available relative to the maximum engine loading allowed on these structures by the railroads using them.

Column No. 1 will be useful in reference in discussion of the various designs as given in the table of comparisons.

Column No. 2 is the length of span.

Column No. 3 gives the cube of the span length.

Column No. 4 is a coefficient which when multiplied by the individual wheel load will give the maximum moment for the span. Coefficient is calculated on the assumption that axles are spaced five feet apart and positions chosen to give the maximum moment. Simple beam action for one span only is considered. Partial continuity due to beams being two span lengths adds to the factor of safety where this construction is used.

Column 5 is the similar coefficient for maximum shear.

Column 6 gives the number of lines of timber in one chord, two chords being required for one track.

Column 7 gives the nominal dimensions of the timber. These are only used to determine the board feet measure of the chords.

Column 8 gives the board feet measure for one chord per linear foot. This column also serves to show the relative costs assuming that the price of timber is the same for all dimensions shown here.

Column 9 gives the minimum actual dimensions of the timber and is used to calculate the succeeding columns.

Column 10 gives the total width of the timber and for any given cap dimension will indicate the relative end bearing stresses between the cap and stringers.

Column 11 gives the total cross-section area, useful in comparing end shearing stresses under like loading.

Column 12 gives the section modulus of the chord.

Column 13 gives values of bh^3 useful in calculating the coefficient for deflection shown in Column 17.

Column 14 gives ratios of actual bearing width to span length. The larger values indicate the more favorable stresses between the cap and the stringers. This ratio is only useful in comparing stresses from uniform loads. With concentrated loads the end stresses vary with the position of the loads.

Column 15 gives ratio of cross-section to the span length. The larger values indicate the more favorable stresses of shear at end sections. This ratio serves for comparisons only for uniform loads. With concentrated loads the end shear stresses vary with the position of the loads.

Column 16 gives ratio of section modulus to span length. The larger values indicate more favorable bending stresses. This ratio is only accurate for comparison under uniform loading.

Column 17 gives the values of the cube of the span length divided by the product of the width and cube of the depth of the stringers. All formula for deflection have this factor in combination with a factor of distribution of loading, weight of loading and the modulus of elasticity. Assuming these other factors constant, the factor $\frac{l^3}{bh^3}$ serves to show the relative deflections. The smaller values indicate small deflections and hence the more rigid chord.

Column 18 gives the ratio of the maximum moment coefficient for the span length to the section modulus of the chord used. The larger values indicate greater fiber stresses in bending. While the moment coefficients were calculated on wheel spacings of five feet, because modern locomotives rarely have spacings closer than five feet, this assumption will serve for the comparisons of spans up to include 16 feet.

Column 19 gives the ratio of maximum shear coefficient for the span length to the cross-section area. The larger values indicate greater unit stresses in both vertical and horizontal shear.

Columns 18 and 19 are better for comparisons of designs than columns 16 and 15, because in a wooden trestle live loads are more important than uniform dead loads in determining the stresses.

Columns under fiber stresses give values based on 40,000, 50,000 and 60,000 lb. axle loadings on five foot spacings with no impact or dead load of deck stresses added. As the basic data does not indicate the limits of loadings put on the various railroad trestles by the railroads using them, it was thought best to display the effect of all three classes of loadings on each of the three determining points of design. Doubtless many of these structures were never designed to carry E 50 and E 60 loadings and may now be protected by limitation of engines allowed to pass over them.

The question of proper impact percentage to be added to the live load for these short spans of timber construction is still believed to be unsettled. However, any value used will materially increase the unit stresses above those shown in the tabulation.

Columns 23, 27 and 31 give the equivalent Cooper's rating assuming the stresses be limited to the amounts given in the table of "Working Unit Stresses for Structural Timber" in the A.R.E.A. Manual. These ratings were computed with dead loads of actual decks deducted from total carrying capacity.

In the recommended standards for loading, your committee finds that in many cases the maximum on any one span of the trestle will occur when two seventy-ton coal cars, fully loaded, and coupled, pass over the structure. Theoretically, this approximates Coopers E50 loading, but is thought to be no more severe on the structure than an engine of E45 class. It is believed E55 will be sufficient for the present needs of nearly all the roads, as that load is exceeded as to its effect on trestles, by comparatively few engines now in service. In E65, your committee feels, is found the maximum load for which a practicable wooden trestle can be designed with the woods generally available for trestle construction.

As to the advisable length of panel, your committee agreed upon twelve feet. Yellow Pine Manufacturers assure us that sixteen inch stringers will be available without undue cost, as long as yellow pine lasts, but evade promising an eighteen inch stringer. Also, the sixteen inch stringer is in general use at this time. With a sixteen inch stringer agreed upon, the twelve foot panel is very nearly a corollary.

Having fixed upon the panel length and loading, we proceed to the remaining features. First comes the pile. We will not discuss varieties of timber, believing the Engineer will use the best available, and make up for any lack of structural strength by increasing the size. It is also thought a fourteen-inch butt will be the minimum size used. It was assumed that piles should, if possible, be so driven as to be safe for a load of fifteen tons plus impact.

Class	*Rating*	*Load on Bent*	*No. of Piles*	*Load on Pile*	*Load Per Sq. In. Area Cap on Pile*
Light	E45	56 tons	4	14 tons	210 lbs.
Medium	E55	68 tons	5	13.6 tons	177 lbs.
Heavy	E65	80 tons	6	13.3 tons	173 lbs.

In the event it becomes necessary to strengthen E45 to carry E55 load, or E55 to carry E-65 load, the weight would be 17 tons and 16 tons respectively on the piles, which would be permissible.

So many varieties of woods are used for caps that only a general rule applying to Pine, Cypress and Fir can be used. We recommend

Light ....Cap 12 in. x 14 in. x 14 ft.
Medium ....Cap 14 in. x 14 in. x 14 ft.
Heavy ....Cap 14 in. x 14 in. x 14 ft.

While more than thirteen feet in length may be unnecessary, since we must pay for even feet there is no cogent reason against using such length. Caps should be surfaced on one or two sides and not dapped over the pile. Dapping is expensive and weakens the cap.

Sway bracing should ordinarily be used on all bents over ten feet from surface of ground to base of rail. When this distance exceeds 18 feet there should be two or more sash braces and corresponding sway braces. Bracing should be on both sides of the pile. The aim should be to so attach the braces as to enable them to give the bent the maximum strength.

The bank bent should be the same as the intermediate bent, save that no bracing is required and that in the E65 design only five piles are recommended for the bank bent.

For frame bents our recommendations are

	Cap	*Posts*	*Sill*
Light	12x12x14	4—12x12	12x12
Medium	14x14x14	5—12x12	12x12
Heavy	14x14x14	6—12x12	12x12

Your committee asks further time for consideration of design of multiple story bents and their bracing. The batter to be used for piles and posts in trestle construction has been given consideration, but no recommendations are made at this time. No conclusion has been reached relative to details of fastenings to be used in securing the posts to sills or caps to posts.

Sway bracing in single story bents should be the same size as in pile bents and similarly attached.

In considering stringers, it was recognized that the two lighter types should be readily strengthened for the next higher loading and in our plans this can be accomplished by inserting an additional stringer under each rail. We recommend

Class	*Size of Stringers*	*Fiber Stress, Lb. Per Sq. In.*	*Long Shear, Lb. Per Sq. In.*	*Compression on Cap, Lb. Per Sq. In.*
Light	6—7x16	1422 lbs.	188 lbs.	221 lbs.
Medium	6—8x16	1346 lbs.	180 lbs.	200 lbs.
Heavy	8—8x16	1257 lbs.	178 lbs.	178 lbs.

It will be noted that in longitudinal shear the stresses much exceed those given in either of the tables before referred to. The Committee invites discussion of this feature.

Ties should be 8″x8″x10′ surfaced on one side, not dapped, 12″ centers and attached to stringers in accordance with recommended practice of the A.R.E.A.

Guard timbers should be 4″x8″ attached to the ties according to recommended practice of the A.R.E.A.

Appendix B

SPECIFICATIONS AND CLASSIFICATION AND GRADING RULES FOR LUMBER AND TIMBER TO BE USED IN THE CONSTRUCTION AND MAINTENANCE OF WAY DEPARTMENTS OF RAILROADS.

Structural Timber

Definitions

Axis.—The line connecting the centers of successive cross-sections of a stick.

Corner.—The line of intersection of the planes of two adjacent longitudinal surfaces.

Cross-Section.—A section of a stick at right angles to the axis.

Edge.—Either of the two narrower longitudinal surfaces of a stick.

Face.—The surface of a stick which is exposed to view in the finished structure.

Full Length.—Long enough to "square" up to the length specified in the order.

Girth.—The perimeter of a cross-section.

Heartwood.—The older and central part of a log, usually darker in color than sapwood. It appears in strong contrast to the sapwood in some species, while in others it is but slightly different in color.

Out of Wind.—Having the longitudinal surfaces plane.

Side.—Either of the two wider longitudinal surfaces of a stick.

Solid.—Without cavities; free from loose heart, wind shakes, bad checks, splits or breaks, loose slivers and worm or insect holes.

Sound.—Free from decay.

Springwood.—The inner part of the annual ring formed in the earlier part of the season, not necessarily in the spring, and often containing vessels or pores.

Square-Cornered.—Free from wane.

Straight.—Having a straight line of an axis.

Summerwood.—The outer part of the annual ring formed later in the season, not necessarily in the summer, being usually dense in structure and without conspicuous pores.

True.—Of uniform cross-section. Defects are caused by wavy or jagged sawing or consist of trapezoidal instead of rectangular cross-sections.

Names for Varieties of Structural Timber

Cedar covers White Cedars: Thuya occidentalis, Maine to Minnesota and northward; Chamœcyparis thyoides, Atlantic Coast from Maine to Mississippi; Chamœcyparis lawsoniana, along the coast line of Oregon; Libocedrus decurrens, Cascades and Sierra Nevada of Oregon and California. Red Cedars: Thuya gigantea, Washington to Northern California and eastward to Montana; Juniperus virginiana, throughout United States. Western Red Cedar: Thuja Plicata.

CYPRESS (Taxodium distichum) covers bald cypress, black, white and red cypress, from swamp and overflow land along the coast and rivers of the Southern States.

DOUGLAS FIR.—The term "Douglas Fir" covers the timber known as yellow fir, red fir, Western fir, Washington fir, Oregon or Puget Sound fir or pine, Northwest and West Coast fir.

HEMLOCK covers Southern or Eastern hemlock; that is, hemlock from all states east of and including Minnesota.

IDAHO WHITE PINE covers the variety of white pine from Western Montana, Northern Idaho and Eastern Washington.

NORWAY PINE covers what is known also as "Red Pine" and Banksian (Pinus Banksiana).

OAK.—Under this heading three classes of timber are used: (a) White Oak, to include White Oak, Burr Oak and Post Oak; (b) Red Oak, to include Red Oak, Scarlet Oak, Black Oak and all bastard oaks; (c) Chestnut Oak, to include only Chestnut Oak.

REDWOOD includes the California wood usually known by that name.

SOUTHERN YELLOW PINE.—This term includes the species of yellow pine growing in the Southern States from Virginia to Texas, that is, the pines hitherto known as longleaf pine (Pinus palustris), shortleaf pine (Pinus echinata), loblolly pine (Pinus taeda), Cuban pine (Pinus heterophylla) and pond pine (Pinus serotina).

SPRUCE covers Eastern spruce; that is, the spruce timber coming from points east of and including Minnesota.

TAMARACK covers the timber known as "Tamarack," or "Eastern Tamarack," from states east of and including Minnesota.

WESTERN HEMLOCK covers hemlock from the Pacific Coast.

WESTERN LARCH covers the species of Larch or Tamarack from the Rocky Mountains and Pacific Coast regions.

WESTERN PINE covers the timber sold as white pine coming from Arizona, California, New Mexico, Colorado, Oregon and Washington. This is the timber sometimes known as "Western Yellow Pine," or "Ponderosa Pine," or "California White Pine," or "Western White Pine."

WESTERN OR SITKA SPRUCE covers spruce timber from the Pacific Coast.

WHITE PINE covers the timber which has hitherto been known as white pine, from Maine, Michigan, Wisconsin and Minnesota.

Classification Terms

LUMBER is the product of the saw and planing mill not further advanced in manufacture than by sawing, resawing and passing lengthwise through a standard planing machine, crosscutting to length, and end matching.

Lumber is classified as yard lumber, shop or factory lumber and structural timber. Different grading rules apply to each class of lumber.

Yard Lumber is lumber that is less than six inches in thickness and is intended for general building and construction purposes. The grading of yard lumber is based upon the use of the entire piece, except when a stated amount of waste to remove defects is provided in the classification of the material under consideration.

Shop or Factory lumber is intended to be cut up for use in further manufacture and 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.

Structural Timber is lumber that is six inches or over in thickness and width. The grading of structural timber is based upon the strength of the piece and the use of the entire piece.

Yard lumber is classified roughly as finishing and construction lumber. There is no sharp line between finishing and construction lumber. The medium grades may be used for either purpose.

Finishing is yard lumber of the higher grades in which appearance, perfection of the surface and finishing qualities are primarily the basis on which the grade is determined. The higher finishing grades are more suitable for "natural" or transparent finishes while the lower finishing grades are smooth and free from serious defects and are particularly adapted to the use of paint.

Construction Lumber is yard lumber which is graded primarily upon the basis of its strength as affected by defects, and its fitness for general construction purposes.

Strips are yard lumber less than two inches thick and under eight inches wide. Strips are usually manufactured into matched and patterned lumber.

Boards are yard lumber less than two inches thick and eight inches or over wide.

Planks are yard lumber two inches and under four inches thick and eight inches and over in width.

Scantlings are yard lumber two inches and under six inches thick and under eight inches wide.

Heavy Joists are yard lumber that is four inches and under six inches thick and eight inches and over wide.

Dimension includes all yard lumber except boards and stripes; that is, yard lumber two inches and under six inches thick and of any width.

Manufactured lumber is classified as rough, surfaced and worked.

Rough lumber is undressed lumber left 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 (as S1S1E, S2S1E, or S1S2E).

Worked lumber is lumber which has been run through a matching machine, sticker or moulder. Worked lumber may be matched, shiplapped or patterned. Patterned lumber is usually matched or shiplapped.

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 rabbeted or lap joint when laid edge to edge.

PATTERNED lumber is worked lumber that is shaped to a patterned or moulded form.

Definitions of Defects and Blemishes.

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 value.

BLEMISH.—Any mark or formation of wood structure marring the appearance.

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.

Knots

KNOT.—The hard mass of wood formed in a trunk of a tree at a branch with the grain distinct and separate from the grain of the trunk.

KNOTS shall be classified according to size, form and quality.

The average of the maximum and minimum diameters shall be used in measuring the size of knots unless otherwise stated.

In all grades of material all knots should be sound and tight unless otherwise specified.

PIN KNOT.—One not over ⅜ of an inch in diameter.

SMALL KNOT.—One between ⅜ and ¾ of an inch in diameter.

STANDARD KNOT.—One between ¾ and 1½ inches in diameter.

LARGE KNOT.—One not over 1½ inches in diameter.

ROUND KNOT.—One whose maximum diameter is not over one and one-half times as great as its minimum diameter.

OVAL KNOT.—One having its maximum diameter one and one-half to three times as great as its minimum diameter.

SPIKE KNOT.—One sawed in a lengthwise direction whose maximum diameter is over three times as great as its minimum diameter.

SOUND KNOT.—One which is solid across its face, and is as hard as the wood surrounding it and shows no indications of decay.

UNSOUND OR ROTTEN KNOT.—One not as hard as the wood surrounding it or one in which decay has started.

TIGHT KNOT.—One so fixed by growth or position that it will firmly retain its place in the piece.

LOOSE KNOT.—One not held firmly in place by growth or position.

LIVE KNOT.—One whose growth rings are completely intergrown with those of the surrounding wood.

ENCASED KNOT.—One whose growth rings are not intergrown and homogeneous with the growth rings of the surrounding wood. The encasement may be partial or complete.

WATERTIGHT KNOT.—One whose growth rings are completely intergrown with those of the surrounding wood on one face of the piece, and which is sound on that face.

PITH KNOT.—Sound knot except that it has a pith hole in the central growth ring. The hole rarely exceeds ¼ of an inch in diameter.

Holes

HOLES in wood may extend partially or entirely through the piece. They are enumerated as knot, dog, picaroon, bird, insect (including pin, shot, spot, grub worms, etc.) metal and wooden rafting pin holes, through pitch pockets and the like.

When holes are permitted, the average of the maximum and minimum diameters at right angles to the direction of the hole shall be used in measuring the size, unless otherwise stated.

WOODEN RAFTING PINHOLES sometimes appear on river timber which has been rafted when holes have been bored in the solid wood for securing the timber, and a solid plug or pin driven in the hole, completely filling it. These defects must be treated and considered the same as Knot Defects. Ordinary Metal Rafting Pin, Cant Hook or Chain Dog-hole is not considered a defect.

GRUB WORM HOLES are usually from about ⅛-inch to 3/16-inch in width, and vary in length from about 1 inch to 1½ inches and are caused by grubs working in the wood.

PIN WORM HOLES are very small holes caused by minute insects or worms. These holes are usually not over 1/16-inch in diameter, the wood surrounding them is sound and does not show any evidence of the worm hole having any effect on the wood other than the opening.

SPOT WORM DEFECTS (also known as Flagworm Defects) are caused, like Pinworm holes, by minute insects or worms working on the timber during the growth. The size of the hole is about the same as Pinworm holes, but the surrounding wood shows a colored spot as evidence of the blemish. This spot is usually sound and does not affect the strength of the piece.

Checks

CHECK is a separation of the wood cells along a radial plane of the tree due to unequal shrinkage during seasoning.

SURFACE CHECK is a shallow check occurring on the surface of a piece.

END CHECK is one occurring on an end of a piece.

THROUGH CHECK is one extending from one surface through the piece to the opposite face or to an adjoining face.

HEART CHECK is one starting at the pith and extending towards but not to the surface of a log and is not necessarily due to seasoning.

STAR CHECK is the combination of several heart checks occurring together.

HONEYCOMBING is checking occurring in the interior of a piece; often the checks are 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.

ORDINARY season checks such as occur in lumber properly covered in yard, or season checks of equal size in kiln-dried lumber shall not be considered defects.

Shakes and Splits

SHAKE is a cylindrical separation of the wood following in general the annual layers (rings) of growth. Thus any shake is a ring shake.

ROUND SHAKE is one completely encircling the pith.

CUP SHAKE is one that does not completely encircle the pith.

THROUGH SHAKE is one extending from one surface through the piece to the opposite face or to an adjoining face.

PITCH SHAKE.—A clearly defined seam or opening between the grain of the wood and may be either filled or not with granulated pitch.

SPLIT is a lengthwise separation of the wood due to tearing apart of the wood cells in rough handling, felling the tree or similar causes. It may run in any direction across the end of a piece.

PITH is the small soft core occurring in the center growth ring of a log. In some woods it is large enough to mar the surface of the piece on which it appears. The wood immediately surrounding the pith often contains small checks, shakes or numerous pin knots and is often discolored; any such combination of defects and blemishes is known as Heart Center.

Pockets

PITCH POCKET.—A well defined opening between the annual layers of growth usually containing more or less pitch, either solid or liquid. Bark may also be present in the pocket. On an edge-grain surface they appear as narrow open seams, and on flat grain surface they vary in appearance from narrow open seams to oval cavities sometimes called "Scab Pitch Pockets." On either surface they are known as very small, small, medium or large, depending upon their size.

VERY SMALL PITCH POCKET.—One not over ⅛ of an inch in width and not over 2 inches in length.

SMALL PITCH POCKET.—One whose maximum width may vary from ⅛ of an inch to ¼ of an inch provided a maximum limit of length of four inches decreases to two inches proportionately as the width increases.

MEDIUM PITCH POCKET.—One whose maximum width may vary from ⅛ of an inch to ⅜ of an inch provided a maximum limit of length of nine inches decreases to three inches proportionately as the width increases.

LARGE PITCH POCKET.—One whose width or length exceeds the sizes stated as permissible for a medium pitch pocket.

BARK POCKET is a patch of bark partially or wholly enclosed in the wood. It may result from wood and bark forming over a place where the tree has been injured. As a defect it is measured in the same manner as a Pitch Pocket.

Streaks and Discolorations

PITCH STREAK.—A well defined and conspicuous accumulation of pitch in the wood cells. It is usually not considered an important blemish unless both springwood and summerwood appear saturated. They are known as small, medium or large, depending upon their size with respect to the piece they are in.

SMALL PITCH STREAK.—One whose area does not exceed the product of one-twelfth the width by one-sixth the length of the face on which it occurs.

MEDIUM PITCH STREAK.—One whose area does not exceed the product of one-sixth the width by one-third the length of the face on which it occurs.

LARGE PITCH STREAK.—One whose area exceeds the product of one-sixth the width by one-third the length of the face on which it occurs.

PITH FLECK is a narrow streak, usually brownish, up to several inches in length on the face of a piece resulting from the larvæ of an insect having burrowed in the growing tissue or cells of the tree.

BIRD PECK is a small hole or patch of distorted grain resulting from birds pecking through the growing cells in the tree. It usually resembles a carpet tack in shape with the point towards the bark and it is usually accompanied by a discoloration extending along the grain and usually to a smaller extent around the layers of growth. A section through the discoloration produced by the bird peck produces what is commonly known as "Mineral Streak."

GUM SPOT OR STREAK is an accumulation of gum-like substance occurring as a small patch or streak in the piece. It may occur in conjunction with a bird peck or other injuries to the growing wood.

DISCOLORATIONS on or in lumber are enumerated as weather, sticker, water or fungus (such as blue stain, etc.) stain, brown stain, kiln burn and similar color changes due to a combination of temperature, moisture, chemicals, etc. Discoloration may follow insect attack, bird peck, etc. Well defined discolorations are known as light, medium and heavy.

LIGHT DISCOLORATION is paler than the medium discoloration and occurs in approximately one-fourth of the stained stock.

MEDIUM DISCOLORATION is a shade most commonly found and which occurs in approximately one-half of the stained stock.

HEAVY DISCOLORATION is darker than the medium discoloration and occurs in approximately one-fourth of the stained stock.

DECAY is disintegration of the wood substance due to the action of certain kinds of fungi. A few of the rot-producing fungi which start in the standing tree do not seem to seriously develop after the tree is cut into lumber.

Red Heart of the pines, spruces, Douglas fir and some other conifers, and peck of cypress and incense cedar are produced by fungi of this type. Decay may be classified as incipient and advanced decay.

Incipient Decay is the early stages of decay, usually detected by a discoloration of the wood which seems to be firm and solid.

Advanced Decay or rot is noticeable as a decided softening or breaking down of the wood.

Water Stain, or what are sometimes called scalded or burnt spots, usually caused by timber lying in the water under certain conditions before it is sawed, and burnt spots where timber is improperly piled while green, are not considered defects, as they do not affect the strength of the piece.

"Sap"—Sapwood is the alburnum of the tree—the exterior part of the wood next to the bark. Sapwood is not considered a defect except as provided herein.

Sound Heart.—The term "Sound Heart" is used whenever that part of the piece which was originally the central part or core of the tree is sound and solid, not decayed.

Grain

Cross Grained Wood is that in which the wood 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 is that 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 is that 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 is that 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 surface.

Dip Grained Wood is that which has one wave or undulation of the fibers such as occurs around knots, pitch pockets, etc.

Curly Grained Wood is that in which the fibers are distorted so that they take a curled direction as in "Birdseye Wood." These patches may vary up to several inches in diameter.

Interlocked Grain is wood that 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.

Distortions and Crooks

Cross Break is a separation of the wood cells across the grain. It may be due to tension resulting from unequal longitudinal shrinkage or mechanical stresses.

Compression Failure is a wrinkling or buckling of the wood cells extending in a more or less irregular plane across the grain. It is due to longitudinal crushing or compression.

Collapse is a caving in of the surface of a piece. It sometimes occurs in streaks giving the surface a corrugated appearance, and is often due to the flattening of the cells when drying wet wood at high temperatures.

Warping is any variation from a true or plane surface. It includes crook, bow, twist or any combination of these.

Crook is a deviation edgewise from a straight line drawn from end to end of a piece and is measured at the point of greatest departure from a straight line. It is known as slight, small, medium and large.

Unless otherwise specified, the different degrees of crook based on a piece four (4) inches wide and 16 feet long shall be as follows:

Slight Crook, a departure of one (1) inch.

Small Crook, a departure of 1½ inches.

Medium Crook, a departure of 2 inches.

Large Crook, a departure of over 2 inches.

For wider pieces it shall be ⅛-inch less for each additional 2 inches of width.

Shorter or longer pieces shall have the same limits for curvature.

Bow is a deviation flatwise from a straight line drawn from end to end of a piece measured at the point of greatest distance from a straight line.

Cupping is the curvature of a piece across the grain or width of a piece.

Twisting is the turning or winding of the edges of a piece so that four corners of any face are no longer in the same plane (i. e., it is the twisting of an edge around the axis of the piece).

Wane is bark or the lack of wood, from any cause, on the edge of a piece.

Note: In preparing the above definitions, the Committee used in a large way the tentative definitions as proposed in progress report of the United States Forest Products Laboratory at Madison, Wisconsin, Mr. Carlile P. Winslow, Director.

Illustrations of Defects.

Note.—The illustrations listed above will be incorporated in the Revised Manual. Page numbers refer to the 1915 Manual.

Defects of Manufacture, Applicable to All Timber and Lumber.

Defects in rough stock caused by improper manufacture and drying will reduce grade, unless they can be removed in dressing such stock to standard sizes.

In structural timber defects of manufacture have usually been omitted, being of minor significance.

Imperfect manufacture in dressed stock, such as torn grain, loosened grain, slight skips in dressing, wane, broken knots, mismatched, insufficient tongue or groove for flooring, ceiling, drop siding, etc., shall be considered defects, and will reduce the grade according as they are slight or serious in their effects on the use of the stock.

Torn grain consists of a part of the wood having been torn out in dressing. It occurs around knots and curly places and is of four distinct characters: slight, medium, heavy and deep. Slight torn grain shall not exceed $\frac{1}{32}$-inch in depth; medium $\frac{1}{16}$ and heavy $\frac{1}{8}$-inch. Any torn grain heavier than $\frac{1}{8}$-inch shall be termed deep.

Loosened grain consists in a point of one grain being torn loose from the next grain. It occurs on the heart side of the piece and is a serious defect, especially in flooring.

Chipped grain consists in a part of the surface being chipped or broken out in small particles below the line of cut and, as usually found, should not be classed as torn grain, and shall be considered a defect only when it unfits the piece for use intended.

Pieces of Flooring, Drop Siding or Partition with $\frac{3}{16}$-inch or more of tongue; and pieces of Ceiling with $\frac{1}{8}$-inch or more of tongue; and pieces of Ship Lap with $\frac{5}{16}$-inch of lap will be admitted in any grade.

Pieces of Flooring, Drop Siding, Ceiling or Partition having not less than $\frac{1}{16}$-inch tongue will be admitted in No. 2 Common. Pieces of Ship Lap having less than $\frac{5}{16}$-inch and not less than $\frac{1}{8}$-inch lap shall be admitted in No. 2 Common.

Standard Sizes.

In the absence of a special agreement between buyer and seller for each order, the following sizes shall be standard for all lumber and timber.

"Rough timbers sawed to standard size" means that they shall not be over one-quarter ($\frac{1}{4}$) inch scant from the nominal size specified For instance, a 12x12 inch timber shall measure not less than 11¾x11¾ inches.

"Standard Dressing" means that not more than $\frac{1}{4}$-inch shall be allowed for dressing each surface. For instance, a 12x12 inch timber, after being dressed on four sides, shall measure not less than 11½x11½ inches.

Dimension S1 S 1E

Nominal Thickness Inches	*Actual Thickness Inches*	*Nominal Width Inches*	*Actual Width Inches*
2	1 5/8	4	3 5/8
2 1/2	2 1/8	5	4 5/8
3	2 5/8	6	5 5/8
4	3 5/8	7	6 5/8
5	4 5/8	8	7 1/2
...	...	9	8 1/2
...	...	10	9 1/2
...	...	12	11 1/2
...	...	14	13 1/2
...	...	16	15 1/2

Standard lengths are multiples of two feet, 4 to 24 feet, inclusive, but lengths shorter than 10 feet shall not be included in miscellaneous or mixed shipments except by agreement.

Common Boards and Strips.

Nominal Thickness Inches	*Actual Thickness Inches*	*Nominal Width Inches*	*Actual Width Inches*
1 R	15/16	4	3 5/8
1 S1S	7/8	6	5 5/8
1 S2S	13/16	8	7 1/2
1 1/4	1 1/16	10	9 1/2
1 1/2	1 5/16	12	11 1/2

Dressed Finishing Lumber S1S

Nominal Thickness Inches	*Actual Thickness Inches*	*Nominal Width Inches*	*Actual Width Inches*
3/8	5/16	4	3 5/8
1/2	7/16	5	4 5/8
5/8	9/16	6	5 5/8
3/4	11/16	7	6 5/8
1	13/16	8	7 1/2
1 1/4	1 1/8	9	8 1/2
1 1/2	1 3/8	10	9 1/2
2	1 3/4	12	11 1/2
2 1/2	2 1/8	14	13 1/2
3	2 5/8	16	15 1/2

The standard lengths are multiples of one foot.

Flooring

Nominal Thickness Inches	*Actual Thickness Inches*	*Nominal Width Inches*	*Actual Width Inches*
3/8	...	..	....
1/2	...	..	....
5/8	...	..	....
			Tongue and Groove
3/4	11/16	3	2 3/8
1	13/16	4	3 1/4
1 1/4	1 1/16	5	4 1/4
1 1/2	1 5/16	6	5 1/4
2	1 5/8	6 Factory	5 1/8
2 1/2	2 1/8	..	....
			Splined
3	2 5/8	6	5 1/2
3 1/2	3 1/8	7	6 1/2
4	3 5/8	8	7 1/2
...	...	9	8 1/2
...	...	10	9 1/2
...	...	12	11 1/2
			Shiplap
...	..	6	5
...	...	7	6
...	...	8	7
...	...	9	8
...	...	10	9
...	...	12	11

Standard lengths are multiples of one foot from 4 to 20 feet. Five per cent. of 8 or 9 foot lengths is allowed in mixed length shipments of "B and Better" and in addition five per cent. of 6 or 7 feet in C, D and No. 1 Common, and in addition five per cent. of four or five feet in No. 2 Common, No. 3 Common, 4 to 20 feet inclusive.

The above percentage of short lengths is customary, and in the interest of conservation will be included, as far as practicable, in all shipments of mixed lengths.

Ceiling

Nominal Thickness Inches	*Actual Thickness Inches*	*Nominal Width Inches*	*Actual Width Inches*
3/8	5/16	3	2 3/8
1/2	7/16	4	3 1/4
5/8	9/16	5	4 1/4
		6	5 1/4
1	3/4	7	6 1/8

Standard lengths are multiples of one foot, from 4 to 20 feet.

Five per cent. of 8 or 9 feet is allowed in mixed length shipments of "B and Better" Ceiling and in addition five per cent. of 6 or 7 feet in No. 1 Common, and in addition five per cent. of 4 or 5 feet in No. 2 Common.

The above percentage of short lengths is customary, and in the interest of conservation will be included, as far as practicable, in all shipments of mixed lengths.

Partition

Nominal Thickness Inches	*Actual Thickness Inches*	*Nominal Width Inches*	*Actual Width Inches*
3/8	5/16	3	2 3/8
1/2	7/16	4	3 1/4
5/8	9/16	5	4 1/4
3/4	11/16	6	5 1/4
1	3/4	7	6 1/8

Standard lengths are multiples of one foot.

Same percentage of short lengths is allowed as in ceiling.

Grooved Roofing

Nominal thickness one (1) inch, actual thickness 13/16-inch.

Nominal Width Inches	*Actual Width Inches*
8	7 1/2
10	9 1/2
12	11 1/2

Roofers

Roofers shall be made of No. 2 boards, 13/16-inch machine run, center matched and of nominal widths 6 or 8 inches as specified.

Fencing

Nominal Thickness Inches	*Actual Thickness Inches*	*Nominal Width Inches*	*Actual Width Inches*
1	13/16	3	2 5/8
1 1/4	1 1/16	4	3 5/8
1 1/2	1 5/16	5	4 5/8
...	...	6	5 5/8

Drop Siding, D&M

Nominal Thickness Inches	*Actual Thickness Inches*	*Nominal Width Inches*	*Actual Width Inches*
5/8	9/16	3	2 1/4
3/4	11/16	4	3 1/4
1	3/4	5	4 1/4
1 1/4	..	6	5 1/4
1 1/2	..	..	...

Drop Siding, Worked Shiplap and Rustic

Nominal thickness one (1) inch, actual thickness three-fourths (3/4) inch.

Nominal Width Inches	*Actual Width Inches*
6	5 1/8
8	7 1/8
10	9 1/8

Standard lengths are multiples of 2 feet from 4 to 20 feet.

Five per cent. of 8 or 9 feet is allowed in mixed length shipments of "B and Better Drop Siding," and in addition five per cent. of 6 or 7 feet in "No. 1 Common" and in addition five per cent. of 4 or 5 feet in No. 2 Common.

The above percentage of short lengths is customary and in the interest of conservation will be included, so far as practicable, in all shipments of mixed lengths.

Shiplap

Nominal thickness one (1) inch, actual thickness three-fourths (¾) inch, ⅜-inch lap.

Nominal Width Inches	*Actual Width Inches*
4	3⅛
6	5⅛
8	7⅛
10	9⅛
12	11⅛

Bevel Siding

Nominal Thickness Inches	*Actual Thickness Inches*	*Nominal Width Inches*	*Actual Width Inches*
½ ¼ E	$\frac{7}{16}$ and $\frac{3}{16}$	4	3½
....	....	5	4½
....	....	6	5½
⅝ ¼ E	$\frac{9}{16}$ and $\frac{3}{16}$	..	...
¾ ¼ E	....	8	7¼
....	....	10	9¼
....	....	12	11¼

Standard lengths are multiples of one foot, from 4 to 20 feet. Five per cent. of 8 or 9 feet is allowed in mixed shipments of "B and Better," Bevel Siding, and in addition five per cent. of 6 or 7 feet in "No. 1 Common" and in addition, five per cent of 4 or 5 feet in "No. 2 Common."

The above percentage of short lengths is customary, and in the interest of conservation will be included, so far as practicable, in all shipments of mixed lengths.

General Instructions on Grading Timber and Lumber

No arbitrary rules for the inspection of lumber can be maintained with satisfaction. The combinations and evaluations of defects are numerous and the interpretation of classification in grading lumber must be left to practical common sense. The general features of these classes are given by the following description of grades.

All lumber is graded with special reference to its suitability for the use intended.

With this in view each piece is considered and its grade determined by its general character, including the sum of all its defects.

Inspection of lumber is not an exact science and a reasonable variation of opinion between inspectors should be recognized; therefore, a variation of not more than 5 per cent. upon reinspection should not disturb the original inspection.

The enumerated defects herein described in any grade are intended to be descriptive of the coarsest piece such grades may contain.

In construing and applying these rules, the defects allowed are understood to be equivalent in damaging effect to those mentioned applying to stock under consideration.

In case of a piece of lumber which lies so close to the boundary line between two grades that there is doubt as to which grade it belongs in, it shall be given the lower grade.

A shipment of any grade must consist of a fair average of that grade and shall not include an unfair proportion of the better or poorer pieces that would pass in that grade. A shipment of mixed widths shall contain a fair assortment of each width. A shipment of mixed lengths shall contain a fair assortment of each length.

Defects in lumber are to be considered in connection with the size of the piece, and for this reason wider and longer pieces will carry more defects than smaller pieces in the same grade. Defects in flooring, ceiling, partition, casing and base, drop siding and rustic are based on a piece 4 inches wide and 12 feet long, except where otherwise specified.

Lumber must be accepted on grade in the form in which it was shipped. Any subsequent change in manufacture or condition will prohibit a reinspection for the adjustment of claims, except with the consent of all parties interested.

What is known as "Yard Lumber," such as Dimension, Common Boards and Finish, etc., is graded from the face side, which is the best side, except that lumber which is dressed one side only is graded from the dressed side.

Factory lumber, which is used for the manufacture of doors, sash, etc., and must show both sides, is always graded from the poorer side. The grade is determined by the quantity of suitable cuttings obtainable in each piece.

All dressed lumber shall be measured and sold at the full size of rough material used in its manufacture.

All lumber one inch or less in thickness shall be counted as one inch thick.

The term "Vertical Grain" is here used as synonymous with edge grain, rift sawed or quarter sawed. The term "Flat Grain" is synonymous with slash grain or plain sawed.

Structural Grades for Bridge and Trestle Timbers

Southern Yellow Pine and Douglas Fir Specifications

Density Requirements.

Shall contain only Southern Yellow Pine or Douglas Fir timbers graded in two grades by the following density rules:

Density Rule for Southern Yellow Pine.

Dense Southern Yellow Pine shall show on either one end or the other an average of at least six annual rings per inch or eighteen rings in three inches as measured over the third, fourth and fifth inches of a radial line from the pith, and at least one-third (1/3) summerwood for girders not exceeding 20 inches in height, and for columns 16 inches square or less. For larger timbers the inspection shall be made over the central three inches on the longest radial line from the pith to the corner of the piece. Wide ringed material excluded by the above will be accepted, provided the amount of summerwood, as above measured, shall be at least 50 per cent.

The contrast in color between summerwood and springwood shall be sharp, and the summerwood shall be dark in color, except in pieces having considerably above the minimum requirement for summerwood.

In cases where timbers do not contain the pith, and it is impossible to locate it with any degree of accuracy, the same inspection shall be made over three inches of an approximate radial line beginning at the edge nearest the pith in timbers over three inches in thickness and on the second inch (on the piece) nearest to the pith in timbers three inches or less in thickness.

In dimension material containing the pith but not a five-inch radial line, which is less than two 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 which does not show a five-inch radial line, the inspection shall apply to the three inches farthest from the pith.

The radial line chosen shall be representative. In case of a disagreement between purchaser and seller as to what is a representative radial line, the average summerwood and number of rings shall be the average of the two radial lines chosen.

Density Rule for Douglas Fir.

Dense Douglas Fir shall show, on either one end or the other, an average of at least six annual rings per inch and at least one-third summerwood measured over three inches on a line located as described hereinafter. Coarse-grained material excluded by this rule shall be acceptable provided the amount of summerwood measured as described shall be at least one-half. Material in which the proportion of summerwood is not clearly discernible shall not be accepted.

Any timber whose least dimension is less than five inches shall not show the pith (heart) on the inspection end; pieces whose least dimension is five inches or more may contain the pith.

When the least dimension is five inches or more, the pith being present, the line over which the rate of growth and per cent. of summerwood measurements shall be made shall run from the pith to the corner farthest from the pith. To find the beginning of the three-inch line, measure a distance of one-half the least dimension of the piece, less two inches, from the pith. This distance may be expressed as follows:

$$a = \tfrac{1}{2} d - 2,$$

where a = distance in inches from pith to beginning of three-inch line.
d = least dimension of piece in inches.

When the rings are very irregular it may be necessary to shift the line somewhat around the piece to get a fair average for inspection, but the distance from the pith to the beginning of the three-inch line must not be changed.

For all pieces where the pith is not present the center of the three-inch line shall be at the center of the end of the piece, and the direction of the three-inch line shall be at right angles to the annual rings.

If a radial line of 3 inches cannot be obtained, the measurement shall be made over the entire radial line that is available.

General Requirements.

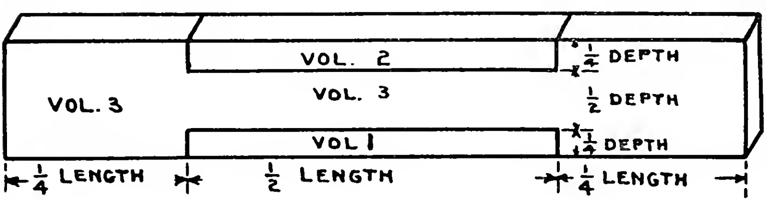
(a) Shall consist of lumber well manufactured, square edges and sawed standard size.

When the timbers 4 x 4 inches and larger are ordered sized, they will be ½ inch less than nominal size, either S1S1E or S4S, unless otherwise specified.

(b) Structural timbers shall be sound and free from rotten or unsound knots, knots in clusters, decay, round or ring shakes occupying more than one-fourth (¼) the least dimension on either end of a timber (a round or ring shake shall be measured on its vertical projection), injurious diagonal grain or other defects that will materially impair its strength. Shakes shall not show on any face of the timber.

Knots limited in size and position as hereinafter provided will be permitted if so fixed by growth or position that they will retain their place in the piece as at time of manufacture.

For the limitation of knots in beams in size and location, a beam shall be considered as divided into three volumes as shown below:



Measurement of Knots

In beams, the diameter of a knot on the narrow or horizontal face shall be taken as its projection on a line perpendicular to the edge of the timber. On the wide or vertical face, the smallest dimension of a knot is to be taken as its diameter.

In columns, the mean or average dimension of a knot on any face shall be taken as its diameter.

Beams shall not have diagonal or spiral grain in Volumes 1 and 2 with slope greater than 1 in 20; in posts the angle shall not be greater than 1 in 15.

Posts and beams have different restrictions as to knots and angle of grain and must be listed accordingly in bills of material.

No. 1 Structural

No. 1 Structural timbers shall be of Dense Southern Yellow Pine or Dense Douglas Fir, and shall meet the General Requirements for Structural Grades.

This grade shall not have tight pitch pockets over six (6) inches long or over ⅜ inch wide or wane exceeding one (1) inch on one corner or over one-sixth (1/6) the length of the piece.

Loose knots larger than one-half (½) inch shall not be permitted.

Beams, Stringers, Girders and Deep Joists

Beams, Stringers, Girders and Deep Joists shall show not less than 85 per cent. of heart on each side of the four sides measured across the sides anywhere in the length of the piece.

Beams, Stringers, Girders and Deep Joists shall not have knots in Volumes 1 and 2 larger in diameter than one-fourth (¼) the width of the face of the beam in which they occur, up to and including six (6) inches, nor larger than one and one-half (1½) inches in a face over six (6) inches. Knots within the center half of the length of a beam shall not exceed in the aggregate the width of the surface of the beam in which they occur.

Beams shall not have knots in Volume 3 larger in diameter than one-fourth the width of the face in which they occur, with a maximum for any one knot of 3 inches in diameter.

When beams are of two spans length and so marked in bill of materials, Volumes 1 and 2 on inspection shall be considered as extending between points located one-eighth (⅛) the length of the beam from each end.

The inspector shall place his stamp on the edge of the beam or stringer to be placed up in service.

Caps and Sills

Caps and Sills shall show 85 per cent. of heart on each of the four sides, measured across the face anywhere in the length of the piece.

Caps and Sills shall be free from knots larger than one-fourth (¼) the width of the face in which they occur with maximum for any one knot of 3 inches in diameter. Knots shall not be in groups.

Posts

Posts shall show not less than 85 per cent. of heart on each of the four sides, measured across the face anywhere in the length of the piece.

Posts shall not have knots larger than one-fourth (¼) the least dimension of the posts nor larger than three inches. Knots shall not be in groups.

Longitudinal Struts or Girts

Longitudinal Struts or Girts shall show all heart on one face; the other face and two sides shall show not less than 85 per cent. of heart, measured across the face or side anywhere in the length of the piece.

Longitudinal Struts or Girts shall be free from knots over two inches in diameter.

Longitudinal Cross Braces, Sash Braces and Sway Braces

Longitudinal Cross Braces, Sash Braces and Sway Braces shall show not less than 85 per cent. heart on two faces.

Longitudinal Cross Braces, Sash Braces and Sway Braces shall be free from knots larger than one-third the width of the face in which they occur, with a maximum of 2 inches in diameter.

Ties and Guard Rails

Ties and Guard Rails shall show one side all heart; the other side and two edges shall show not less than 75 per cent. heart, measured across the surface anywhere in the length of the piece.

Ties and Guard Rails shall be free from any large knots or other defects which will materially injure their strength; and where surfaced the remaining rough face shall show all heart.

No. 2 Structural

No. 2 Structural Timbers shall meet the General Requirements for Structural Grades, and shall include timbers not passing the No. 1 Grade because of having less density than is required or greater defects than are permitted.

This grade shall not have pitch pockets longer than twelve (12) inches or over ⅜ inch wide or wane exceeding two (2) inches on one corner or the equivalent on two or more corners of 10 x 10 timbers, with wane in proportion on small or large sizes.

Beams, Stringers, Girders and Deep Joists

Beams, Stringers, Girders and Deep Joists shall not have knots in Volumes 1 and 2 larger than as follows:

If of Dense Southern Yellow Pine or Dense Douglas Fir, one-third (⅓) the width of the face of the beam in which they occur, up to and including nine (9) inches, nor larger than three (3) inches in a face over nine (9) inches.

If not of Dense Southern Yellow Pine or Dense Douglas Fir, one-fourth (¼) the width of the face of the beam in which they occur, up to and including six (6) inches, nor larger than one and one-half (1½) inches, in a face over six (6) inches.

Knots in the center half of the length of a beam shall not exceed in the aggregate twice the width of the surface of the beam in which they occur.

Beams shall not have knots in Volume 3 larger in diameter than one-third (⅓) the width of the face in which they occur.

Loose knots larger than one-half (½) the size of knots allowed above shall not be permitted; beams shall not have loose knots, in Volume 3, larger than one and one-half (1½) inches.

Caps and Sills

Caps and Sills shall be free from knots larger than one-half (½) the width of the face in which they occur with a maximum for any one knot of three (3) inches in diameter. Knots shall not be in groups.

Posts

Posts shall not have knots, if of Dense Southern Yellow Pine or Dense Douglas Fir, larger than one-third (⅓) the least dimension of the post, nor larger than four inches; if not of Dense Southern Yellow Pine or Dense Douglas Fir, larger than one-fourth (¼) the least dimension of the post, nor larger than three (3) inches.

Longitudinal Struts or Girts

Longitudinal Struts or Girts shall be free from knots over 2 inches in diameter.

Longitudinal Cross Braces, Sash Braces and Sway Braces

Longitudinal Cross Braces, Sash Braces and Sway Braces shall be free from knots larger than one-third the width of the face in which they occur, with a maximum of 2 inches in diameter.

Specifications for Timber to Be Treated

Specifications for timber to be treated are the same as for untreated timber, except that no restriction is to be placed upon the amount of sap wood allowed in the timber which is to be treated.

Many varieties of timber can be used, if treated, that would not be satisfactory to use in the untreated state on account of being subject to rapid decay if they are not treated.

Commercial Timber and Lumber Grades

TIMBER.

Selected Common.

Selected Common shall be sound, strong timber, well manufactured and free from defects that materially impair its strength. Must be suitable for high-class construction purposes, free from shake, splits, loose or rotten knots. Will allow sound and tight knots, if not in clusters and which in no case shall exceed in diameter one-sixth the width of the face in which such knots occur up to and including 12x12-inch; and further providing that such sound and tight knots in 14x14-inch and larger shall in no case exceed 2½ inches in diameter.

The select common grade also will allow tight pitch pockets, not over six inches in length, wane not to exceed one inch on one corner and not exceeding one-sixth the length of the piece.

White sap or a slight amount of sound stained sap on the back shall not be considered a defect in this grade.

No. 1 Common.

No. 1 Common Timber 6x10 inches and larger shall be sound stock well manufactured and free from defects that will materially weaken the piece. Occasional slight variation in sawing allowed.

Ten by ten-inch timbers may have a 2-inch wane on one corner or the equivalent on two or more corners, checks and season checks not extending over one-eighth the length of the piece. Smaller and larger timbers may have wane in proportion. In addition will allow large sound and tight knots, which approximately should not be more than one-fourth the width in diameter of any one side in which they may appear, spike knots, stained sap one-third the width and slight streak of heart stain extending not more than one-fourth the length of the piece.

No. 2 Common.

No. 2 Common Timbers will admit large, loose or rotten knots; a 10x10-inch may have a 3-inch wane on one corner or the equivalent on two or more corners, larger and smaller sizes in proportion; shake or rot that does not impair its utility for temporary work.

Dimension Plank, Joists, Scantling and Small Timbers.

Selected Common.

Selected Common shall be sound, strong lumber well manufactured and free from defects that materially impair the strength. Must be suitable for high-class construction purposes and free from shake, loose or rotten knots.

Will allow occasional variation in sawing, sound and tight, small and standard knots and tight pitch pockets not over 6 inches in length.

Twelve inches and wider may contain, in addition to the above, a couple of large knots not to exceed 2 inches in diameter when well placed, a slight amount of sap admissible.

No. 1 Common.

No. 1 Common must be sound stock, well manufactured and suitable for all ordinary construction purposes without waste and must be sound and tight-knotted stock.

Will admit knots which in a 2x4 or 3x4 piece may be approximately 1½ inches; in a 2x6-inch or 3x6-inch piece, 2 inches; in a 2x8-inch or 3x8-inch or 2x10-inch or 3x10-inch piece, 2½ inches; and one-fourth the width of the piece in 12 inches and wider; spike knots that do not materially weaken the piece; wane not over one-fourth the thickness of the piece 1 inch wide on face up to 6 inches, and 1½ inches wide on face of 8 inches and wider, extending not more than one-third the length of the piece or a proportionate amount for a shorter distance on both edges, in any case one side and two edges should provide a good nailing surface, and in no case shall wane extend over one-half the side of the piece.

Note: Commercial Timber and Lumber Grades here given apply to Southern Yellow Pine, Douglas Fir, White Pine, Western Pine, Idaho White Pine, Norway Pine, Spruce, Tamarack and Redwood products.

Pith knots or small defective knots which do not weaken the piece more than the knots above allowed are admitted, solid pitch, pitch pockets, sap stain, a limited number of worm holes well scattered, limited torn grain, seasoning checks, splits in ends, not exceeding in length the width of the piece, firm red heart, heart shakes that do not go through.

May contain crook of 1½-inch in 2x4—16 feet, and ⅛ inch less in each additional 2 inches in width up to and including 2x12—16 feet. Length longer or shorter than 16 feet of No. 1 Common Dimension may contain crook in proportion to the above.

No. 2 Common.

This grade shall consist of lumber suitable for a cheaper class of construction than No. 1 Common.

Will admit large, coarse sound knots, which in a 2x4 and 3x4-inch piece should not be larger than 2½ inches in diameter; in 2x6 or 2x8 or 3x6 or 3x8-inch pieces, 3 inches, and in 2x10 or 3x10 or wider pieces one-third the width of the piece in diameter, spike knots, smaller, loose, hollow or rotten knots that do not weaken the piece more than the knots aforesaid, worm holes well scattered, large pitch pockets, rotten streaks, small amount of fine shake, split not to exceed one-quarter the length of the piece, heart and sap stains in any amount, decayed sap, wane if leaving a fair nailing surface.

May contain crook of 2 inches in 2x4—16 feet, and ⅛ inch less in each additional 2 inches in width up to and including 2x12—16 feet. Length shorter or longer than 16 feet may contain crook in proportion to the above.

Miscut 2-inch Common which does not fall below 1½ inches in thickness or ⅛ inch scant in width from standard size, shall be admitted in No. 2 Common, provided such pieces are in all other respects as good as No. 1 Common at point of miscut.

A very serious combination of above defects must not be permitted in any one piece.

No. 3 Common.

No. 3 Common will include all pieces falling below No. 2 Common which are sound enough to use for cheap building material by wasting 25 per cent. of each piece or one-third of number of pieces in any one item of a shipment but it must not be more than ½ inch scant of standard finished width nor ⅜ inch scant of standard finished thickness. This grade will admit a greater degree of all the imperfections allowed in No. 1 and No. 2 Common, but shall not admit useless culls.

Boards, Ship Lap and D & M.

Selected Common.

Selected Common shall be square edged, well manufactured. Will admit sound tight knots not over 1 inch in diameter in 4-inch and 6-inch, not over 1½ inches diameter in 8-inch, medium sized tight pitch pockets not over 6 inches in length, two pith knots, the equivalent of one split not to exceed in length the width of the piece, torn grain, pitch pockets, slight shake, sap stain, seasoning checks, firm red heart, small amount of slightly stained sap. These boards must be of a sound, strong character.

No. 1 Common.

No. 1 Common will admit any two of the following or their equivalent of combined defects:

Sound and tight knots approximately 1½ inches in diameter in 4 and 6-inch; 2 inches in diameter in 8 and 10-inch; 2½ inches in 12-inch and not over 3 inches in diameter in widths over 12 inches.

Pitch pockets, seasoning checks, one straight split not longer than the width of the piece, sap stain, slight streak of heart stain, pith knots, torn grain, slight shake, firm red heart, wane ½ inch deep on edge not exceeding 1 inch in width on face and extending not over one-third the length of the piece, a limited number of pin worm holes well scattered.

These boards must be firm, sound and suitable for use in ordinary construction except finishing purposes without waste.

No. 1 Common Ship Lap or D & M or Barn Siding shall be graded by rules governing No. 1 Common Boards, except as to wane which shall not be so deep as to extend into the tongue or one-half the thickness of the top lip on the groove in D & M, or over one-half the thickness of the lap in Ship Lap on the face side; pieces of Ship Lap with $\frac{5}{16}$ inch of lap will be admitted in any grade.

No. 2 Common.

No. 2 Common will admit large coarse knots not necessarily sound, approximately 2 inches in diameter in 4 and 6-inch stock; 2½ inches in 8 and 10-inch and one-third the width of the piece in 12-inch and wider, spike knots, solid heart or sap stain, solid pitch or pitch pockets, a limited number of well scattered worm holes, splits one-fourth the length of the piece. Small amount of fine shake, wane 2 inches wide if it does not extend into the opposite face, or through heart shakes over one-half the piece or through rotten streaks when firm, ½ inch wide over one-fourth the length of the piece or its equivalent of unsound red heart or combination of defects equivalent to the above but a serious combination of above defects in any one piece not permitted.

A knot hole 2 inches in diameter will be admitted provided the piece is otherwise as good as No. 1 Common.

Miscut 1-inch Common Boards which do not fall below ¾ inch in thickness shall be admitted in No. 2 Common, provided the grade of such thin stock is otherwise as good as No. 1 Common.

No. 3 Common.

No. 3 Common will admit of stock below the grade of No. 2 Common that is suitable for cheap sheathing. The general appearance is coarse. It will admit large coarse knots without restrictions as to size, loose knots, unsound knots, knot holes, pitch pockets, solid pitch, very wormy pieces, shake, heart or sap stain, decayed sap, decayed streaks, well scattered small rotten spots, split, blue sap, wane but a serious combination of above defects in any one piece not permitted. It should cut 75 per cent. of lumber as sound as No. 2 Common.

No. 4 Common.

No. 4 Common shall include all pieces that fall below the grade of No. 3 Common, excluding such pieces as will not be held in place by nailing. After wasting one-fourth the length of the piece by cutting into two or three pieces.

The predominating defect characterizing this grade is red rot. Other defects are numerous large worm holes, several knot holes, or pieces that are extremely coarse knotted, waney, shaky or badly split, extremely cross-checked.

No. 5 Common.

No. 5 Common is the lowest grade and admits of all defects known in lumber provided the piece is strong enough to hold together when carefully handled.

Thick Common Lumber.

Common lumber, 1¼ inches and thicker, shall be graded the same as 1-inch lumber.

Rough Stock for Finish.

Finish must be evenly manufactured and shall embrace all sizes from 1 to 2 inches inclusive in thickness by 3 inches and over in width.

One, 1¼ and 1½-inch finishing lumber unless otherwise ordered shall measure when dry, not more than 1/16 inch scant in thickness and 2-inch not more than ⅛ inch scant in thickness when seasoned.

Stock width shipments of "C" and "Better," either rough or dressed on one or two sides, shall be accepted as standard where not more than 20 per cent. of any shipment is ¼ inch scant on 8-inch widths and under; ⅜ inch scant on 9 or 10-inch; and ½ inch scant on 11 and 12-inch and wider when seasoned; pieces narrower than the above and pieces in excess of 20 per cent. of the shipment that are of the minimum measurement given, should be measured as of the next lower standard width and not reduced in grade.

Standard lengths are 8 to 20 feet; and in shipments of mixed lengths, 5 per cent. of 8 feet in grade of "C" and "Better" shall be admitted. The above percentage of short lengths is customary and in the interest of conservation will be included as far as practicable in all shipments of mixed lengths.

Wane and other defects that will dress out in working standard sizes are admissible.

Finishing lumber ordered rough if thicker than count thickness for dry or green stock, may be dressed to such count thickness, and when so dressed, shall be considered as rough.

Rough finish shall be graded on the best side, but the reverse side must not be more than one grade lower.

Subject to the foregoing provisions, Rough Finishing Lumber shall be graded according to the rules applying to Dressed Finishing Lumber.

When like grade on both faces is required, special contract must be made.

Dressed Finishing Lumber.

Selected Flat Grain.

Selected Flat Grain shall be finishing lumber free from all sap or defects on face and edges and shall be selected for beauty and character of grain.

"A" Finishing inch, 1¼, 1½ and 2-inch dressed one or two sides up to and including 12 inches in width, must show one face practically clear of all defects, except that it may have such wane as would dress off if surfaced four sides; 13-inch and wider "A" Finishing will admit two small defects or their equivalent. "B" Finishing, inch, 1¼, 1½ and 2-inch dressed one or two sides, up to and including 10 inches in width in addition to the equivalent of one split in end which should not exceed in length the width of the piece, will admit any two of the following or their equivalent of combined defects; slightly torn grain, three pin knots, one standard knot, three small pitch pockets, one standard pitch pocket, one standard pitch streak, 5 per cent. of sap stain or firm red heart; wane not to exceed 1 inch in width, ¼ inch in depth and one-sixth the length of the piece, small seasoning checks.

Eleven-inch and wider "B" Finishing will admit three of the above defects or their equivalent, but sap stain or firm red heart shall not exceed 10 per cent.

"C" Finishing up to and including 10-inch in width will admit in addition to the equivalent of one split in end which should not exceed in length the width of the piece, any two of the following, or their equivalent of combined defects: 25 per cent. of sap stain, 25 per cent. firm red heart, two standard pitch streaks, medium torn grain in three places, slight shake, seasoning checks that do not show an opening through, two standard pitch pockets, six small pitch pockets, two standard knots, six pin knots, wane 1 inch in width, ½ inch in depth and one-third the length of the piece. Defective dressing or slight skips in dressing will also be allowed that do not prevent its use as finish without waste. Eleven-inch and 12-inch "C" Finishing will admit one additional defect or its equivalent. Pieces wider than 12 inches will admit two additional defects to those admitted in 10-inch or their equivalent, except sap stain which shall not be increased.

Selected Flat Grain.

Pieces otherwise as good as "B" will admit of twenty worm holes.

Special Finish.

In case both sides are desired, "A," "B" or "C" grade, or free from all defects, special contract must be made. Defective dressing or slight skips in dressing on the reverse side of Finishing are admissible.

Moulded Casing, Base, Window and Door Jambs.

Moulded Casing and Base shall be worked to ¾ inch thick as per established patterns.

Window and Door Jambs are to be dressed, rabbeted and plowed as ordered.

Grades A, B and C.

"A" Grade must be practically free from defects on the face side and well manufactured.

"B" Grade shall admit the same defects as are admissible in the same widths of "B" Finishing except wane.

"C" Grade shall admit the same defects as are admissible in the same widths of "C" Finishing except wane.

Moulding.

"B and Better" Moulding. One-third of any item may contain any one of the following defects or its equivalent: One pin knot, small pitch pockets, pitch 1 inch wide, 6 inches long, three pin worm holes, slight defects in dressing.

Standard lengths; 8 feet and longer, and in shipments of mixed lengths 5 per cent. of 6 or 7 feet shall be admitted, even though the number of feet of each length be specifically stated.

Drop Siding.

Defects named in Drop Siding are based upon a piece manufactured from 1x6—12 feet, and pieces larger or smaller than this will take a greater or lesser number of defects, proportioned to their size on this basis.

The amount of crook permissible in No. 1 Common and Better Drop Siding may be as follows:

Sixteen-foot lengths as a basis for 4-inch widths, 3 -inch crook.

Sixteen-foot lengths as a basis for 6-inch widths, 2½-inch crook.

Lengths longer or shorter than 16 feet may have a proportional amount of crook.

In all grades of Drop Siding wane on the reverse side, not exceeding one-third the width and one-sixth the length of any piece is admissible, providing the wane does not extend into the tongue.

"A" Drop Siding.

"A" Drop Siding must be practically free from defects on the face side and well manufactured.

Slight roughness in dressing admissible.

A piece 14 feet or longer may have one defect located 4 feet or more from the end that can be cut out by wasting not more than 1½ inches of the length, provided balance of piece be practically free from other defects.

"B" Drop Siding.

"B" Drop Siding will admit any two of the following defects: Medium torn grain, three pin knots, one standard knot, 15 per cent. sap stain, 15 per cent. firm red heart, small seasoning checks, six pin worm holes or any one of the above defects combined with either three small pitch pockets or one small pitch streak.

A piece that is otherwise as good as "B" grade may have a defect that can be cut out by wasting not more than 2½ inches in the length of the piece, providing the defect is 4 feet or more from the end.

No. 1 Drop Siding.

No. 1 Common Drop Siding will admit numerous small or several medium or one large pitch pocket, one standard pitch streak and in addition sound knots not over one-half the width of the piece in the rough, a couple of small knot holes, pin worm holes or a few well scattered grub-worm holes, sap stain, firm red heart, slight shake, heavy torn grain, seasoning checks that do not show an opening through, defects in manufacturing that will lay without waste. A very serious combination of above defects not permissible in any one piece.

Pieces otherwise as good as "B" Drop Siding may have one defect (like a knot hole) that can be cut out by wasting 2½ inches of the length of the piece, provided both pieces are 16 inches or over in length after cutting out such defects.

No. 2 Common Drop Siding.

No. 2 Common Drop Siding admits of all pieces not as good as No. 1 Common that can be used without waste of more than one-fourth the length of any one piece.

Bevel Siding.

Bevel Siding shall be graded according to the rules for Drop Siding and will admit in addition slight imperfections on the thin edge, which will be covered by the lap when laid 2½ and 4½ inches to the weather.

Rustic Siding.

Rustic Siding shall be graded according to the rules for Drop Siding.

FLOORING.

Special.

Defects named in Flooring are based upon a piece manufactured from 1x4—12 feet long, and pieces larger or smaller than this will take a greater or lesser number of defects, proportioned to their size on this basis, except that standard knots shall not exceed 1¼ inches in diameter in 3-inch flooring.

The amount of crook permissible in No. 1 Common and Better Flooring may be as follows:

Sixteen-foot lengths as a basis for 3-inch widths, 3½-inch crook.
Sixteen-foot lengths as a basis for 4-inch widths, 3 -inch crook.
Sixteen-foot lengths as a basis for 6-inch widths, 2½-inch crook.

Lengths longer or shorter than 16 feet may have a proportionate amount of crook.

Standard Matched Flooring to be surfaced two sides with scored back.

Center Matched Flooring (S2S and C. M.) shall be required to come up to grade on one side only, and the defects admissible on the reverse side of standard match shall be allowed.

GRADES A, B, C, D, AND NO. 1 COMMON, EDGE OR VERTICAL GRAIN.

GRADES A, B, C, D, NO. 1 COMMON, NO. 2 COMMON, NO. 3 COMMON OR NO. 3 SHEATHING, FLAT GRAIN.

Grade "A" Edge Grain Flooring.

Admits no piece in which angle of the grain exceeds 45° from vertical at any point. This grade shall be well milled on face, must have perfect edges and be practically free from all defects on the face side. Bright sap showing not more than one-third of face half the length of piece will be admitted.

Grade "B" Grain Flooring.

Admits no piece in which angle of the grain exceeds 45° from vertical at any point. This grade will admit any two of the following or their equivalent of combined defects: Five per cent. sap stain, 15 per cent. firm red heart, three pin knots, one standard pitch streak, slight torn grain, small seasoning checks.

Grade "C" Edge or Vertical Grain Flooring.

Admits no piece in which angle of the grain exceeds 45° from vertical at any point. This grade will admit any two of the following defects or their equivalent or combined defects. Fifteen per cent. sap stain, 25 per cent. firm red heart, six pin knots, two standard knots, small pitch pockets, two standard pitch pockets, two standard pitch streaks, twelve pin worm holes, slight shake that does not go through, seasoning checks that do not show an opening through, medium torn grain or other machine defects that will lay without waste.

A piece 12 feet or longer otherwise as good as "B" may have a defect that can be cut out and the piece laid with a loss of not more than 2½ inches in its length, providing the defect is 4 feet or more from the end of the piece.

Grade "D" Edge or Vertical Grain Flooring.

Admits no piece in which angle of the grain exceeds 45° from vertical at any point. This grade will admit the following defects or their equivalent of combined defects. Sap stain, firm red hearts, sound knots not over one-half the cross-section of the piece in the rough and any one point throughout its length, three pith knots, pitch, pitch pockets, a limited number of pin worm holes well scattered, shake that does not show an opening through, loosened or heavy torn grain or other machine defects that lay without waste.

Pieces otherwise as good as "B" Flooring may have one defect (like a knot hole) that can be cut out by wasting 20 inches of the length of the piece, provided both pieces are 16 inches or over in length after cutting out such defects.

It is generally understood that this grade will admit such defects or combination of defects as will not impair its utility for cheap floors.

No. 1 Common Flooring is the combined grade of C and D Flooring and will admit all pieces that will not grade "B" and are better than No. 2 Common Flat Grain Flooring.

Flat Grain Flooring shall take the same inspection as Edge or Vertical Grain, except as to requirement of angle of the grain.

No. 2 Common Flooring.

Admits all pieces that will not grade as good as "D" Flooring that can be used for cheap floors without waste of more than one-fourth the length of any one piece.

Pieces of flooring having not less than $\frac{1}{16}$ inch tongue will be admitted in No. 2 Common.

No. 3 Common on No. 3 Sheathing.

Admits all pieces that cannot be used as No. 2 Common Flooring but are still available as cheap sheathing or lathing without waste of more than one-fourth the length of any one piece.

Ceiling.

Defects in Ceiling are based upon a piece manufactured from 1x4—12 feet long, and pieces larger or smaller than this will take a greater or lesser number of defects, proportionate to their size on this basis.

The amount of crook permissible in No. 1 Common and Better Ceiling may be as follows:

Sixteen-foot lengths as a basis for 3-inch widths, 3½-inch crook.
Sixteen-foot lengths as a basis for 4-inch widths, 3 -inch crook.
Sixteen-foot lengths as a basis for 6-inch widths, 2½-inch crook.

Lengths longer or shorter than 16 feet may have a proportionate amount of crook. In all grades of Ceiling wane on the reverse side, not exceeding one-third the width and one-sixth the length of any piece, is admissible providing the wane does not extend into the tongue.

Ceiling may be specified either as Edge or Vertical Grain or Flat Grain. The inspection will be the same for either kind.

"A" Ceiling.

"A" Ceiling must be practically free from defects on the face side, well manufactured, will admit of slight roughness in dressing, through close pitch pockets, each not to exceed 2 inches in length, or one sound and tight smooth pin knot, or the equivalent of combined defects.

"B" Ceiling.

"B" Ceiling will admit of any two of the following defects or their equivalent of combined defects: Slight torn grain, three pin knots, two small or one standard knot, three small pitch pockets, any two of which may be open, one standard pitch pocket, one small pitch streak, small seasoning checks, 15 per cent. sap stain, 15 per cent. firm red heart, six pin worm holes.

A piece otherwise as good as No. 2 may have a defect that can be cut out and the piece laid with a waste of not more than 2½ inches in length, providing the defect is 4 feet or more from the end of the piece.

No. 1 Common Ceiling.

No. 1 Common Ceiling will admit the following defects or their equivalent of combined defects: Heavy torn grain, sound knots not over one-half the cross-section of the piece in the rough, pitch, pitch pockets, seasoning checks that do not show an opening through, a sap stain, firm red heart, slight shake, defects in manufacture that will lay without waste, a limited number of pin worm holes well scattered.

Pieces otherwise as good as "B" Ceiling may have one defect (like a knot hole) that can be cut by wasting 2½ inches of the length of the piece, providing both pieces are 16 inches or over in length after cutting out such defects.

No. 2 Common Ceiling.

No. 2 Common Ceiling admits of all pieces not as good as No. 1 Common that can be used without waste of more than one-fourth the length of any one piece.

Pieces of Ceiling having not less than $\frac{1}{16}$ inch tongue, will be admitted in No. 2 Common.

Partition.

Grades "A," "B," No. 1 Common and No. 2 Common. Partition shall be graded according to Ceiling rules and must meet the requirements of the specified grades on the face side only, but the reverse side shall not be more than one grade lower, and shall not cause waste in No. 1 Common and Better.

Specifications for Construction Oak

General Instructions.

Those who are not familiar with the anatomy of the oak tree should, when reading over these rules, take into consideration that the rule describes the poorest piece that goes into the grade and that a large per cent. is above the grade described.

Definition of Oak for Construction Purposes.

The term "Construction Oak" means all such products of oak in which the strength and durability of the timber is the controlling element in its selection and use. The following is a list of products which are recommended for consideration as "Construction Oak."

Firsts are to be sound and free from heart shakes and checks, but may have other defects as follows:

Construction Oak.

Trestle and Bridge Timbers.—Mud Sills, Stringers, Caps, Posts, Bracing, Bridge Ties, Struts, Guard Rails, Girts, Sash and Sway Braces.

Docking and Platform Timbers.—Mud Sills, Posts, Bracing, Caps, Stringers, Joists, Dock and Platform or Flooring Plank and Wales.

Platform or flooring plank can be either square-edged or matched.

Ties.—Switch ties.

Framing for Building.—Mud Sills, Posts, Girders, Framing Joists, etc. etc.

Bridge and Crossing Plank.—Railroad Crossing Plank, Bridge Floor Planking.

Sheet Piles.—Same as Crossing Plank, except may contain an unlimited amount of heart.

Round Piling.

Stock Guards.

Track or Bumper Posts.

Standard Names for Construction Oak.

Unless specifically mentioned, the terms "White Oak" and "Red Oak" include the following:

"White Oak"	"Red Oak"
White Oak	Red Oak
Chestnut or Tanbark Oak	Pin Oak
Burr or Mossy Cup Oak	Black Oak
Rock Oak	Water Oak
Post or Iron Oak	Willow Oak
Overcup Oak	Spanish Oak
Live Oak	Turkey Oak
Basket or Cow Oak	Black Jack or Barn Oak
Swamp Post Oak	Shingle or Laurel Oak
Yellow or Chinquapin Oak	Scarlet Oak

Term—Mixed Oak means any kind of Oak.

Specifications for Structural Oak Timbers

General Requirements.

(1) Except as noted, all Structural Timbers shall be White Oak, to be sound timber and sawed specified sizes, free from ring shakes, crooked grain, rotten knots, large knots in groups, rot, dote, wane in amounts greater than allowed in these specifications.

Boxed Hearts.

(2) Boxed Hearts are permitted in pieces of 5 by 5 inches square and larger. The center of the heart should be boxed as near the center of the piece as practical, and not to exceed 30 per cent of the pieces can have the center of the heart nearer than 1½ inches from any face; 20 per cent may show one heart face, corner or edge, not to exceed 75 per cent of the length of the piece.

Wane.

The term 20 per cent of number of pieces or amount shipped refers to each item and size of each car shipped.

(a) Pieces 5 x 5 to 8 x 8 inches square may show 1 inch wane, side measurement, on any two corners or edges, and this wane not to exceed more than 25 per cent of the length of the piece singly, or 50 per cent in aggregate. In the absence of wane on all corners excepting one, the one corner may contain wane 50 per cent of the length of the piece as above described; not to exceed 20 per cent of number of pieces may have this defect.

(b) Pieces over 8 x 8, including 12 x 12 inches square, may show 1½ inch wane, side measurement, edge of any two corners or edges, and this wane not to exceed more than 33⅓ per cent of the length of the piece singly, or 66⅔ per cent in aggregate. In the absence of wane on all of the length of the piece as above described, not to exceed 20 per cent of the number of pieces may have this defect.

(c) Pieces over 12 by 12 inches square may show 1¾ inch side measurement, any two corners of edges, and this wane not to exceed more than 40 per cent of the length of the piece singly, or 80 per cent in aggregate, in the absence of wane on all corners, excepting one, the corner may contain wane 80 per cent of the length of the piece as above described; not to exceed 20 per cent of number of pieces may have this defect.

(d) In event that pieces have two faces as wide as above described and two faces narrower, the proportion of the amount of wane is admissible.

(e) Pieces 1 inch to 5 inches thick, not exceeding 8 inches wide, are governed by defect specifications above mentioned, with the exception that they shall not contain wane, and not to exceed 20 per cent of pieces 2 inches and thicker may show sound heart on one face; pieces under 2 inches thick must be free of heart. Pieces 8 inches and wider may contain wane as per paragraphs b and d.

(f) Rough sizes of Structural Timber shall not vary more than ¼ inch scant of specified size. Dressed sizes may be ½ inch scant after dressing.

Ties.

(1) **Switch Ties Sawed.** Thickness cut to order, widths cut to order; lengths cut to order; unless noted to be White Oak. Must contain three sound solid sides. One face or one corner (not both) may show sound heart. Large sound knots, pin spot or an occasional grub-worm hole not considered a defect. Sizes may vary ½ inch from specified sizes.

Bridge, Dock, Crossing Plank.

Lengths, cut to order
Widths, cut to order
Thickness, cut to order

Sizes cut to order, probably 2 inches, 3 inches and 4 inches thick, 6 inches, 8 inches, 10 inches and 12 inches wide, 12 feet, 14 feet and 16 feet long.

This product is intended to work full one good sound face, and this face side must be square edge. Sound knots, small pin and spot worm holes no defect on face side.

Must be free from rot and shake; practically square edges, admitting 1 inch of wane on each edge of reverse face, running two-thirds the length. Sound hearts on one side, rafting pin holes, knot holes or grub holes not exceeding 2 inches in diameter admitted.

Sheet Piles.

Same as Ties, except that it may contain sound heart in heart check.

Stock Guards.

To be governed by specifications for Construction Oak.

Track End or Bumping Posts.

To be governed by specifications for Structural Timbers.

Classification and Grading Rules for Cypress Lumber and Shingles

General Instructions.

Cypress lumber shall be graded according to the following rules and specifications, bearing in mind that as no arbitrary set of rules and specifications can be maintained in every case, each must be left to the commonsense and best judgment of the inspector.

1. Lumber shall be manufactured and shipped in standard lengths and thickness.

2. Tank, 1st and 2d and worked partition shall be graded from the poorer side.

3. Select lumber, flooring, ceiling, bevel siding and finishing shall be graded from the better or finished side, but the reverse side should in no case be more than one grade lower.

4. All lumber shall be tallied surface or face measure, the tally counted up, and the one-quarter or one-half added to the total where the lumber is one and one-quarter or one and one-half inches thick, and 2 inches and thicker to be multiplied by the thickness.

5. In the measurement of all lumber, fractions exactly on the one-half foot are to be given alternately to the buyer and seller; the fractions below the one-half foot are to be dropped, and all fractions above one-half foot are to be counted to the next higher figure on the board rule.

6. In "line boards," pieces 14 feet and longer shall be given the advantage in grade; pieces 12 feet and shorter shall be reduced in grade.

7. Recognized defects in cypress are knots, knot holes, shakes, splits, wane, wormholes, stained sap and peck.

Standard Lengths.

8. Random standard length stock may be furnished in odd as well as even foot lengths, but there shall not be to exceed 20 per cent of odd lengths in any one item.

9. Tank stock and No. 1 barn shall be 8 feet and longer.

10. 1st and 2d and select shall be 10 to 20 feet.

11. Finish, flooring, ceiling, partition, bevel and drop siding shall be 10 to 20 feet.

12. Moldings and battens of all sizes 6 to 20 feet, in both odd and even foot lengths, but not exceeding 10 per cent of 6, 7, 8 and 9 foot lengths.

13. No. 2 barn, 6 feet and longer.

14. Cull or peck, 4 feet and longer.

Standard Finished Sizes of Cypress.

15. Lumber shipped in the rough (except 8/4 inch No. 1 and No. 2 "Dimension," which grades may be ¼ inch under or ¼ inch over the size specified, both in thickness and width) shall be of sufficient thickness to S2S to standard thickness, as follows:

16. 4/4 Lumber S1S or S2S shall be 13/16 inch thick.

17. 5/4 Select, 1st and 2d clear, selected common tank and tank lumber S1S or S2S, shall be 1⅛ inches thick.

18. 6/4 Select 1st and 2d clear, selected common tank and tank lumber S1S or S2S, shall be 1⅜ inches thick.

19. 6/4 Peck, No. 1 and No. 2 barn and finishing lumber S1S or S2S shall be 1 5/16 inches thick.

20. 8/4 Lumber, except No. 1 and No. 2 barn dimension S1S or S2S, shall be 1¾ inches thick.

21. 8/4 No. 1 and No. 2 barn or dimension S1S or S2S, shall be 1⅝ inches thick.

22. 10/4 Lumber S1S or S2S, shall be 2¼ inches thick.

23. 12/4 Lumber S1S or S2S, shall be 2¾ inches thick.

24. All lumber S1E takes off ⅜ inch. S2E, ½ inch.

25. All flooring shall be S2S and CM.

26. 4/4 Flooring shall be 13/16 inch by 2¼ inch, 3¼ inch, 4¼ inch, 5¼ inch face.

27. 5/4 Flooring shall be 1 1/16, 6/4 shall be 1 5/16, by same widths as 4/4.

28. 3/8 Ceiling shall be worked 5/16 inch, S1S only.

29. 1/2 Ceiling shall be worked 7/16 inch, S1S only.

30. 5/8 Ceiling shall be worked 9/16 inch, S1S only.

31. 3/4 Ceiling shall be worked 11/16 inch, S1S only.

32. Widths of ceiling to be the same as flooring, unless otherwise specified. Ceiling up to ¾ inch face to have one bead on one edge and ceiling wider than 3¼ inch face to be beaded center and edge.

33. Partition to be finished the same as ceiling, but on both faces

34. Drop siding shall be worked ¾ inch by 3¼ inch, 4½ inch, 5¼ inch, 7¼ inch, 9¼ inch face, S2S and CM or shiplapped.

35. Bevel siding or bevel cribbing shall be worked ½ inch less in width than the rough strip measure.

Tank Stock.

36. Shall be random widths, and will not be furnished in specified widths, and shall be graded from the poorer side.

37. Shall be 5 inches and wider, 1½ inches to 4 inches thick and 8 feet and over in length. Pieces up to 7 inches shall be free from sap. Pieces 7 inches to 13 inches may have one inch of sound sap on one edge, not to exceed half the length and half the thickness of the piece. Pieces 14 inches and wider may have 1 inch of sound sap on both edges not to exceed half the length and half the thickness of the piece. In all widths sound knots that do not impair usefulness for tank purposes may be admitted.

First and Second Clear.

38. Shall be random widths, and will not be furnished in specified widths, and shall be graded from the poorer side.

39. Shall be 8 inches and wider, 1 inch to 4 inches thick and 10 feet and over in length. Pieces 8 inches to 10 inches may have 1 inch of bright sap on each edge, or its equivalent on one or both edges, otherwise they must be clear. Pieces 10 inches and under 12 inches may have 1½ inches of bright sap on each edge or 3 inches on one edge, and may have one standard knot or its equivalent. Pieces 12 inches wide may have 2 inches of bright sap on each edge, or 4 inches on one edge and may have one standard knot; or, in lieu

of sap, may have two standard knots or their equivalent. Pieces wider than 12 inches may admit of defects as specified above in proportion as width increases. Pieces 10 inches and wider may admit of one end split, which shall not exceed in length the width of the piece. Pieces 12 inches and less in width, free from other defects, may have bright sap across one face at one end, but this sap shall not exceed in length one-tenth of the length of the piece. In pieces 13 inches and wider bright sap is not a defect.

Selects.

40. Shall be random widths, and will not be furnished in specified widths, and shall be graded from the better side, but the reverse side shall not be of a lower grade than No. 1 shop or No. 1 barn.

41. Shall be 7 inches and wider, but will not be furnished wider than 12 inches; shall be 1 inch to 4 inches thick, 10 feet and longer. Pieces 10 inches and under in width shall admit two standard knots or their equivalent and an additional standard knot or its equivalent for every 2 inches in width over 10 inches. Pieces free from other defects, 10 inches and over in width, to admit pin wormholes on one edge one-tenth the width of the piece. Bright sap is not a defect in this grade. Slight wane on pieces 10 inches and over in width is allowed on one edge not over 3 feet in length. When no other defect appears, slight amount of stained sap may be allowed. Pieces 10 inches and wider may admit of one end split, which shall not exceed in length the width of the piece.

Selected Common Tank Stock.

42. Shall be 4 inches wide, or wider, 1½ inches and 2 inches thick, 8 feet and over in length. Sound sap no defect in this grade, but must be free from unsound knots or other defects that extend through the thickness of the piece, and must be square edged to work the full length of the piece.

No. 1 Barn or Dimension.

43. Shall be specified widths only, shall be 3 inches and wider, 1 inch and thicker, 8 feet and over in length, admitting sap, bright or stained, shake, season checks, knots, pin wormholes, a small amount of peck on one side and one edge, or very slight peck on both sides and both edges of pieces comparatively free from coarse defects; which defects, however, shall not be sufficient to seriously impair the strength, or prevent the use of each piece for "common" purposes in its full length and full width.

No. 2 Barn or Dimension.

44. Shall be specified widths, 3 inches and wider, 1 inch and thicker, 6 feet and over in length, admitting all the defects allowed in No. 1 barn, but same may be larger and coarser, and in addition

will admit peck on both sides; however, the defects shall not be sufficient to prevent the use of each piece in full length and full width for low-grade fencing and other very common purposes.

Cull or Peck.

45. May be random or specified widths 3 inches and wider, 1 inch to 4 inches thick, 4 feet and over in length. Shall admit all pieces below the grade of No. 2 boxing, and shall also admit the product of that part of the log known as "pecky;" however, each piece shall have sufficient strength and nailing surface to permit its use as a low-grade boxing, crating, sheathing and foundation material.

Finishing.

46. Shall be specified widths 4 inches and wider, 1 inch to 2 inches thick, 10 feet and over in length, and shall be graded from the better side, A, B and C, but the reverse side should not be more than one grade lower. All grades of finish, rough or S1S or S2S may vary ¼ inch from the width specified.

47. "A" **Finish.**—Pieces 4 inches and 5 inches wide shall be clear of sap, knots and other defects. Pieces 6 inches wide may have 1 inch of bright sap, or, in lieu of sap, one small sound knot. Pieces 7 inches and 8 inches wide may have 2 inches of bright sap, or, in lieu of sap, one small sound knot. Pieces 9 inches and 10 inches wide may have 3 inches of bright sap, or, in lieu of sap, two small sound knots, or 1½ inches of bright sap and one small sound knot. Pieces 12 inches wide may have 4 inches of bright sap, or, in lieu of sap, one standard knot, or two small sound knots, or two inches of bright sap and one small sound knot. Pieces 14 inches or wider may have more defects in proportion as the width increases.

48. "B" **Finish.**—Pieces 4 inches, 5 inches and 6 inches wide may have 2 inches of bright sap and one or two small sound knots, or in lieu of knots may have all bright sap. Pieces 7 inches and 8 inches wide may have 3 inches of bright sap and two small sound knots, or in lieu of knots may have all bright sap. Pieces 9 inches and 10 inches wide may have 4 inches of bright sap and one standard knot or three small sound knots, or in lieu of knots may have all bright sap. Pieces 12 inches wide may have 6 inches of bright sap and one standard or four small sound knots, or in lieu of knots may have all bright sap. This grade will not be furnished wider than 12 inches.

49. "C" **Finish.**—All widths in this grade shall admit small sound knots, stained sap, pin worms and other defects except shake; but none that will prevent the use of same in its full width and length as a paint grade, and will admit pieces containing one coarse defect which can be removed by making two cuts with a waste of not to exceed 5 per cent in the one piece removed, but which pieces are otherwise "B" grade or better. This grade will not be furnished wider than 12 inches.

50. "D" **Finish.**—All widths will admit sound knots, stained sap, pin worms, slight shakes and other defects; but none that will prevent the use of same in its full width and length as a common paint grade. This grade will not be furnished wider than 12 inches.

Siding.

51. Siding shall be 4 inches and 6 inches in width, 10 feet to 20 feet in length, and graded from the finished side, A, B, C and D.

52. "A" **Siding.**—May have one inch of bright sap on thin edge and may contain one small sound knot.

53. "B" **Siding.**—May have any amount of bright sap, or, if not all bright sap, may have three small sound knots, shake, split or pin worm holes not exceeding in damage the three small knots as above, and may have slight wane on the thin edge. In the absence of other defects a small amount of stained sap will be permitted.

54. "C" **Siding.**—May have one to 5 knots, the whole not aggregating over 3 inches in diameter, or knots, splits or other defects that can be removed in two cuts with waste not exceeding 10 per cent. of the length, or may have small amount of stained sap and pin worm holes not exceeding in damage the five small knots above described.

55. "D" **Siding.**—May have stained sap and pin worm holes, or may have other defects that will not cause a waste to exceed one-third the piece.

Flooring and Ceiling.

56. Shall be specified widths, 10 feet to 20 feet in length and graded from the finished side, or, if both sides are finished, it shall be graded from the better side, A, B, C and D.

57. "A"—May have bright sap on one edge one-fourth its width, otherwise must be clear.

58. "B"—May have one-half of its face bright sap if otherwise clear, or, in lieu of sap, may contain two small sound knots, or may have a split not to exceed 9 inches at one end.

59. "C" (10 to 20 feet)—May have all bright sap, or may have one to five knots, the whole not aggregating over 3 inches, or knots or other defects that can be removed in two cuts with waste not exceeding 10 per cent. of the length, or may have three pin worm holes, or may have check or split at one end, not to exceed 10 per cent. of the length.

60. "C" (4 to 9 feet)—May have all bright sap, small sound knots, stained sap, pin worm holes and other defects except shake, but none that will prevent the use of each piece the full length.

61. "D"—May have stained sap and pin worm holes, or may have unsound knots or other defects that will not cause a waste to exceed one-third the piece

Partition.

62. Shall be same widths and lengths as flooring and ceiling, but shall be graded from the poorer side, A, B, C and D, same grading to apply as in flooring and ceiling.

Pickets.

63. Shall be graded No. 1 and No. 2.
64. 1 Inch by 1 inch shall be Headed and S4S to $\frac{13}{16}$ inch by $\frac{13}{16}$ inch.
65. 1¼ Inches by 1¼ inches shall be Headed and S4S to 1$\frac{1}{16}$ inches by 1$\frac{1}{16}$ inches.
66. 1½ Inches by 1½ inches shall be Headed and S4S to 1$\frac{5}{16}$ inches by 1$\frac{5}{16}$ inches.
67. 1 Inch by 3 inches shall be Headed and S4S to ¾ inch by 2½ inches.
68. No. 1—Shall be well manufactured, bright sap no defect, and may contain one small sound knot.
69. No. 2—Shall admit stained sap, sound knots, pin worm holes, slight shake, and pickets thrown out of the No. 1 grade because of poor manufacture.

Battens.

70. Battens, both flat and OG, are not moldings. Same are invariably used with "common" lumber and shall, therefore, be graded No. 1 barn and better, admitting all defects allowed in No. 1 barn, but none that will prevent the use of each piece in full length for batten purposes. Three-eighth inch battens shall be 1 inch strips S2S to $\frac{13}{16}$ inch by 2½ inches and resawed, or 1 inch by 2¾ inches to 3 inches S2S and resawed. Unless otherwise specified, ⅜-inch or flat battens shall be S2S only and resawed.

71. OG battens shall be manufactured in the sizes and pattern shown in the Universal Molding Book.

Shingles.

72. **Bests.**—A dimension shingle, 4, 5 and 6 inches in width, 16 inches long, each width packed separately, 5 butts to measure 2 inches, to be all heart and free of shake, knots and other defects.

73. **Primes.**—A dimension shingle, 4, 5 and 6 inches in width, 16 inches long, each width packed separately, 5 butts to measure 2 inches, admitting tight knots and sap, but free of shake and other defects, but with no knots within 8 inches of the butts.

74. This grade may contain shingles clipped two-thirds of the width and one-eighth of the length on the point.

75. **Star a Star.**—A random width shingle, 3 inches and wider, 14 inches to 16 inches long, otherwise the same as primes.

76. **Economy.**—Dimensions 4, 5 and 6 inches, each width separately bunched, admitting sap and sound knots; may have slight peck 5 inches from butts, imperfections on points no objection and admitting 14-inch shingles.

77. **Clippers.**—All shingles below the above grades which are sound for 5 inches from butts, wormholes and slight peck excepted, random widths 2½ inches and wider.

78. The count of manufacture of shingles, of all grades, is based on 4,000 linear inches in width, making 1,000 standard shingles, consequently there would be only 667 6-inch shingles packed and counted as 1,000 standard shingles; 5 inches dimension being counted in like proportion.

79. In making re-inspection of shingles, one bundle out of 20 bundles, taken at random, shall be cut open, the results of this investigation to form the basis of arriving at the grade of the entire shipment.

Classification and Grading Rules for Hemlock Lumber

Sap

White or bright sap shall not be considered a defect in any of the grades provided for and described in these rules, except where stipulated.

Water Stain

In hemlock will often be found streaks or patches of red or brown discolorations, sound and firm, the presence of which does not weaken the wood, nor detract seriously from its utility. Water stain should not be confused with rot, being firm and strong, while rot is soft and decayed wood.

Standard Sizes for Hemlock

Rough Lumber

Piece Stuff.

Standard lengths for Rough Piece Stuff are 4, 6, 8, 9, 10, 12, 14, 16, 18, 20, 22 and 24 ft. Standard widths are 4, 6, 8, 10 and 12 inches. Standard thickness is 1⅞ inches.

Boards.

Standard lengths for Rough Boards are 4, 6, 8, 10, 12, 14, 16, 18 and 20 ft. Standard widths are 4, 6, 8, 10 and 12 inches. Standard thickness is 15/16 inch.

Dressed Lumber

Piece Stuff.

Standard sizes for Piece Stuff S1S1E are: 1¾x3¾, 1¾x5¾, 1¾x7¾, 1¾x9¾, 1¾x11¾.

Boards.

The standard thickness for inch lumber S1S is $\frac{13}{16}$ inch.

Flooring, Ceiling, Shiplap, Drop Siding.

Standard widths are: 3¼, 5¼, 7¼, 9¼ and 11¼ in. face. Standard thickness is $\frac{13}{16}$ in.

Estimated Weights of Hemlock Lumber

Per M Feet, Shipping Dry.

3 in. Plank, Rough	3,000
3 in. Plank and 4x4 to 8x8, S1S1E	2,700
3 in. Plank, S4S or D & M	2,500
4x10 to 12x12, Rough	3,500
4x10 to 12x12, S1S1E	3,200
4x4 to 8x8, Rough	3,000
Thick D & Better, S1S	2,500
Thick D & Better, S1S1	2,200
2 in. Piece Stuff, S1S1E	2,200
2 in. Piece Stuff, Rough or S1E	2,500
2 in. Piece Stuff, S4S or D & M	2,000
1 in. Boards, Rough	2,400
1 in. Boards, S1S or S2S	2,000
1 in. Clear and Select, S1S	2,000
Shiplap, D & M, or Drop Siding	1,800
1x6 Well Tubing, Beveled Edges	1,800
Sheathing Lath	1,500
Lath	500
32 in. Lath	300

Grading Rules

Thick D and Better.

1. Thick D and Better shall be 4 in. wide and wider, 1¼ in., 1½ in. and dimension thickness.

2. This grade shall have sound, square edges, and be of grade of Inch D Stock and Better on the face side, and not below the grade of Inch No. 1 Common on the back of the piece.

Boards and Strips.

There are six grades made in Boards and Strips:

Inch Clear and Select.	No. 2 Common.
Inch D Stock	No. 3 Common.
No. 1 Common	No. 4 Common.

Inch Clear and Select.

1. Inch Clear and Select should be 4 in. and wider, and 8 ft. long and longer, not to exceed 10 per cent. 8 ft. long.

2. This grade is especially adapted for interior finish and only the face, or best side, is expected to show, although some attention should be given to the back of the piece.

3. The face shall show no wane, but the back may show such an amount of wane or other defects as will not interfere with the use of the piece for finishing purposes.

4. No shake or season check shall be allowed on the face side, but a very little tight shake and checks that are not deep may appear on the back of the piece.

5. This grade will admit on the face side several tight pin knots not over 3/8 in. in diameter. In a 4 or 6 in., 12 ft. and longer piece, not more than three knots are admissible, and proportionately more in a wider piece.

6. A 10 or 12 in. piece, 12 ft. and longer, will not admit of more than three sound, firmly set knots, not to exceed 3/4 in. in diameter. Narrower and shorter pieces will admit of fewer large knots, but not a combination of large knots and other defects.

7. Pieces 12 ft. and longer are admissible that will, with not more than 10 per cent. of waste, produce two clear cuts, each four feet long or longer.

Inch D Stock.

1. Inch D Stock shall consist of Boards and Strips below the grade of Clear and Select 4 in. and wider, and 8 ft. long and longer, not to exceed 10 per cent. 8 ft. long, and must be of a sound and water-tight character.

2. All knots must be sound and firmly set. Red knots must not exceed 1 1/4 in. in diameter, and spike knots must not exceed in length one-fourth the width of the piece. Black knots must not exceed 3/4 in. in diameter, and must be especially well set.

3. A 6-in. strip 12 ft. long shall not contain more than three defects of the extreme sizes. A wider or longer piece may contain relatively more of these defects, and narrower and shorter pieces relatively less. The general appearance of the piece must be taken into consideration.

4. No shake shall be allowed in this grade, but slight season checks and water stain shall not be considered defects.

5. This grade shall be suitable for sound Drop Siding, Ceiling and Flooring, and shall have a smooth appearance, especially on the edges.

Inch No. 1 Common.

1. The grade of No. 1 Common in Boards or Strips includes stock of a generally sound character.
2. Some shake is admissible.
3. Numerous knots, whether red or black.
4. Some water stain of a firm character.

Inch No. 2 Common.

1. Boards or Strips will admit of considerable shake.
2. Black, unsound knots.
3. Two or three good-sized knot holes, or more of small ones.
4. Streaks, or patches of discoloration, showing partial decay.
5. This grade can be safely recommended for general building purposes.

Inch No. 3 Common.

1. The defects may consist of excessive shake.
2. Very coarse, unsound knots.
3. Some soft rot.
4. Some cross checks.

Inch No. 4 Common.

4 In. and Wider, 4 Feet and Longer.

This grade includes all serviceable lumber below the grade of No. 3.

Piece Stuff or Dimension.

No. 1 Dimension

1. The grade of No. 1 Dimension will admit of shake that will not materially affect the strength of the piece.

2. Also knots, either black or red, that are well located and fairly sound.

3. Or some slight cross checks or sound water stain.

4. This grade, while admitting the above defects, must at the same time retain the element of strength required for any building purpose.

No. 2 Dimension

1. The grade of No. 2 Dimension includes stock not good enough to be classed as No. 1, and the defects admissible are of the same general character as the defects found in No. 1, except that they are more pronounced.

2. Considerable shake, large unsound knots, loose knots, knot holes and cross checks are all admissible in this grade, but not a serious combination of these defects in any one piece.

Merchantable

The grade of Merchantable is a combination of No. 1 and No. 2, consisting of approximately 50 per cent. of each.

No. 3 Dimension

1. The defects are excessive shake, numerous knot holes, coarse, rotten knots, or considerable rot.

2. This grade can be recommended for cheap, light construction.

No. 4 Dimension

2x4 and Wider, 4 Feet and Longer.

This grade includes all serviceable Dimension below the grade of No. 3.

CLASSIFICATION OF THE USES OF LUMBER

1. **Bridge and Construction Timber.**

A. Combination and Howe Truss Spans.
1. Compression members.
2. Tension members.
3. Diagonals subject to reversal of stress.
4. Floor beams.
5. Stringers.
6. Ties.
7. Guard timbers.
8. Railing.
9. Stiffeners.
10. Splices.
11. Nailing strips.
12. Grillage.
13. Deck plank.
14. Bridging.

B. Pile and Frame Trestles.
1. Piles.
2. Sills and mud sills.
3. Posts.
4. Caps.
5. Cross bracing.
6. Sash bracing.
7. Longitudinal bracing.
8. Girts.
9. End plank.
10. Stringers.
11. Ties.
12. Guard timbers.
13. Planking for ballasted deck.
14. Railing.

C. Falsework.
1. Piles.
2. Sills and mud sills.
3. Posts.
4. Caps.
5. Stringers.
6. Truss timbers.
7. Centering.
8. Lagging.
9. Bracing.
10. Wedges.
11. Scaffolding.

D. Concrete Forms.
1. Dimension lumber.
2. D. & M. planks.
3. Bracing.

E. Tanks and Supports.
1. Piles.
2. Sills.
3. Posts.
4. Caps.
5. Bracing.
6. Joists.
7. D. & M. flooring.
8. Staves.
9. Rafters.
10. Roof.
11. Ladders, etc.
12. Frost-box material.

F. Docks and Wharves.
1. Piles.
2. Timber sheet piling.
3. Timber in cribs.
4. Caps.
5. Stringers.
6. Bracing.
7. Guard timber.
8. Ties.
9. Plank decking.
10. Mooring posts.
11. Fenders and wales.
12. Warehouse. (See II.)

G. Coaling Stations and Ore Stations.
1. Piles.
2. Sills and mud sills.
3. Posts.
4. Caps.
5. Bracing.
6. Stringers.
7. Joists.
8. Bin lining.
9. Rafters.
10. Flooring.
11. Chutes.
12. Decking.
13. Coal pockets or bins.
14. Roofing.

2. **Frame Buildings.**

A. Station Buildings, Passenger, Freight, Platform Shelters.
1. Piles.
2. Caps.
3. Sills.
4. Posts.
5. Stringers.
6. Joists.
7. Bridging.
8. Sub-flooring.
9. Finish flooring.
   (a) Pine.
   (b) Fir.
   (c) Maple or oak.
10. Studding and plates.
11. Sheathing.
12. Furring.
13. Siding.
14. Ceiling.
15. Lath.
16. Truss timbers.
17. Purlins.
18. Rafters.
19. Roof boards.
20. Shingles.
21. Door and window frames.
22. Outside finish lumber.
23. Inside finish lumber.
24. Millwork.
   (a) Mouldings.
   (b) Stairs.
   (c) Doors.
   (d) Windows.
25. Partitions.
26. Shelving.

B. Engine House.
1. Piling.
2. Caps.
3. Sills.
4. Posts.
5. Stringers.
6. Joists.
7. Bridging.
8. Flooring.
9. Pit timbers.
10. Studding.
11. Sheathing.
12. Furring.
13. Siding.
14. Ceiling.
15. Lath.
16. Truss timbers.
17. Purlins.
18. Rafters.
19. Roof boards.
20. Shingles.
21. Door and window frames.
22. Outside finish lumber.
23. Inside finish lumber.
24. Millwork.
25. Sleepers.

C. Machine Shops.
1. Piling.
2. Caps.
3. Sills.
4. Posts.
5. Stringers.
6. Joists.
7. Bridging.
8. Flooring.
9. Studding.

10. Sheathing.
11. Furring.
12. Siding.
13. Ceiling.
14. Lath.
15. Truss timbers.
16. Purlins.
17. Rafters.
18. Roof boards.
19. Shingles.
20. Door and window frames.
21. Outside finish lumber.
22. Inside finish lumber.
23. Millwork.
24. Sleepers.

D. Section Houses.
1. Posts.
2. Sills.
3. Caps.
4. Stringers.
5. Joists.
6. Bridging.
7. Sub-flooring.
8. Finish flooring.
9. Studding and plates.
10. Sheathing.
11. Furring.
12. Siding.
13. Ceiling.
14. Lath.
15. Rafters.
16. Roof boards.
17. Shingles.
18. Door and window frames.
19. Outside finish lumber.
20. Inside finish lumber.
21. Millwork.

E. Miscellaneous Small Buildings.
1. Posts.
2. Sills.
3. Caps.
4. Stringers.
5. Joists.
6. Bridging.
7. Sub-flooring.
8. Finish flooring.
9. Studding and plates.
10. Sheathing.
11. Furring.
12. Siding.
13. Ceiling.
14. Lath.
15. Rafters.
16. Roof boards.
17. Shingles.
18. Door and window frames.
19. Outside finish lumber.
20. Inside finish lumber.
21. Millwork.

F. Warehouses.
1. Piling.
2. Caps.
3. Sills.
4. Posts.
5. Stringers.
6. Joists.
7. Bridging.
8. Sub-flooring.
9. Finish flooring.
10. Studding and plates.
11. Sheathing.
12. Furring.
13. Siding.
14. Ceiling.
15. Lath.
16. Truss timbers.
17. Purlins.
18. Rafters.
19. Roof boards.
20. Shingles.
21. Door and window frames.
22. Outside finish lumber.
23. Inside finish lumber.
24. Millwork.
25. Sleepers.

G. Ice Houses.
1. Piling.
2. Sills.
3. Caps.
4. Posts.
5. Stringers.
6. Joists.

7. Bridging.
8. Sleepers.
9. Sub-flooring.
10. Finish flooring.
11. Studding.
12. Sheathing.
13. Furring.
14. Siding.
15. Ceiling.
16. Lath.
17. Truss timbers.
18. Purlins.
19. Rafters.
20. Roof boards.
21. Shingles.
22. Door and window frames.
23. Outside finish lumber.
24. Inside finish lumber.
25. Millwork.

3. Ties.

A. Track Ties.
B. Switch Ties.

4. Miscellaneous Roadway Material.

A. Crossing Plank.
B. Platforms.
 1. Posts.
 2. Caps.
 3. Sills.
 4. Stringers.
 5. Joists.
 6. Bridging.
 7. Planking.
 8. Railing.
 9. Steps.
 10. Skids.
C. Stock Guards.
 1. Posts.
 2. Ties.
 3. Wing fences and aprons.
 4. Slats.
 5. Fillers.
D. Signs and Posts.
 1. Posts.
 2. Bracing.
 3. Sign boards.
 4. Moulding.
E. Fencing, Including Snow Fence.
 1. Posts.
 2. Bracing.
 3. Stringers.
 4. Fence boards.
 5. Gate material.
 6. Stakes.
F. Culverts and Drains.
 1. Sills.
 2. Bracing.
 3. Timbers.
 4. Planking.
 5. Grillage.
G. Stock Pens.
 1. Posts.
 2. Sills.
 3. Fencing.
 4. Studding.
 5. Sheathing.
 6. Rafters.
 7. Roof boards.
 8. Shingles.
 9. Outside finish lumber.
H. Poles.
I. Conduits.
J. Bumping Blocks.
K. Cross-arms.

WORKING STRESSES PERMISSIBLE FOR STRUCTURAL TIMBERS (Pounds per Square Inch)

Species	Bending. Allowable stress in extreme fiber. Damp or wet location (docks, piling, and sills)	Outside, not in contact with soil (bridges and open sheds)	Under shelter in a dry location (factories and ware-houses)	Allowable horizontal shear stress. All locations	Compression. Allowable stress parallel to grain "Short Columns." Wet location	Outside location	Dry location	Allowable stress perpendicular to grain. Wet location	Outside location	Inside location
Cedar, western red	750	800	900	80	650	700	700	125	150	200
Cedar, northern white	600	650	750	70	450	500	550	100	140	175
Chestnut	700	850	950	90	600	700	800	150	200	300
Cypress	900	1100	1300	100	800	1100	1100	225	250	350
Douglas fir—										
No. 1 structural	1100	1400	1600	100	900	1100	1200	225	250	350
No. 2 structural	900	1100	1300	90	800	900	1000	200	225	300
Rocky Mountain region	700	900	1100	85	700	800	800	200	225	275
Fir, balsam	600	750	900	70	500	600	700	100	125	150
Gum, red	800	900	1100	100	650	750	800	150	200	300
Hemlock, western	900	1100	1300	75	800	900	900	200	225	300
Hemlock, eastern	800	900	1000	70	600	700	700	200	225	300
Hickory	1200	1500	1900	140	1000	1200	1500	350	400	600
Larch, western	900	1100	1200	100	800	1000	1100	200	275	325
Maple, sugar or hard	1000	1300	1500	150	900	1100	1200	300	375	500
Maple, silver or soft	700	900	1000	100	600	700	800	200	250	350
Oak, white or red	1000	1200	1400	125	800	900	1000	300	375	500
Pine—										
Southern yellow (dense)	1100	1400	1600	125	900	1100	1200	225	250	350
Southern yellow (sound)	900	1100	1300	105	800	900	1000	200	225	300
Eastern white	750	800	900	85	650	750	750	125	150	250
Western white	750	800	900	85	650	750	750	125	150	250
Norway	800	1000	1100	85	700	800	800	150	175	300
Redwood	800	1000	1200	70	750	900	1000	125	150	250
Spruce, red, white and Sitka	800	900	1100	85	650	750	800	125	150	250
Spruce, Engelmann	500	650	750	70	450	550	600	100	140	175
Tamarack, eastern	900	1100	1200	95	800	900	1000	200	225	300

REPORT OF COMMITTEE VIII—ON MASONRY

J. J. Yates, *Chairman;*
J. T. Andrews,
R. Armour,
G. E. Boyd,
T. L. Condron,
L. N. Edwards,
J. E. Freeman,
T. L. D. Hadwen,
Geo. T. Hand,
W. K. Hatt,
L. J. Hotchkiss,
S. C. Hollister,
Job Tuthill, *Vice-Chairman;*
R. L. Humphrey,
Noah Johnson,
M. S. Ketchum,
W. S. Lacher,
A. E. Owen,
W. M. Ray,
F. E. Schall,
Z. H. Sikes,
F. P. Sisson,
L. L. Tallyn,
C. C. Westfall,

Committee,

To the American Railway Engineering Association:

The subjects assigned by the Board of Direction for study and report for 1920 and the sub-committees appointed by the Chairman were as follows:

1. Make thorough examination of the subject-matter in the Manual, and submit definite recommendations for changes.

Sub-Committee (1). A. E. Owen, Chairman; Z. H. Sikes, F. P. Sisson.

2. Report on distintegration of concrete and corrosion of reinforcing materials in connection with the use of concrete in sea water.

Sub-Committee (2). F. E. Schall, Chairman; J. T. Andrews, R. Armour, S. C. Hollister.

3. Report on (a) the effect upon the strength and durability of concrete not having a sufficiency of moisture present throughout the period of hardening, as compared with concrete fully supplied with moisture; (b) methods for providing moisture during this period; (c) remedy for concrete hardening with insufficient moisture.

Sub-Committee (3). J. E. Freeman, Chairman; L. N. Edwards, R. L. Humphrey, Noah Johnson.

4. Study and report on the distribution of loads through ballast and embankments as affecting the design of masonry structures.

Sub-Committee (4). Job Tuthill, Chairman; W. M. Ray, W. K. Hatt.

5. Report on methods for conveying and depositing concrete.

Sub-Committee (5). T. L. Condron, Chairman; L. J. Hotchkiss, L. L. Tallyn, T. L. D. Hadwen.

6. Review and keep advised as to the practical application of specifications relating to design of concrete and reinforced concrete structures as developed by the Joint Committee on Concrete and Reinforced Concrete.

Sub-Committee (6). Job Tuthill, Chairman; G. E. Boyd, Geo. T. Hand, M. S. Ketchum, W. S. Lacher, F. E. Schall, C. C. Westfall, J. J. Yates.

Joint Committee on Standard Specifications for Concrete and Reinforced Concrete. Organized February 11th, 1920.

This committee consists of five members each for the American Society of Civil Engineers, American Concrete Institute, Portland Cement Association, American Society of Testing Materials, American Railway Engineering Association.

R. L. Humphrey, Chairman; J. J. Yates, Vice-Chairman; D. A. Abrams, Secretary-Treasurer.

The members appointed by the Board of Direction were G. E. Boyd, F. E. Schall, C. C. Westfall, H. T. Welty, J. J. Yates.

Special Joint Committee composed of two members each of the American Society of Civil Engineers, American Society for Testing Materials, American Concrete Institute, American Concrete Pipe Association, American Railway Engineering Association to prepare Specification for Concrete Pipe.

The members assigned by the Board of Direction were Job Tuthill and A. F. Robinson.

Committee Meetings

The following meetings of the Full Committee were held: Chicago, May 20th; New York, August 24th; New York, October 25th.

The following meetings of the Joint Committee on Standard Specifications on Concrete and Reinforced Concrete were held: Philadelphia, February 11, 1920; Asbury Park, June 22-23-24; New York, October 26-27-28; New York, December 15-16-17; New York, March 2-3-4, 1921.

In addition there were several meetings of the Joint Committee on Specifications for Concrete Pipe.

Reports

The Committee presents reports on Subjects 2 and 3.

The work of the Committee has been largely confined to the Joint Committee on "Standard Specifications on Concrete and Reinforced Concrete," a report of which Committee is expected in 1921.

Pending the receipt of the report of this Joint Committee, reports on Subjects 1-5 and 6 are deferred, as the subject-matter contained therein is being considered in connection with the work of that Committee.

Progress is being made on Subject 4 and on the Special Committee on "Specifications for Concrete Pipe" and the experimental work is well under way.

CONCLUSIONS

Your Committee recommends the following action be taken on its report:

That Conclusions 1, 2, 3, 4, 5 and 6 as given in Appendix A be approved and substituted in the Manual for Conclusions 1, 2, 3 and 4 as they appear on page 294 of the 1915 Manual under Disintegration of Concrete and Corrosion of Reinforcing Metal.

That the report of Sub-Committee 3 as given in Appendix B be accepted and printed in the Proceedings as information.

Suggestions for Future Work

Continue Subjects 1-4 and 6.

Continue representation on Joint Committees on "Standard Specifications for Concrete and Reinforced Concrete" and "Specifications for Concrete Pipe."

Substitute for Subject 3 the following:

"Study and report on the developments in the art of making Concrete."

Study and report on Failures of Concrete Structures.

Respectfully submitted,

THE COMMITTEE ON MASONRY,

J. J. YATES, *Chairman.*

Appendix A

(2) DISINTEGRATION OF CONCRETE AND CORROSION OF REINFORCING MATERIAL IN CONNECTION WITH THE USE OF CONCRETE IN SEA WATER

F. E. SCHALL, *Chairman*, Sub-Committee.

General.

The report of the Masonry Committee of March, 1919, contains a list of a large number of articles published relating to the use and action of concrete in sea water, either deposited in sea water or precast, and, after seasoning, placed in sea water.

From the long list, it will be seen that a great deal of attention has been given in the past to this subject, not only on the American Continent, but also in Europe and other countries.

Many of the investigations published, however, are based upon laboratory tests, which, while very interesting and valuable, do not furnish all the facts as to the action of sea water on concrete. Concrete placed in sea water is not only subject to a chemical action taking place in the transformation of some of the elements composing the concrete, but more particularly to the mechanical attacks due to the action of the tides, waves, ice, drift or accident, the variation of temperature, especially in the colder latitudes, all tending to injure the film of the exposed surface. When this film is once pierced or abraded, the aggregates and binding material offering less resistance, are exposed to these attacks, causing the more or less rapid destruction and failure of the concrete.

Engineering publications in the past record many failures of concrete placed in sea water; the causes are variously ascribed to the chemical effect of sea water on concrete, to the mechanical action of the tides and waves (largely aggravated in Northern latitudes by alternate freezing and thawing between high and low water level), poor selection of aggregates or lack of proper workmanship, etc.

Whether such failures were due to any one of the causes mentioned or to their combined action cannot be answered directly. It is known, however, that in the development of the various methods of proportioning, mixing and depositing of concrete during the past few years, much has been accomplished to make a concrete that will better serve the general requirements of good concrete construction. With proper study of all the conditions encountered in a particular piece of work, and with first-class material and workmanship, it is thought possible that concrete may be made that will withstand the action of sea water in warm climates, if guarded against abrasion, and by providing special face protection against the action of frost or floating objects, between low and high water, concrete may also withstand sea water in the colder climates.

The most valuable recent addition to the multitude of publications on the subject under treatment was made by Messrs. Rudolph Wig of the U. S. Bureau of Standards, and Lewis R. Ferguson of the Portland Cement Association, in a series of five articles published in the Engineering News-Record between September 20th and October 25th, 1917, covering examination and criticism of most of the marine structures on the various coasts of the United States.

Your Committee has made a study of many of the publications on tests, experiences and results of concrete construction in sea water; some report good results, others failures. The question arises, upon what basis are satisfactory results reported in one case and what caused the failure in another?

Plain Concrete in Sea Water.

For concrete structures in sea water particular attention is to be given to designing, to the avoidance of all sharp corners, offsets or pockets tending to obstruct the flow or gliding of waves and floating objects past the structure.

The cement used in this class of work to be Portland Cement, which must meet the requirements of the current specifications of the American Railway Engineering Association.

In the proportioning of fine and coarse aggregates, it is most important that a highly dense, impervious product be obtained. It is recommended that thorough tests be made to establish that mix which will result, with the aggregates used, in securing the greatest density of the concrete, and to continue these tests to maintain this proper mix at all times, until the completion of the work. Allowance should be made for the loss of cement when concrete is deposited into sea water. Special attention must be given to exposed surfaces to secure a hard, even and non-porous face of concrete.

For pre-cast concrete blocks, piles, etc., placed in sea water, the foregoing requirements are equally important. Better results have generally been obtained heretofore with pre-cast blocks than with concrete deposited into sea water, but the blocks must be well seasoned before being placed in position.

The sand must be free from clay or other foreign matter; clean well graded fine to coarse sand will produce the best results.

The coarse aggregate should be carefully selected. It must be uniformly hard and durable. Non-porous screened washed gravel is preferable for sea water work, especially in colder climates, although sound hard crushed stone may be used. Gravel affords better mixing and it settles more easily into place. Bank-run gravel, however, should not be used, since generally its quality is not uniform.

Sea water has been used in the gauging of concrete, and it was found that the strength of the concrete is affected only to a small extent. Fresh water should be used when such can be obtained without unreasonable expense.

The gauging of the concrete is of great importance; the consistency should neither be too dry nor too wet. If deposited in air, a consistency that permits of light tamping and packing to bring water to the surface without much effort, will generally be best; rodding, to secure greater density, may be employed to good advantage.

The time of mixing of the concrete for sea water construction must receive special attention, and should be tested out with the particular mix used, so that all particles of the fine and coarse aggregates are thoroughly coated and the full strength of the cement used obtained. It is an established fact that the strength of the concrete increases, according to the time allowed for mixing, up to a certain point, and full advantage should be taken of this element; two minutes is considered a minimum.

In depositing concrete into sea water, continuous operations must be employed and the greatest care exercised if failure is to be avoided, either using a well-designed watertight tremie or a bottom drop bucket. It is important that the concrete be deposited systematically. If a tremie is used, it must be kept filled at all times; when a charge is lost, the tremie must be withdrawn and refilled. If a drop bucket is used, the concrete is to be discharged from the bucket alongside the last previously placed; the whole of the surface should be kept as level as possible. In all cases, enclosed cofferdams should be used to prevent washing. In case of unavoidable interruption of the work, it is most important that the top surface be thoroughly cleaned of laitance after the stoppage of work before additional concrete is placed. The concrete above the low water line should be tamped and compacted as it is placed and thoroughly worked next to the forms, to obtain a dense smooth non-porous surface.

If the foregoing is followed, a good and lasting plain concrete should be obtained, but this is only possible by constant vigilance, rigid supervision and care, in every detail of the process of construction. The least infraction on the established proportions or laxity in thorough workmanship may lead to failure.

Reinforced Concrete in Sea Water.

The protection of reinforcing steel in concrete placed in sea water is dependent upon the density, impermeability and lasting qualities of the concrete in which it is embedded, and the distance of the reinforcing steel from the surface of the concrete. When the surface film of the concrete is once abraded by mechanical or other action, the reinforcement may be reached by the sea water either through capillary attraction or exposure of the metal. The steel will then rust, causing its destruction, and also the spalling of the concrete by reason of the enlargement of the rusted steel. It is, therefore, imperative to construct a dense, impermeable concrete when steel reinforcement is employed.

Where possible, mass construction should be adopted for such part of concrete structures as will come in contact with sea water, between high and low water, and even for the parts above the high water line, steel reinforcement should be so placed that there is at least 3 inches dense concrete between the surface of concrete and the face of the steel to prevent moisture from the salt air penetrating to the metal.

Conclusions

1. Concrete for sea water work should be mixed in the proportions of one part Portland Cement to not more than six parts of fine and coarse aggregates, measured separately and combined in such proportions as will produce a concrete of maximum density and impermeability. Only enough water should be added to secure plastic workability. The concrete shall be mixed in a batch mixer for not less than two minutes after all the materials are in the drum. Where concrete is deposited into sea water, the above proportions should be reduced to one part of cement to not more than five parts of separately measured aggregates. Tests should be made from time to time during the progress of the work to maintain the proper proportions of the aggregates throughout construction.

2. Concrete should be deposited in the air wherever practicable. When necessary to deposit concrete in water, it should be protected from currents by cofferdams or similar means.

3. The concrete, where practicable, should be deposited in a continuous operation to a point 5 ft. above high water. In case of unavoidable stoppage of the work, the previously cast concrete should be thoroughly cleaned of all laitance.

4. From 2 ft. below low water to 2 ft. above high water, or from a plane below to a plane above wave action, the face of the concrete should be adequately protected against mechanical abrasion and frost action. Construction or other joints should in every case be avoided within this zone. Sharp corners and projections should also be avoided, but where necessary they should be rounded to reduce abrasion to a minimum.

5. If reinforcement is used in concrete in sea water, special attention should be given in the design to the position of the reinforcement. In no case should the steel be nearer than 3 in. to any plane or curved surface, and not less than 4 in. from any two adjacent surfaces.

6. The most rigid rules in regard to workmanship and inspection should be established and constantly enforced on all sea water work.

Appendix B

(3) (A) THE EFFECT UPON THE STRENGTH AND DURABILITY OF CONCRETE NOT HAVING A SUFFICIENCY OF MOISTURE PRESENT THROUGHOUT THE PERIOD OF HARDENING; (B) METHODS FOR PROVIDING MOISTURE DURING THIS PERIOD; (C) REMEDY FOR CONCRETE HARDENING WITH INSUFFICIENT MOISTURE.

J. E. FREEMAN, *Chairman*, Sub-Committee.

This subject was covered by report of the committee as published in Volume 20, page 748, and there is little to add this year, but in reviewing its work the Committee was impressed with the desirability of broadening its investigation to include other important elements affecting the strength and durability of concrete.

The Committee therefore recommends that the next assignment be included under the subject "Study and Report on the Developments in the Art of Making Concrete."

It also recommends that a bulletin be prepared and issued next year incorporating the Specifications for Cement, Reinforcement and Concrete and Reinforced Concrete as they appear in the Manual, together with an appendix of selective information on the art of making concrete that may be of use to the constructing and designing engineer.

In line with the above, the Committee presents the following as information:

EFFECT OF AGE AND CONDITION OF STORAGE UPON THE STRENGTH OF CONCRETE (SEE NOTE)

A series of tests have been made at the University of Illinois supplemented by investigations made by the C. B. & Q. R. R. to determine the effect of age and condition of storage upon the strength of concrete. The results of the tests have been summarized as follows: (See Figs. 1 and 2.)

"1. The strength of the concrete which was stored in contact with moisture increased rapidly up to an age of 1 year; the increase in strength at ages greater than 1 year, although considerable, took place at a much less rapid rate.

2. The air-stored concrete attained nearly its final strength at a comparatively early age and gained little strength with the lapse of time.

3. The concrete which had been stored in air for a considerable time increased in strength greatly after it had been stored in contact with moisture so that further hydration of the cement could take place; the strength of the specimens stored in damp sand 2 years and 8 months

after they were 2 years and 4 months old was 1.46 times the strength of the specimens which remained stored in air for 5 years.

4. The strength of the concrete at an age of 7 days for both damp sand storage and air storage was about 70 per cent. of the strength at 28 days; at an age of 1 year the strength of the concrete stored in damp sand was about twice as strong as at 28 days and the air-stored concrete was only 10 per cent. stronger than at 28 days. At an age of 5 years the strength of the concrete stored in damp sand was about 2.5 times the strength at 28 days and the strength of the air-stored concrete about 1.3 times the strength at 28 days.

5. At ages of 3 and 5 years the strength of the concrete stored in damp sand was about 1.9 times the strength of the air-stored concrete.

6. For the specimens stored in air the strength at an age of 8 years was slightly more than that at 6 months.

7. The strength of the specimens stored in water for 10 months after they were 7 years old was 1.3 times the strength of the specimens which remained stored in air for 8 years.

It seems apparent that concrete in structures exposed to air which is not damp will gain little strength beyond that attained at the earlier ages, in the portions where loss of moisture takes place, while concrete in contact with moisture or dampness will continue to gain in strength for some years."

Note.—For full description of tests see: "Some Tests on the Effect of Age and Condition of Storage on the Compressive Strength of Concrete."—H. F. Gonnerman, University of Illinois. Proceedings American Concrete Institute, Vol. XIV, page 101 (1918).

TABLE I.—COMPRESSIVE STRENGTH OF CONCRETE AT DIFFERENT AGES FOR VARIOUS CONSISTENCIES AND CONDITIONS OF STORAGE

Each Value, Unless Otherwise Indicated, is an Average of Four or More 6x6-in Cylinders. Proportions, 1:2½:3½ by Weight.

Series	Consistency	Water Used in Mixing, per cent.	Storage Conditions	Compressive Strength in lb. per sq. in. at Age of									
				7 Days	14 Days	21 Days	28 Days	2 Mos.	6 Mos.	1 Yr.	2 Yrs.	3 Yrs.	5 Yrs.
D	Dry	8.4	Damp Sand	1751	2140	2658	2615	3332	3934	3945	4890	5340	4540
S	Normal	9.3	Damp Sand	1390	1775	1816	1820	3063	3431	3765	4042	5116	5174
W	Wet	10.2	Damp Sand	1103	1354	1623	1657	2410	3281	3757	3914	4278	4295
A	Normal	9.3	Air of Lab	1481	2061	2126	2116	2232	2049	2350	2189	2780 3455#	2774 4058#
P	Normal	9.3	Coated with paraffin, damp sand	....	....	....	2314	2521	3329	3671	4235	4340	4472

#Stored in damp sand when two years and four months old.

Tests for Plasticity of Concrete

Concrete must be plastic in order that it may be molded to the desired outlines and placed around the reinforcing members, but an excess of water in the mixture has a very detrimental effect upon the strength and other properties of concrete. Similarly a deficiency in the quantity of mixing water reduces the strength of the concrete though not to such a marked extent.

The curve shown in Figure 3 indicates the variation in strength resulting from a variation in the quantity of mixing water. The amount of water required to produce the consistency needed for greatest strength is taken as 100 per cent. or "Normal Consistency." The use of more or less than this amount of water results in a decided falling off in strength.

Slump Test.

For measuring the plasticity of a concrete mixture a method has been developed called the "Slump Test." A metal form is used, the form having the shape of a truncated cone 4 in. in top diameter, 8 in. in bottom diameter and 12 in. high. Figure 4 shows a plan for making this form. It should be made of No. 20 gauge iron or heavier, and provided with a handle for lifting. If desired a ring or several lugs may be fastened to the outside of the cone at the base to assist in holding it down with the foot when filling with concrete.

The slump test is made as follows: Place the concrete in the form in three layers of approximately 4-in. thickness, puddling each layer with 25 to 30 strokes from a ⅝-in. round steel bar 21 in. long, pointed at the lower end. Immediately after molding, remove the form by a steady upward pull and measure the height of the concrete in inches; this height subtracted from 12 in. is the "slump.' (Fig. 5.)

Concrete of "Normal Consistency" will give a slump of ½ to 1 in. (Fig. 6.) If the plastic condition of the concrete regardless of the quality of water used is called the "Relative Consistency," which is assumed to be 1.00 for "Normal Consistency," then a relative consistency of 1.10 contains 10 per cent. more water, etc. A relative consistency of 1.10 to 1.20 represents about the driest concrete that can be used in construction work without interfering with its workability.

Flow Table.

Another method for measuring the plasticity or flowability of concrete has been developed by the U. S. Bureau of Standards and makes use of an apparatus called a "flow table." (Figs. 7 and 8.) A metal covered table top supported on a frame is arranged so that it can be raised vertically by means of a cam working at the bottom of a vertical post to which the table top is attached. The amount of drop can be adjusted by means of a bolt at the lower end of the post.

A sheet metal mold placed at the center of the table top is filled with mortar or concrete. This mold has the shape of a hollow frustrum of a cone and for aggregates up to 2 in. maximum size is 6 in. high, 8 in.

in diameter at the top and 12 in. at the bottom. For smaller aggregates when made up in small quantities a 3 in. cone, 4 in. in diameter at the top and 6 in. at the bottom is substituted. (Figs. 9 and 10.)

The concrete when placed in the mold is tamped just enough to fill it completely, then the mold is withdrawn vertically and by turning the cam shaft the table top is dropped 15 times in about 10 seconds through a distance of ½ in. This causes the concrete to flatten out and spread over the table top, usually concentrically. Two diameters at right angles to each other—the long and the short if there is apparent difference—are measured with a self-reading caliper, so graduated that the sum of the two readings is the value for "flowability." This may also be calculated by dividing the new diameter by the old and multiplying by 100.

A typical curve indicating the relation between the quantity of mixing water used and resulting flowability of concrete is shown in Figure 11.

Table 2—Approximate Quantity of Mixing Water Required for Certain Concrete Mixtures*

Mix.		Appropriate Mix as Usually Expressed.			Water Required (Gallons per Sack of Cement.)	
Cement	Volume of Aggregate After Mixing	Cement	Aggregate		Minimum	Maximum
			Fine	Coarse		
1	3	1	1¼	2½	5	5½
1	4	1	1½	3	5½	6
1	4½	1	2	3	5¾	6¼
1	5	1	2	4	6	6½
1	6½	1	2½	5	7¼	7¾
1	7¾	1	3	6	8¼	8¾

*Revision of Table on page 729, Vol. 20.

Effect of Low Temperatures on Concrete

Cold retards the hardening action of cement and the effect produced increases with the decrease in temperature until the hardening action practically ceases at temperatures below freezing.

By heating aggregates and mixing water in cold weather the temperature of the concrete is increased to that approaching normal temperatures during warm weather or even exceeding such temperatures, which, combined with adequate protection of the concrete while hardening so as to maintain favorable temperature and moisture conditions, enables the concrete to harden properly.

There has been a tendency to relax cold weather precautions when temperatures slightly above the freezing point (35 deg.-40 deg.) are encountered, but the hardening action of cement at such temperatures is very slow and good judgment requires that under such conditions the aggregates and mixing water be heated so that the concrete will have a temperature of at least 50 deg. Fahr. and precautions taken to maintain this temperature in the concrete for three days at least.

Hool & Johnson state in "Concrete Engineer's Handbook," p. 77, "At 40 deg. Fahr. concrete requires four times as long a period to attain a given strength as the same concrete at 50 deg. Fahr.; and at 40 deg. Fahr. about nine times as long as at 70 deg. Fahr. Below 40 deg. Fahr. the ratio still further increases." A. B. McDaniel in his paper "Influence of Temperature on the Strength of Concrete" (Proceedings Am. Conc. Institute, 1916, p. 241), states in his conclusions:

"It is evident that if the concrete is to acquire a reasonable self-sustaining or a load-bearing strength in a short time (conditions which ordinarily obtain on building work), it is necessary to place the concrete under the most favorable conditions and maintain these conditions during the first few days. Concrete which is protected and maintained at a temperature of from 60 deg. to 70 deg. Fahr. will at the age of one week have practically double the strength of the same material which is kept unprotected at a low temperature of from 32 deg. to 40 deg. Fahr. Under freezing temperature conditions the materials should be heated so that the concrete will have an average temperature of from 60 deg. to 70 deg. Fahr., and the concrete in place kept under an air temperature of not less than 45 deg. Fahr. by artificial heat during the first week. This provision for favorable temperature conditions avoids the well-known injurious effect of the freezing of the water in the concrete, and also the deteriorating effect of the alternate freezing and thawing of the concrete."

When aggregates and mixing water are heated the temperature of the concrete when placed will generally be well above 50 deg. This minimum was set to prevent use of cold materials and water at temperatures close to but above freezing, as that would make the temperature of the concrete 35 to 40 deg. Fahr. and would seriously reduce its ability to gain in strength, without considering the effect of a sudden drop in temperature upon such a weak concrete.

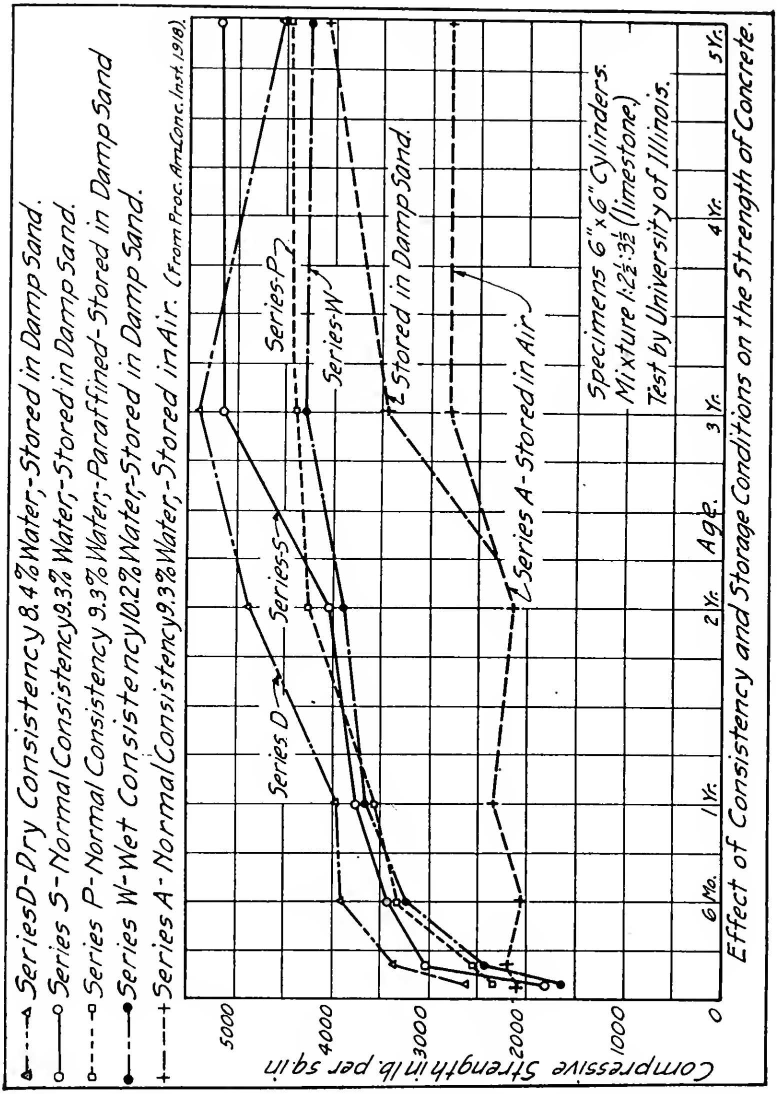


FIG. 1—EFFECT OF AGE ON COMPRESSIVE STRENGTH OF CONCRETE OF DIFFERENT CONSISTENCIES AND STORAGE CONDITIONS.

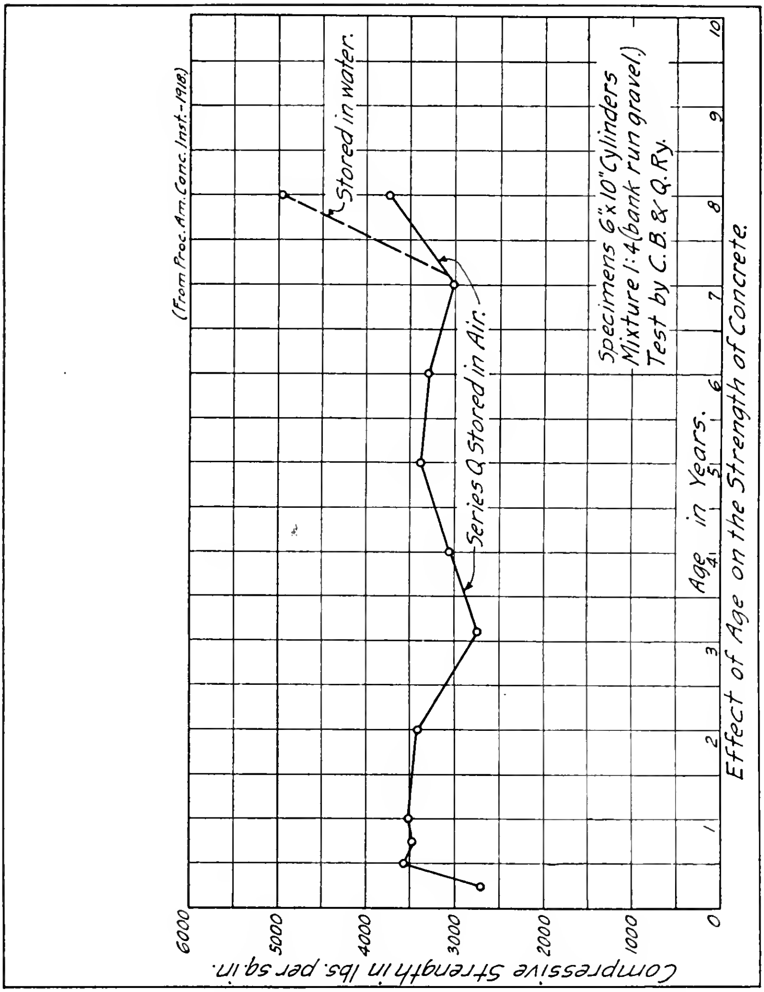


Fig. 2—Effect of Age and Condition of Storage on Compressive Strength of Concrete.

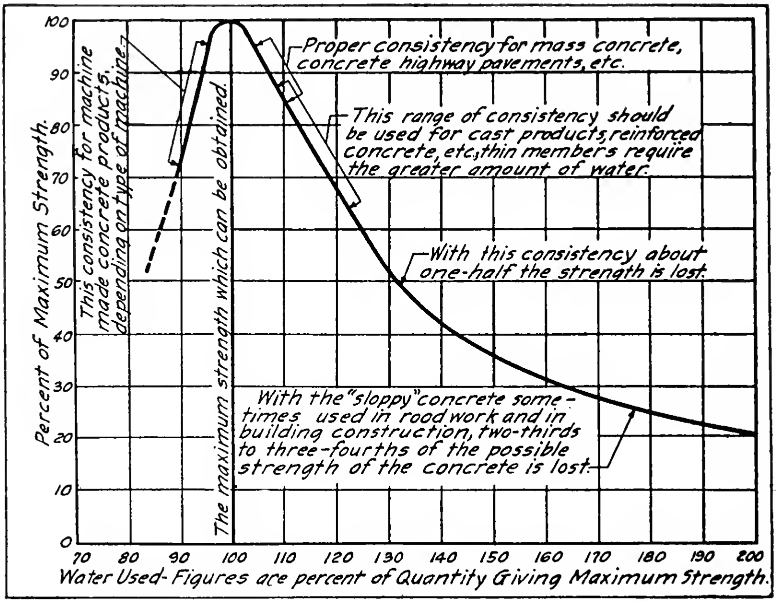


Fig. 3—Effect of Quantity of Mixing Water on the Strength of Concrete.

From tests made by Structural Materials Research Laboratory, Lewis Institute, Chicago.

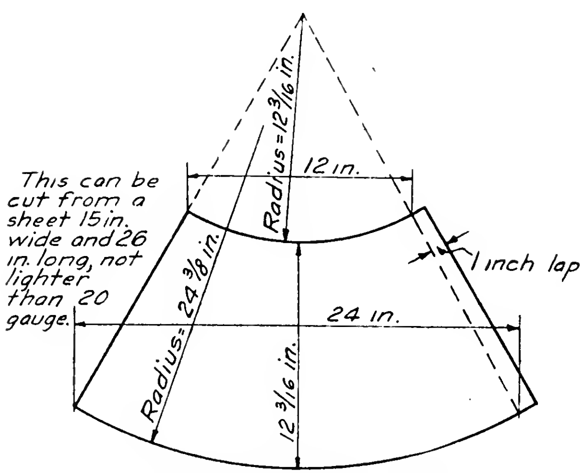


Fig. 4—Plan of Metal Form Used for Slump Test.

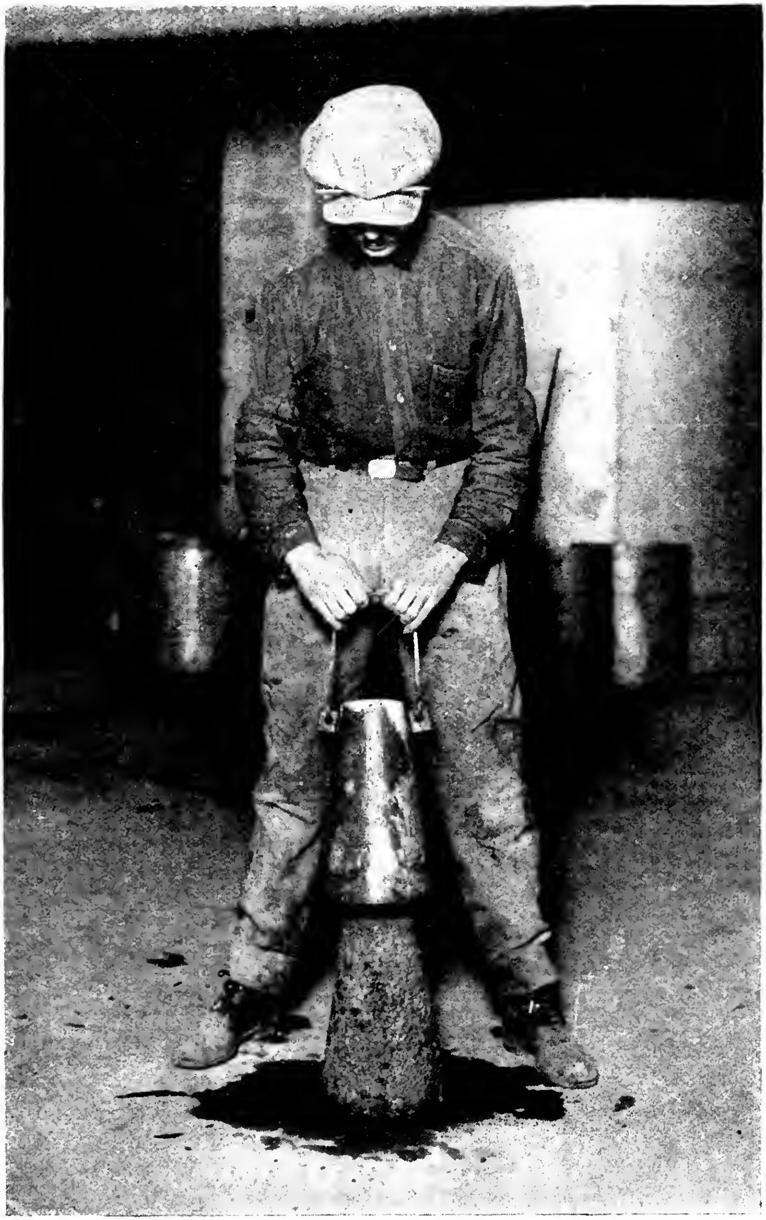


Fig. 5—Making the Slump Test for Plasticity of Concrete.

Fig. 6—Results of the Slump Test.

Batches of concrete of varying consistency showing "slump" after removal from the mold. Percentages of normal consistency are shown by figures below each pile. Figures to the side show the amount each pile has slumped from 12 inches, the height of the mold.

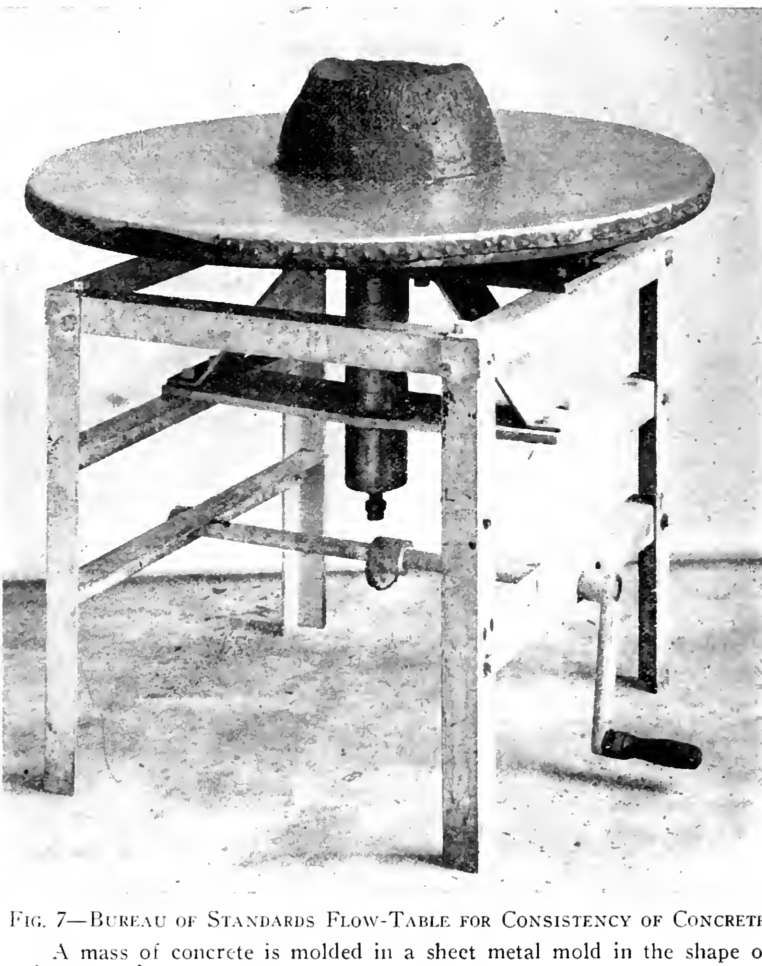


Fig. 7—Bureau of Standards Flow-Table for Consistency of Concrete.

A mass of concrete is molded in a sheet metal mold in the shape of a frustum of a cone.

Fig. 8—Flow-Table for Consistency of Concrete.

By means of a cam the table top is raised ½ inch and dropped 15 times. The flowability is determined by measuring the spread of the mass of concrete.

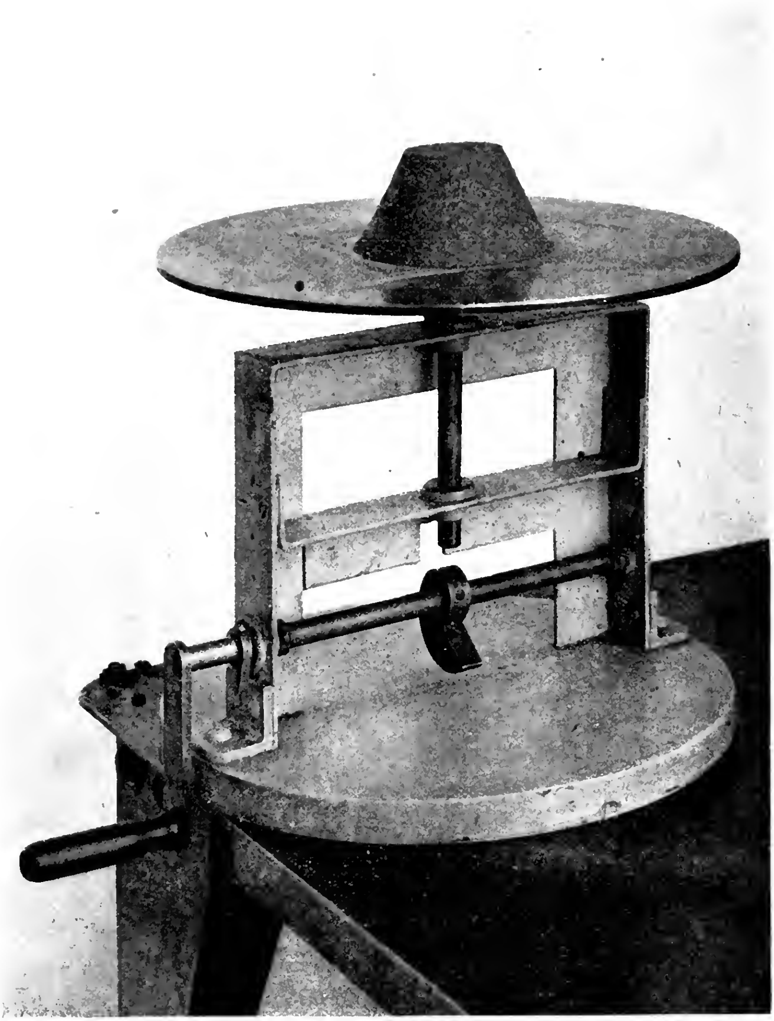


Fig. 9—Bureau of Standards Flow-Table Used for Normal Consistency Tests of Neat Cement and Standard Sand Mortars.

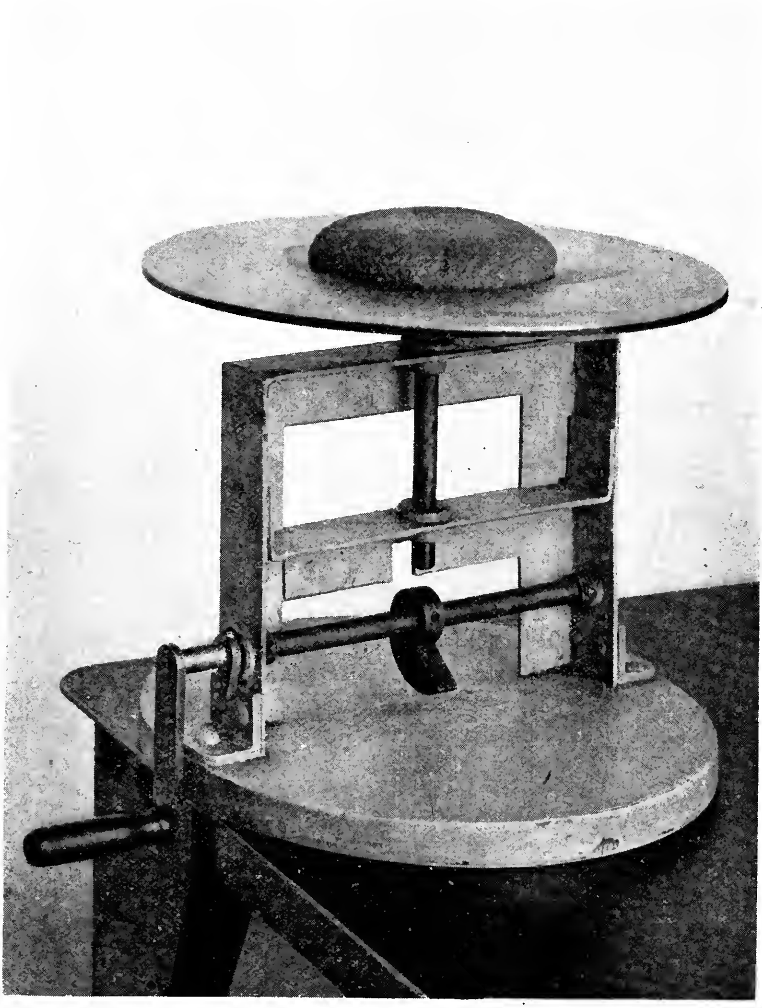


FIG. 10—THIS SMALLER FLOW-TABLE CAN BE USED MORE CONVENIENTLY IN MAKING FLOWABILITY TESTS OF CEMENT MORTARS THAN THE TABLE REQUIRED FOR CONCRETE MIXTURES.

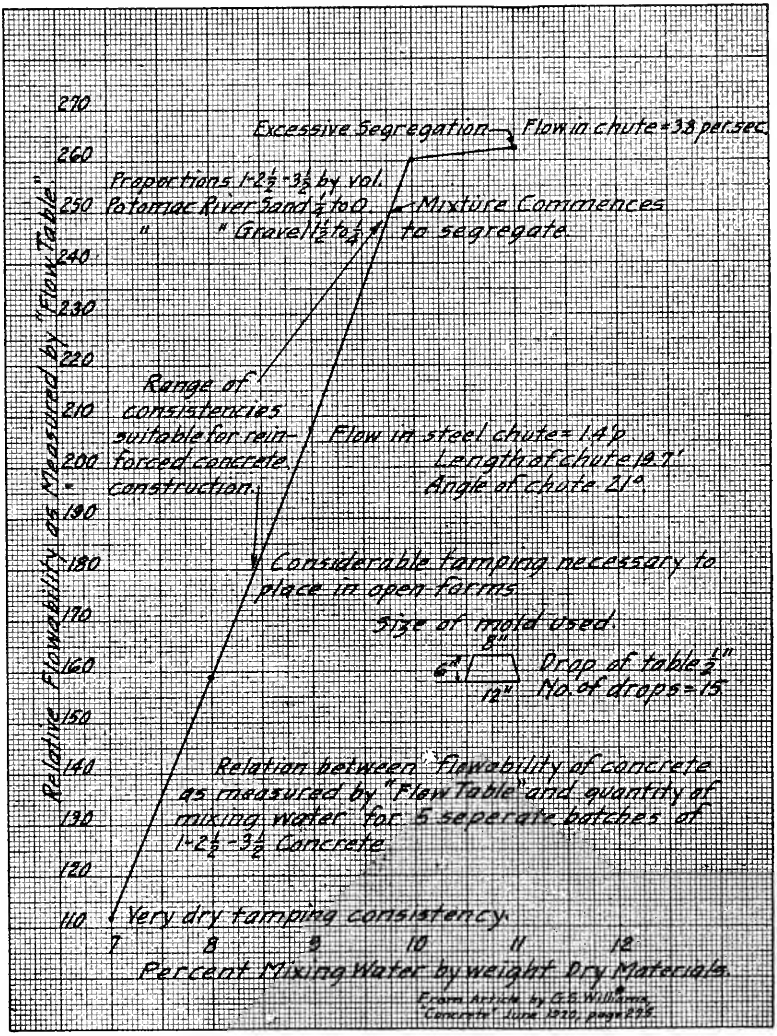


FIG. 11—EFFECT OF QUANTITY OF MIXING WATER ON PLASTICITY OR FLOWABILITY OF CONCRETE AS MEASURED BY "FLOW TABLE."

REPORT OF COMMITTEE XVI—ECONOMICS OF RAILWAY LOCATION

C. P. Howard, *Chairman;*
F. H. Alfred,
R. N. Begien,
Willard Beahan,
Edwin J. Beugler,
W. J. Cunningham,
C. T. Delamere,
A. C. Dennis,
W. A. James,
Fred Lavis,
E. H. McHenry,
A. S. Going, *Vice-Chairman;*
Edward C. Schmidt,
H. C. Searls,
A. K. Shurtleff,
C. H. Splitstone,
C. W. Stark,
M. F. Steinberger,
John G. Sullivan,
Walter Loring Webb,
M. A. Zook,

Committee.

To the American Railway Engineering Association:

The following subjects were assigned the Committee on Economics of Railway Location for study and report:

1. Make thorough examination of the subject-matter in the Manual, and submit definite recommendations for changes.
2. Report on the resistance of trains running between 35 and 75 miles per hour.
3. Report on effect of curvature on cost of:
   (a) Maintenance of way;
   (b) Maintenance of equipment.
4. Report on the effect of train resistance on the amount of fuel consumed.
5. Make final report, if practicable, on the question of economics of railway location as affected by the introduction of electric locomotives.

Committee Meetings

Meetings of the Committee were held in Chicago, May 25th and August 30th. The names of members in attendance have been given in the Minutes of the meetings, which have been printed in the Bulletin.

(1) Revision of Manual

In Appendix A proposed changes in the Manual are given.

(2) Resistance of Trains Between 35 and 75 Miles Per Hour

In Appendix B will be found report of the Sub-Committee, with diagrams, tables and conclusions recommended for adoption and inclusion in the Manual.

(3) Effect of Curvature on Cost of Maintenance of Way and Equipment

No progress made on this subject.

(4) Effect of Train Resistance on Amount of Fuel Consumed

The Committee wishes to call attention again to data now in the Manual covering this subject. With the aid of this data fuel consumption may be estimated for any combination of train and grade resistances and length of run, using ordinary coal burning (excluding Mallet) locomotives.

(5) Economics of Location As Affected By Electric Locomotives

In Appendix C will be found the report of the Sub-Committee and conclusion recommended for adoption and inclusion in the Manual.

Recommendations for Future Work

The general subject of future work and of the means for securing desired results was considered at both meetings of the Committee. The Committee believes that funds should be appropriated and expert assistance employed to collect data, conduct investigations and classify and formulate results, and that the great problems involved in the proper layout and improvement of the railways of America will amply justify such expenditure.

Respectfully submitted,

The Committee on Economics
of Railway Location,
C. P. Howard, *Chairman.*

Appendix A

(1) REVISION OF MANUAL

F. Lavis, *Chairman;*	A. K. Shurtleff,
Willard Beahan,	C. W. Stark,
W. J. Cunningham,	Major Walter Loring Webb,
C. P. Howard,	M. A. Zook,
	Sub-Committee.

The subject assigned to it was: "Make thorough examination of the subject-matter of the Manual, and submit definite recommendations for changes."

The changes recommended are as follows:

Present Form.	*Proposed Form.*
Section 5. In order to make an economical location of a railway, the Engineer must know or make a reasonable assumption of the amount, direction and class of traffic that the railway will be called upon to handle, class of power and the approximate efficiency and cost of fuel that will be used, the rate of wages that will be paid to employes, the cost of maintenance, materials, and the rate of interest considered a proper return for additional expenditures involved in the improvement of the line for the reduction of operating expenses.	In order to make a location on an economic basis, the Engineer must know, or make a reasonable assumption of, the amount, direction of movement, and class of traffic which the railway will be called upon to handle and the probable cost of operation. He must also consider variations in the amount and character of traffic that may be occasioned by changes in line, gradients or other features of location.
Section 8. If passing sidings must of necessity be located on ruling gradients, then such gradients should be compensated through and preferably for a full train length in each direction from either end of the siding. The rate of compensation will be governed by the ruling gradient.	If passing siding must of necessity be located on ruling gradients, then such gradients should, if practical, be compensated for the whole length of the siding and for a full train length beyond each end, so as to permit the maximum train load, which can be hauled over the ruling gradient to be started from a full stop at any point within the limits given. Due consideration must also be given to the compensation required on the curves at each end of the turnout.

The Committee desires to call attention to the following changes which were approved at the 1917 meeting but not incorporated in the Supplement to the Manual subsequently issued.

Change the words *grade* and *grades* to gradient and gradients throughout the text.

Changes of Sections 9 and 13 as now written in the 1915 Manual.

Also the suggestion that when a new Manual is issued that the matter under "Economics of Railway Location" be provided with suitable headings and the following captions are suggested:

Definitions;
Locations Governed by Traffic;
Engine Districts;
Passing Sidings;
Ruling Gradients;
Lessening First Cost;
Momentum Gradients
Comparison of Alternate Locations;
  Train Resistance;
  Minor Details;
Special Structures;
Time;
Distance and Revenue.

The Committee offers for the consideration of the whole Committee the following *new* matter for the Manual.

Add to Section 13 (as amended at the 1917 meeting) the following:

Inertia resistance, or the additional energy required to increase the velocity of a train from V_1 velocity to V_2 velocity may be computed by the formula:

$$P = (V_2^2 - V_1^2)\frac{70}{s}, \text{ in which}$$

P = required force in pounds per ton,

V_2 and V_1 = the higher and lower velocities respectively in miles per hour, and

s = the distance in feet in which such acceleration is accomplished.

For many calculations V_1 = zero. The formula allows 5 per cent for the extra energy required to produce rotation of the wheels and axles.

This should be inserted after the first paragraph of Section 13.

Appendix B

(2) THE RESISTANCE OF TRAINS RUNNING BETWEEN 35 AND 75 MILES PER HOUR

MAJOR EDWARD C. SCHMIDT, *Chairman;*
A. C. DENNIS,
Sub-Committee.

Sub-Committee (2) was directed to "report on the resistance of trains running between 35 and 75 miles per hour," with the suggestion by the chairman "that additional data be secured if practicable, and that a study be made of the results of tests made by the University of Illinois and published in recent bulletins."

The publications referred to are Bulletins 43 and 110 of the Engineering Experiment Station of the University of Illinois. Bulletin 43, *Freight Train Resistance,* deals exclusively with the resistance of freight trains running on straight track at speeds up to 40 miles per hour, and with average weights per car varying from 15 to 75 tons. Bulletin 110, *Passenger Train Resistance,* deals with the resistance of passenger trains running at speeds up to 75 miles per hour and with average weights per car ranging from 30 to 75 tons.

The Sub-Committee has been unable to learn of any important development in the subject of train resistance since the publication of the bulletins. It believes that they present reliable information adequate for all the ordinary purposes of the members of the Association, and that this report therefore may be confined to summarizing the results presented in these publications.

Throughout this report the terms "resistance" and "train resistance" mean the number of pounds of tractive effort required for each ton of the train in order to keep it in motion on straight and level track, at uniform speed. This resistance is only that of the train behind the locomotive tender—the resistance of the locomotive and tender, themselves, is not included.

The results here presented relate to trains running on good track and in moderate weather when the temperature is above 30 deg. Fahr. and the wind velocity not over 20 miles per hour. Poor track, extremely low temperature, and high winds all increase train resistance; but there is not yet available enough information to enable the influence of any of these factors to be evaluated. The influence of low temperature is probably the most important.* and some allowance should be made for it in attempting to predict resistance during extreme winter weather.

*See Bulletin No. 59, "The Effect of Cold Weather Upon Train Resistance and Tonnage Rating," Engineering Experiment Station of the University of Illinois.

It should be emphasized that the resistance of both freight and passenger trains depends not only upon speed, but upon the average weight of the cars composing the train. In order to predict resistance at any speed, the average weight of the cars must be either known or assumed.

Freight Train Resistance

The final results of the tests discussed in Bulletin 43 are presented in Fig. 1 and Table 1 of this report. In using this figure and table the conditions and limitations of the tests must be understood and the following summary, extracted from the bulletin, is therefore given.

The tests were made with a variety of trains in regular freight service upon well-constructed and well-maintained main-line track, 94 per cent of which was laid with 85-lb. rail, the remainder being laid with 75-lb. rail. The track was ballasted with broken stone. The experiments were carried on during moderate weather when the minimum air temperature encountered was 34 deg. Fahr. and the wind velocities were less than 20 miles per hour.

The results are applicable to trains of all varieties of make-up to be met with in service. They may be applied, without incurring material error, to trains which are homogeneous and to those which are mixed as regards individual car weight.

The results are primarily applicable to trains which have been in motion for some time. When trains are first started from yards, or after stops on the road of more than about 20 minutes' duration, their resistance is likely to be appreciably greater than is indicated by the results here presented. In rating locomotives, no consideration need be given this matter except in determining "dead" ratings for low speeds, and then only when the ruling grade is located within six or seven miles of the starting point or of a regular road stop.

It is to be expected that some trains to be met with in service will have a resistance about 9 per cent in excess of that indicated by Fig. 1 and Table 1, due to variations in make-up or in external conditions within the limits to which the tests apply. If operating conditions make it essential to reduce to a minimum the risk of failure to haul the allotted tonnage, then this 9 per cent allowance should be made. This consideration, like the one preceding, is important only in rating locomotives for speeds under 15 miles per hour. At higher speeds, the occasional excess in the resistance of individual trains will result in nothing more serious than a slight increase in running time. It should be understood that this allowance, if made, is to be added to the resistance on level track—not to the gross resistance on grades. For all ordinary purposes, however, Fig. 1 and Table 1 may be used as they stand to estimate the resistance of freight trains running on straight and level track of good construction during moderate weather.

The train speeds in these experiments did not exceed 40 miles per hour and the original curves and tables in Bulletin 43 are limited to that speed. The Committee believes, however, that the original curves may

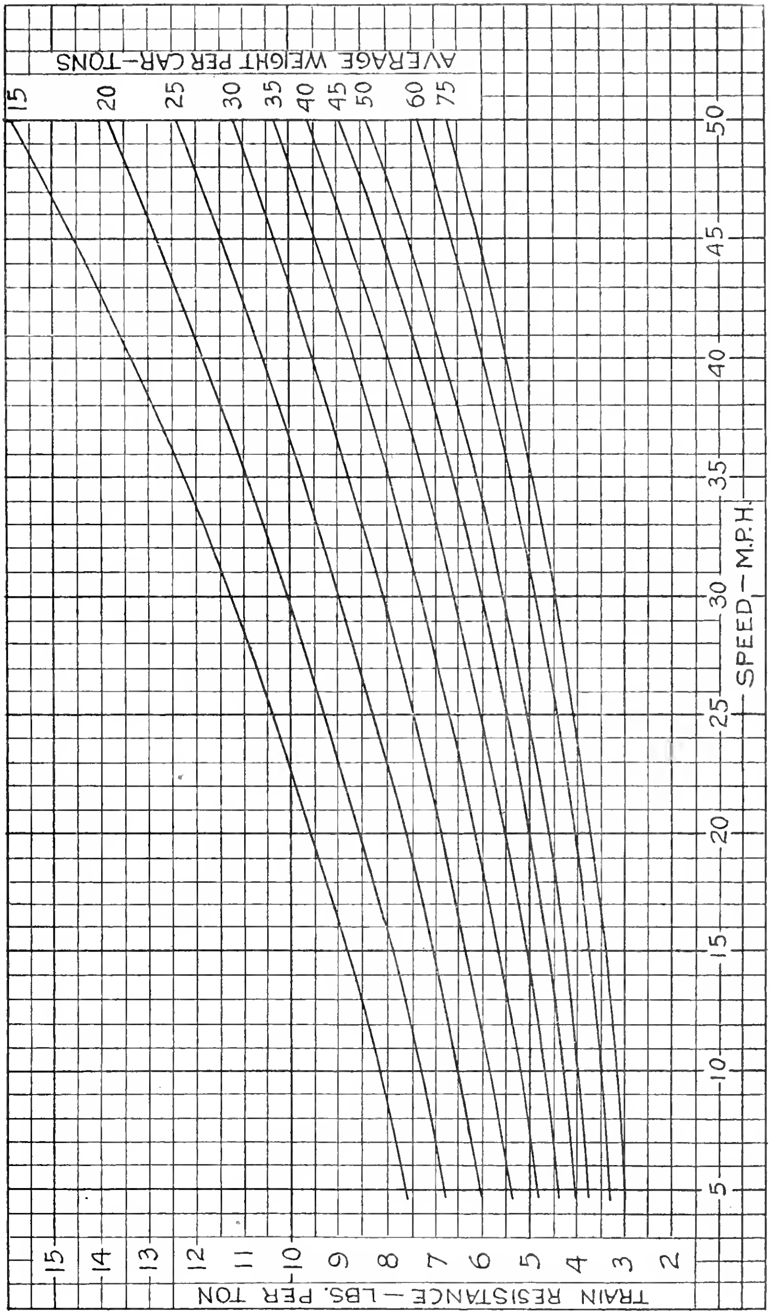


Fig. 1—The Relation Between Freight Train Resistance and Speed for Various Average Weights per Car.

TABLE 1—VALUES OF FREIGHT TRAIN RESISTANCE AT VARIOUS SPEEDS AND FOR TRAINS OF DIFFERENT AVERAGE WEIGHTS PER CAR.

Speed miles per hour	Train Resistance—Pounds per ton													Speed miles per hour
	Column Headings Indicate the Average Weights Per Car													
	15 tons	20 tons	25 tons	30 tons	35 tons	40 tons	45 tons	50 tons	55 tons	60 tons	65 tons	70 tons	75 tons	
5	7.6	6.8	6.0	5.4	4.8	4.4	4.0	3.7	3.5	3.3	3.2	3.1	3.0	5
6	7.7	6.9	6.1	5.5	4.9	4.4	4.1	3.8	3.5	3.3	3.2	3.1	3.0	6
7	7.8	7.0	6.2	5.5	5.0	4.5	4.1	3.8	3.6	3.4	3.2	3.1	3.1	7
8	8.0	7.1	6.3	5.6	5.0	4.6	4.2	3.9	3.6	3.4	3.3	3.2	3.1	8
9	8.1	7.2	6.4	5.7	5.1	4.6	4.2	3.9	3.6	3.4	3.3	3.2	3.1	9
10	8.2	7.3	6.5	5.8	5.2	4.7	4.3	4.0	3.7	3.5	3.3	3.2	3.2	10
11	8.3	7.4	6.6	5.9	5.3	4.8	4.3	4.0	3.7	3.5	3.4	3.3	3.2	11
12	8.4	7.5	6.7	6.0	5.4	4.8	4.4	4.0	3.8	3.6	3.4	3.3	3.3	12
13	8.6	7.6	6.8	6.1	5.5	4.9	4.5	4.1	3.8	3.6	3.5	3.4	3.3	13
14	8.7	7.8	6.9	6.2	5.5	5.0	4.5	4.2	3.9	3.7	3.5	3.4	3.4	14
15	8.8	7.9	7.0	6.3	5.6	5.1	4.6	4.2	3.9	3.7	3.6	3.5	3.4	15
16	9.0	8.0	7.1	6.4	5.7	5.1	4.7	4.3	4.0	3.8	3.6	3.5	3.5	16
17	9.1	8.1	7.2	6.5	5.8	5.2	4.8	4.4	4.1	3.9	3.7	3.6	3.5	17
18	9.3	8.3	7.4	6.6	5.9	5.3	4.8	4.5	4.1	3.9	3.7	3.7	3.6	18
19	9.4	8.4	7.5	6.7	6.0	5.4	4.9	4.5	4.2	4.0	3.8	3.7	3.6	19
20	9.6	8.5	7.6	6.8	6.1	5.5	5.0	4.6	4.3	4.0	3.9	3.8	3.7	20
21	9.7	8.7	7.7	6.9	6.2	5.6	5.1	4.7	4.3	4.1	3.9	3.9	3.8	21
22	9.9	8.8	7.9	7.0	6.3	5.7	5.2	4.8	4.4	4.2	4.0	3.9	3.8	22
23	10.0	9.0	8.0	7.1	6.4	5.8	5.3	4.9	4.5	4.3	4.1	4.0	3.9	23
24	10.2	9.1	8.1	7.3	6.6	5.9	5.4	4.9	4.6	4.3	4.2	4.1	4.0	24
25	10.4	9.3	8.3	7.4	6.7	6.0	5.5	5.0	4.7	4.4	4.2	4.1	4.0	25
26	10.5	9.4	8.4	7.5	6.8	6.1	5.6	5.1	4.8	4.5	4.3	4.2	4.1	26
27	10.7	9.6	8.5	7.7	6.9	6.2	5.7	5.2	4.8	4.6	4.4	4.3	4.2	27
28	10.9	9.7	8.7	7.8	7.0	6.3	5.8	5.3	4.9	4.7	4.5	4.4	4.3	28
29	11.1	9.9	8.8	7.9	7.1	6.5	5.9	5.4	5.0	4.8	4.6	4.5	4.4	29
30	11.3	10.0	9.0	8.0	7.3	6.6	6.0	5.5	5.1	4.9	4.7	4.5	4.5	30
31	11.4	10.2	9.1	8.2	7.4	6.7	6.1	5.6	5.2	5.0	4.8	4.6	4.5	31
32	11.6	10.4	9.3	8.3	7.5	6.8	6.2	5.8	5.3	5.0	4.9	4.7	4.6	32
33	11.8	10.5	9.4	8.5	7.6	7.0	6.3	5.9	5.4	5.2	5.0	4.8	4.7	33
34	12.0	10.7	9.6	8.6	7.8	7.1	6.5	6.0	5.5	5.3	5.1	4.9	4.8	34
35	12.3	10.9	9.7	8.8	7.9	7.2	6.6	6.1	5.7	5.4	5.2	5.0	4.9	35
36	12.5	11.1	9.9	8.9	8.0	7.4	6.7	6.2	5.8	5.5	5.3	5.1	5.0	36
37	12.7	11.2	10.0	9.0	8.2	7.5	6.9	6.4	5.9	5.6	5.4	5.2	5.1	37
38	12.9	11.4	10.2	9.2	8.3	7.6	7.0	6.5	6.0	5.7	5.5	5.3	5.2	38
39	13.1	11.6	10.4	9.4	8.5	7.8	7.1	6.6	6.2	5.8	5.6	5.4	5.3	39
40	13.4	11.8	10.6	9.5	8.6	7.9	7.3	6.8	6.3	6.0	5.7	5.6	5.5	40
45	14.5	12.8	11.4	10.3	9.5	8.7	8.1	7.5	7.0	6.6	6.4	6.2	6.0	45
50	15.8	13.8	12.4	11.2	10.3	9.6	8.9	8.4	7.7	7.3	7.0	6.8	6.7	50

be extended without material error to 50 miles per hour, which is the maximum speed ordinarily encountered in freight train operation. In reproducing the curves and the table in this report they have therefore been extended to 50 miles per hour.

For freight train resistance the Association has already adopted a straight line formula, which is given on pages 525 and 536 of the Manual. This formula, for any stated loading, gives uniform resistances for all speeds from 5 to 35 miles per hour. It is not intended at this time to suggest the abandonment or modification of this formula, which has the advantage of great simplicity and is most useful for ordinary purposes. The Committee has consequently suggested in its Conclusion No. 1 the use of Fig. 1 or Table 1 in determining freight train resistance at the higher speeds of 35 to 50 miles per hour, without recommendation as to their use for lower speeds or as regards revision of the formula now in use.

Passenger Train Resistance

The final results of the University of Illinois experiments on passenger train resistance are shown here in Fig. 2 and Table 2, which are reproduced without modification from Bulletin 110. A summary of the conditions surrounding these tests follows.

The results are derived from tests of twenty-eight passenger trains in "local" and "through" service. The average weight per car in these trains varied from 33 to 71 tons, and the number of cars from 4 to 12. The speeds ranged up to about 67 miles per hour. The tests were made upon well-constructed and well-maintained main-line track laid with 85-lb. and 90-lb. rail, and ballasted with broken stone. The experiments were carried on during moderate or warm weather, when the temperatures were above 40 degrees F. and the wind velocity generally less than 20 miles per hour.

Of the 240 cars composing these twenty-eight test trains, 178 had six-wheel trucks and 62 had four-wheel trucks. All trains, except one, contained both four-wheel and six-wheel trucks, but in varying proportions. Concerning this matter Bulletin 110 comments as follows: "Since car weight affects the specific resistance, not only through its influence on air resistance, but through its influence on journal and rolling resistance as well, there is apparently an inconsistency in method in grouping—as is done in this Bulletin—trains including both four-wheel and six-wheel truck cars, and especially in thus grouping trains which have in their makeup different proportions of the two kinds of trucks. This apparent inconsistency, considering the purpose of the investigation, is not so objectionable as may appear. It was not possible under the conditions under which the tests were made to control the makeup of the trains. The tests had to be made in regular service and the trains had to be accepted with their usual makeup. This limitation has not defeated the main purpose of the tests, for they were undertaken, not to distinguish the resistance of four-wheel and six-wheel truck cars, but to measure the

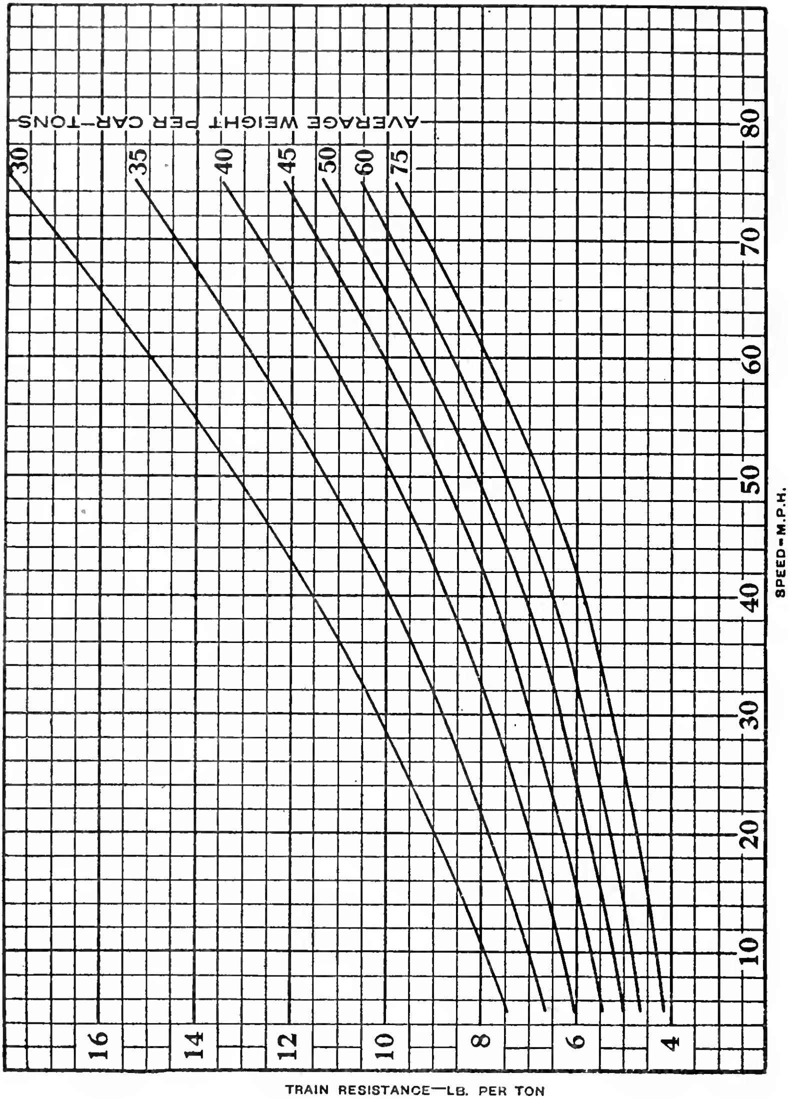


FIG. 2—THE RELATION BETWEEN PASSENGER TRAIN RESISTANCE AND SPEED FOR VARIOUS AVERAGE WEIGHTS PER CAR.

TABLE 2—VALUES OF PASSENGER TRAIN RESISTANCE AT VARIOUS SPEEDS AND FOR TRAINS OF VARIOUS AVERAGE WEIGHTS PER CAR.

Speed Miles per Hour	Train Resistance—Pounds per Ton										Speed Miles per Hour
	Column Headings Indicate the Average Weights per Car—Tons										
	30	35	40	45	50	55	60	65	70	75	
5	7.4	6.6	6.0	5.4	5.0	4.8	4.6	4.4	4.3	4.1	5
6	7.5	6.7	6.0	5.5	5.0	4.8	4.6	4.4	4.3	4.2	6
7	7.6	6.8	6.1	5.5	5.1	4.8	4.7	4.5	4.3	4.2	7
8	7.7	6.8	6.2	5.6	5.1	4.9	4.7	4.5	4.4	4.2	8
9	7.8	6.9	6.2	5.6	5.2	4.9	4.8	4.6	4.4	4.3	9
10	7.9	7.0	6.3	5.7	5.2	5.0	4.8	4.6	4.4	4.3	10
11	8.0	7.1	6.4	5.8	5.2	5.0	4.8	4.7	4.5	4.3	11
12	8.1	7.1	6.4	5.8	5.3	5.0	4.9	4.7	4.5	4.4	12
13	8.2	7.2	6.5	5.9	5.3	5.1	4.9	4.7	4.5	4.4	13
14	8.3	7.3	6.5	5.9	5.4	5.1	5.0	4.8	4.6	4.4	14
15	8.4	7.4	6.6	6.0	5.4	5.2	5.0	4.8	4.6	4.5	15
16	8.5	7.5	6.7	6.0	5.5	5.2	5.0	4.9	4.7	4.5	16
17	8.6	7.6	6.7	6.1	5.5	5.3	5.1	4.9	4.7	4.5	17
18	8.7	7.7	6.8	6.1	5.6	5.3	5.1	5.0	4.8	4.6	18
19	8.8	7.7	6.9	6.2	5.7	5.4	5.2	5.0	4.8	4.6	19
20	9.0	7.8	7.0	6.3	5.7	5.4	5.2	5.0	4.9	4.7	20
21	9.1	7.9	7.0	6.3	5.8	5.5	5.3	5.1	4.9	4.7	21
22	9.2	8.0	7.1	6.4	5.8	5.5	5.3	5.1	6.0	4.8	22
23	9.3	8.1	7.2	6.4	5.9	5.6	5.4	5.2	5.0	4.8	23
24	9.4	8.2	7.2	6.5	5.9	5.6	5.4	5.2	5.0	4.9	24
25	9.5	8.3	7.3	6.6	6.0	5.7	5.5	5.3	5.1	4.9	25
26	9.6	8.4	7.4	6.6	6.1	5.7	5.6	5.4	5.1	5.0	26
27	9.8	8.5	7.5	6.7	6.1	5.8	5.6	5.4	5.2	5.0	27
28	9.9	8.6	7.5	6.8	6.2	5.9	5.7	5.5	5.2	5.1	28
29	10.0	8.7	7.6	6.8	6.2	5.9	5.7	5.5	5.3	5.1	29
30	10.1	8.8	7.7	6.9	6.3	6.0	5.8	5.6	5.4	5.2	30
31	10.3	8.9	7.8	7.0	6.4	6.0	5.8	5.6	5.4	5.2	31
32	10.4	9.0	7.9	7.1	6.4	6.1	5.9	6.7	5.5	5.3	32
33	10.5	9.1	8.0	7.1	6.5	6.2	6.0	5.8	5.5	5.4	33
34	10.7	9.2	8.0	7.2	6.6	6.2	6.0	5.8	5.6	5.4	34
35	10.8	9.3	8.1	7.3	6.7	6.3	6.1	5.9	6.7	5.5	35
36	10.9	9.4	8.2	7.4	6.7	6.4	6.2	6.0	5.7	5.5	36
37	11.1	9.5	8.3	7.4	6.8	6.5	6.2	6.0	5.8	5.6	37
38	11.2	9.6	8.4	7.5	6.9	6.5	6.3	6.1	5.9	5.7	38
39	11.4	9.8	8.5	7.6	7.0	6.6	6.4	6.2	5.9	5.7	39
40	11.5	9.9	8.6	7.7	7.0	6.7	6.4	6.2	6.0	5.8	40
41	11.7	10.0	8.7	7.8	7.1	6.8	6.5	6.3	6.1	5.9	41
42	11.8	10.1	8.8	7.9	7.2	6.9	6.6	6.4	6.2	6.0	42
43	12.0	10.3	9.0	8.0	7.3	6.9	6.7	6.5	6.3	6.0	43
44	12.2	10.4	9.1	8.1	7.4	7.0	6.8	6.6	6.4	6.1	44
45	12.3	10.5	9.2	8.2	7.5	7.1	6.9	6.7	6.4	6.2	45
46	12.5	10.7	9.3	8.3	7.6	7.2	7.0	6.8	6.5	6.3	46
47	12.6	10.8	9.4	8.4	7.7	7.3	7.1	6.9	6.6	6.4	47
48	12.8	11.0	9.6	8.5	7.8	7.4	7.2	7.0	6.7	6.5	48
49	13.0	11.1	9.7	8.6	7.9	7.5	7.3	7.1	6.8	6.6	49
50	13.1	11.2	9.8	8.8	8.0	7.6	7.4	7.2	7.0	6.7	50
51	13.3	11.4	9.9	8.9	8.1	7.7	7.5	7.3	7.1	6.8	51
52	13.5	11.5	10.1	9.0	8.2	7.8	7.6	7.4	7.2	6.9	52
53	13.7	11.7	10.2	9.1	8.4	7.9	7.7	7.5	7.3	7.0	53
54	13.8	11.8	10.3	9.2	8.5	8.1	7.8	7.6	7.4	7.1	54
55	14.0	12.0	10.5	9.4	8.6	8.2	8.0	7.7	7.5	7.2	55

TABLE 2—Continued.

Speed Miles per Hour	Train Resistance—Pounds per Ton. Column Headings Indicate the Average Weights per Car—Tons: 30	35	40	45	50	55	60	65	70	75	Speed Miles per Hour
56	14.2	12.1	10.6	9.5	8.7	8.3	8.1	7.8	7.6	7.3	56
57	14.4	12.3	10.8	9.6	8.9	8.4	8.2	8.0	7.7	7.5	57
58	14.6	12.5	10.9	9.8	9.0	8.6	8.3	8.1	7.8	7.6	58
59	14.8	12.6	11.1	9.9	9.1	8.7	8.4	8.2	8.0	7.7	59
60	15.0	12.8	11.2	10.0	9.2	8.8	8.6	8.3	8.1	7.8	60
61	15.1	12.9	11.3	10.2	9.4	8.9	8.7	8.4	8.2	7.9	61
62	15.3	13.1	11.5	10.3	9.5	9.1	8.8	8.6	8.3	8.1	62
63	15.5	13.2	11.7	10.5	9.7	9.2	9.0	8.7	8.5	8.2	63
64	15.7	13.4	11.8	10.6	9.8	9.3	9.1	8.8	8.6	8.3	64
65	15.9	13.6	11.9	10.7	9.9	9.5	9.2	8.9	8.7	8.4	65
66	16.1	13.8	12.1	10.9	10.0	9.6	9.3	9.1	8.8	8.6	66
67	16.3	13.9	12.2	11.0	10.2	9.7	9.4	9.2	9.0	8.7	67
68	16.5	14.1	12.4	11.1	10.3	9.9	9.6	9.3	9.1	8.8	68
69	16.7	14.3	12.5	11.3	10.5	10.0	9.7	9.5	9.2	9.0	69
70	16.9	14.4	12.7	11.4	10.6	10.1	9.9	9.6	9.4	9.1	70
71	17.1	14.6	12.8	11.6	10.7	10.3	10.0	9.7	9.5	9.2	71
72	17.3	14.8	13.0	11.7	10.9	10.4	10.1	9.9	9.6	9.4	72
73	17.5	15.0	13.1	11.9	11.0	10.6	10.3	10.0	9.8	9.5	73
74	17.7	15.1	13.3	12.0	11.2	10.7	10.4	10.1	9.9	9.7	74
75	17.9	15.3	13.5	12.1	11.3	10.8	10.5	10.3	10.0	9.8	75

resistance of ordinary passenger trains of widely different average car weight; and wide variation in car weight carries with it, in American practice, a variation in truck construction similar to that encountered in the trains here discussed. Any train of 35 to 40 tons average car weight is sure to include in its makeup four-wheel truck cars—and in about the proportion which prevailed in these tests. Even the heaviest through trains are likely occasionally to include a car or two with four-wheel trucks.

A number of the trains tested developed resistance about 8 per cent. greater than those found in Fig. 2 and Table 2, and it is to be expected that trains will occasionally be encountered which have a similar excess resistance, even under conditions of air temperature and wind velocity such as prevailed during these experiments. In general, however, Fig. 2 and Table 2 may be safely used to predict the resistance of ordinary passenger trains running on straight and level track of good construction during moderate weather.

Conclusions

The resistance data here presented rest upon experiments which were carefully conducted and adequate in scope, and the Sub-Committee believes that the results of these tests may be used with confidence for all the ordinary purposes of the members of the Association; and that, until there are radical changes in car or track construction or until these results are supplanted by much more comprehensive experiments, they may continue to be so used.

It accordingly presents the following conclusions:

(1) Fig. 1 or Table 1 may be used in estimating freight train resistance at speeds from 35 to 50 miles per hour for Class A rating and temperatures of 35 deg. Fahr. and upwards.

(2) Fig. 2 or Table 2 may be used in estimating passenger train resistance at speeds from 5 to 75 miles per hour and temperatures of 35 deg. Fahr. and upwards.

Appendix C

(5) ECONOMICS OF LOCATION AS AFFECTED BY INTRODUCTION OF ELECTRIC LOCOMOTIVES

A. S. GOING, *Chairman;*
F. H. ALFRED,
E. J. BEUGLER,
E. H. MCHENRY,
C. H. SPLITSTONE,
M. F. STEINBERGER,
Sub-Committee.

Railroad electrification, while most desirable from the point of view of the conservation of our fuel resources, is a matter that can not be undertaken wholesale, for several reasons. First, the capital outlay would be enormous; second, each individual railroad system or even subdivision is a problem in itself, to be judged on its own merits.

The modern steam locomotive by the use of brick arches, feed water heaters, superheater, stokers and trailer boosters has had its efficiency increased practically 50 per cent. At the same time its size and capacity have increased with this advance, and the question arises wherein the electric locomotive is superior. From an operating standpoint it has a number of minor advantages. It eliminates the turntable; cuts down standby losses; removes the delay at water tanks and coaling stations; its availability for service is very much greater, and its maintenance is considerably lower. Its capacity is increased with cold weather—the reverse of the steam engine. Its simplicity of control relieves the crew from many duties necessary on a steam engine, and permits closer observation of track and signals. When properly designed, it is much easier riding and can have a more uniform distribution of weights with less nosing and track pounding, and under some conditions tends to lower track maintenance. In addition there is one great inherent advantage which the electric locomotive possesses, namely, the ability to concentrate large amounts of horse power under single control.

In steam railway operation each train has its own source of power, which has no relation to the propulsion of the other trains on the line. In electric railway operation every train draws its power from one or more centrally located power houses.

Steam trains are handled by locomotives only. Electric trains may be propelled either by electric locomotives or by motor cars.

Advantages of Electric Operation

The operation of trains by electric power is a benefit to the traveling public and to those near the right-of-way in that the smoke nuisance is entirely eliminated.

It is the contention of the exponents of electric operation that the electric locomotive is in numerous respects more efficient than the steam locomotive. It is pointed out that the entire weight of the electric locomotive can be and frequently is on the drivers, while but 65 per cent. to 75 per cent. of the steam locomotive (except the switching type) is thus utilized. A steam engine must haul its own fuel and water, and that this additional weight cannot be utilized to increase the adhesion by being carried on the driving wheels.

An electric locomotive allows an increase in tractive effort without a decrease in speed. A limiting factor of the H. P. output of a steam locomotive is the steaming capacity of the boiler, as well as the amount of coal per hour which the fireman can throw into the grate continuously throughout the shift. (The latter does not apply in the case of automatic stoker fired engines).

A comparison between the maximum weight of train permissible with the steam locomotive and the standard weight of train prescribed for electric locomotives shows there is an increase over steam operation of from 18 per cent. to 25 per cent. The tractive effort, and the motor capacity are far greater in the electric locomotives, due to the more effective application of power.

An advantage which is ascribed to electric operation is the benefit derived from the elimination of work at terminals necessary when steam locomotives are used. A steam engine must take on coal and water, its fires must be cleaned, at the beginning of the day its fires must be started or raked forward, at the end of the day the fires must be drawn or banked. This not only causes additional expense, but requires that the locomotive be out of service for considerable periods. The electric locomotive requires no work of this character. It must be frequently inspected, but the same is necessary for steam locomotives. Outside of this, the electric locomotive need not be taken from service at all. It may be used constantly for 24 hours a day. With the same service to be handled there should be less electric locomotives necessary than steam locomotives, unless there are peculiarities in the service itself. There are conditions where this advantage is nullified.

It is maintained that under electric operation there is a saving in fuel of 50 per cent. to 65 per cent. It is pointed out that the central plant which furnishes the power to electric trains is much more efficient than the steam locomotive, that in the use of coal it consumes but one-half the amount required by steam locomotive to haul the same tonnage.

Assuming it is correct in stating that the power house consumes but one-half as much coal for the same number of ton miles, the cost of power would be more than one-half of the cost of coal. There are other factors entering powerhouse costs which do not appear in the cost of coal. The cost of other supplies than coal are the cost of power house labor, and the expense of maintaining the power house and its equipment, all of which are items of no mean importance. This fact should be constantly borne in mind when discussing relative costs of power and fuel. Another factor entering into the cost of power which does not affect the cost of fuel, is the transmission loss between the power house and the locomotive. These losses increase with the distance between the power house and the train. A fair comparison of the cost of repairs to steam and electric locomotives is particularly difficult, since the latter are yet in the experimental stage. The cost of locomotive supplies does not materially differ between the two types of locomotives except in the winter months. On turning to engine house expense we find the chief items of engine house expenses are eliminated. While the engine house expenses of steam locomotives are important factors they are insignificant in electric operation. It is here that it effects one of its most marked economics. There is an indirect saving which is made under electric operation, a saving applying to freight and switching service, namely, the saving in drawbars on freight cars. This economy cannot be easily determined, but a considerable saving is made.

Unit costs of electric operation decrease as the volume of traffic increases, whereas the unit costs in the case of steam operation remain comparatively constant.

Disadvantages of Electric Operation

As regards the disadvantages of electric operation, the most important objection is the enormous first cost and the heavy fixed charge which that involves.

Electric equipment is more costly than steam equipment.

Electrification must not only bring about economics, but very large reduction in operating cost in order to prove itself economical.

The electric locomotive is a piece of transforming apparatus which receives its power from an outside source, and is, therefore, subject to overloads. The capacity of the electric locomotive is limited by the heating of its motors. This heating must be kept within safe limits to prevent injury to the insulation, just as the water in a steam locomotive must be kept at a safe level to prevent injury to the boiler.

The steam locomotive is a self-contained mechanical unit and it is hardly possible to injuriously overload it.

There is additional danger to the lives of the employees and others. This is, of course, much more serious when the power is transmitted at higher voltage and where freight and switching service as well as passenger is operated by electric power. Elaborate precautions have been taken by all roads using electric power to guard the lives of employees and others who might come into contact with wires or other apparatus charged with electricity.

Another argument against electric operation is that which deals with the additional liability of train delays. In addition to equipment failures which occur on both steam and electric service, there are failures of the transmission lines. It has been noted that extreme conditions of heat and cold will sometimes cause a large number of failures on the line. There is in addition to the line failure the possibility of the power house being out of commission, in which case the entire electrified section is tied up. It should be said, however, that these delays are rare.

With electric traction the territory protected with automatic block signals of the usual continuous current track circuit battery type will have to be replaced with alternating current track circuit apparatus, because the use of track circuits with propulsion currents in the rails requires selective apparatus to prevent false indications. Traffic movements of units are dependent upon the total integrity of generating and transmission system.

Normal traffic cannot be exceeded for periods of long duration unless the system has been designed to take care of maximum traffic, which greatly adds to the capital charge.

Unless other load than the railway is carried on the generating stations on small systems a poor load factor is liable to be encountered which adds to the capital charge through maintenance of under-loaded equipment. It is susceptible to the vagaries of the weather, as in addition to the snow, washouts, and other conditions that affect steam operation, lightning is apt to interrupt the electrical operation.

Steam locomotives are strictly interchangeable and can be moved from division to division, as the necessity for varying motive power capacity develops. Electric locomotives are limited in their field of operation strictly to electrified track. Traffic must be handled as circumstances require. It cannot be spaced conveniently for power demands, but the terminal yards must be cleared as the cars accumulate.

General

As to the comparative efficiency of the two types of locomotives in the matter of failures, the electric locomotive seems to hold its own. There are certain factors, however, which within the last few years have made the steam locomotive a more formidable competitor of electrification. These are, particularly, the various outside valve gears, the superheater, the brick arch and the automatic stoker, which have increased the tractive power and sustained hauling power of an engine as well as resulting in greater economy of fuel and water.

From available data on the results of heavy electrification it would appear that the ton miles moved by six and one-half pounds of coal in a steam locomotive is approximately equal to that which can be moved by one kilowatt hour delivered from the power station, varying, of course, with the quality of coal. In a great majority of cases the profits from electrification must be realized indirectly rather than directly—increased track capacity, postponing second tracking or the like.

Steam railroads will generally consider electrification favorably when the reduction in operating expenses will pay the interest on the necessary investment, provided the capital requirements can be met, leaving the unevaluated advantages to be gained by electric operation as an additional asset. Also, when the traffic capacity is imperative and this can only be supplied by a large additional expenditure or by electrifying.

Location Economics

The effect of new elements introduced by electric traction upon economic values indicates that the values heretofore assumed under classified heads of Distance, Rise and Fall, Curvature and Rate of Grade will be affected.

Distance

Train wages, fuel and repairs are the largest single items of expense, which vary with distance. The first is but little affected. A new additional charge is created for the operation and maintenance of power stations and of transmission and distributing systems.

Fuel is materially affected. The saving being from 50 per cent. to 70 per cent., depending upon class of service. Engine repairs are also reduced—possibly 50 per cent. Track maintenance under some conditions may be increased by the additional charge for the maintenance of overhead or third rail contact and distributing systems.

Rise and Fall

The unit values of the several minor classifications under this head will be determined as before with modified factors of cost. Two new elements will be introduced and must be included in the final results, viz.: the time and temperature limitations of the electric motor and the possibilities of regeneration of power on descending grades. The cost of Rise and Fall will be reduced if advantage is taken of opportunities for the regeneration of power by trains on descending grades. The value of such regeneration is considerable under proper conditions. The actual percentage of power which can be utilized will depend upon the length and steepness of incline, total length of electrified section and the number and distribution of daily trains. Regenerative braking does not become economical except on long mountain grades.

Curvature

The effect of a change to electric operation as affected by curvature, will be in degree rather than in kind, with the possible exception that the shorter rigid wheel base of some types of electric locomotives will result in reduced resistance and wear of wheels and rails.

Rate of Grade

The effects of rate of grade and of rise and fall are more closely inter-related in electric than in steam operation. Train tonnage ratings in steam service over lines of moderate grades are often determined by the average resistance of the division and the boiler H. P. of the engine rather than by the resistance of the maximum grades. If the inherent characteristics of the electric motor permit the development of higher speed and horsepower, within its nominal rating, then the resistance of the maximum grade may become the limiting factor, and its rate becomes economically important.

In heavy service, and especially on mountain grades, the economic value of electric operation may be quite high, as it is possible to add engine units without adding engine crews.

Other differences affecting unit costs differ more in degree than in kind.

Conclusion

Taking into consideration the heavy fixed charges of investment, no general conclusion can be given at this time as to the relative economy of electric and steam operation. Each case must be considered by itself, taking into consideration all elements of cost and expense, both special and general, as well as operating conditions and the public comfort and safety.

REPORT OF COMMITTEE XXIII—ON SHOPS AND LOCOMOTIVE TERMINALS

F. E. Morrow, *Chairman;*
C. N. Bainbridge,
G. W. Burpee,
Leland Clapper,
C. G. Delo,
G. H. Gilbert,
Walter Goldstraw,
J. G. Gwyn,
E. M. Haas,
R. J. Hammond,
G. W. Harris,
E. A. Harrison,
A. T. Hawk, *Vice-Chairman;*
J. L. Haugh,
L. P. Kimball,
W. T. Krausch,
M. A. Long,
J. B. Maddock,
Adam Ritter,
L. K. Sillcox,
John Schofield,
E. M. Tucker,
A. M. Turner,
Committee.

To the American Railway Engineering Association:

The following subjects were assigned the Committee on Shops and Locomotive Terminals for study and report:

1. Report on Ashpits.

2. Report on Engine House and Power Plants and Shop Extension, collaborating with Division V—Mechanical.

3. Report on Storehouses.

4. Report on Design of Car Shops.

5. Report on Design of Coaling Stations.

6. Report on Typical Layouts for Storage and Distribution of Fuel Oil, including Fuel Oil Stations between Terminals, collaborating with Division V—Mechanical.

Committee Meetings

Meetings of the Committee were held in Chicago, May 25th and September 17th, with Committee of Division V—Mechanical, American Railway Association, on Engine Terminals, Design and Operation, and in Cleveland, Ohio, November 9th and 10th, 1920.

(1) Ashpits

The Committee has actively studied this subject, but is not prepared at this time to make a final report. Certain information has been compiled by the Committee which is shown in Appendix B.

(2) Engine House and Power Plants and Shop Extension, Collaborating with Division V—Mechanical

The Committee reports progress. Sub-Committees have been assigned to collaborate with the Mechanical Committee on Engine Terminals, Design and Operation.

(3) Storehouses

The Committee reports progress.

(4) Design of Car Shops

The Committee reports progress. In Appendix A is shown certain studies which have been prepared by the Committee and is submitted as information. The Committee in the further study of the subject expects to collaborate with the Mechanical Division Committee assigned to this subject.

(5) Design of Coaling Stations

The Committee reports progress.

(6) Typical Layouts for Storage and Distribution of Fuel Oil, Including Fuel Stations Between Terminals, Collaborating with Division V—Mechanical

The Committee reports progress.

Recommendations for Future Work

The Committee recommends that subjects (1) to (6), inclusive, be reassigned.

Respectfully submitted,

THE COMMITTEE ON SHOPS AND LOCOMOTIVE TERMINALS,

F. E. MORROW, *Chairman.*

Appendix A

DESIGN OF CAR SHOPS

L. K. Sillcox, *Chairman;*
Walter Goldstraw,
Adam Ritter,
J. G. Gwyn,
E. M. Tucker,
A. M. Turner,

Sub-Committee.

Many railroad companies find it desirable to provide shops for handling repairs to freight cars either on account of climatic conditions, legal requirements, or the belief that the provision of such shops will result in a higher degree of efficiency. Arguments advanced in favor of such shops are that their provision will insure a better grade of workmanship, a lower rate of labor turnover, and that cars repaired in a shop will give better service.

The Committee feels that each railroad company must from the very nature of the problem determine in accordance with its own operating methods and conditions whether a shop is justified and what expenditure is warranted, so that the fixed charges per car, due to this expenditure, may not exceed the advantages secured by better workmanship, lower unit cost and less delay in conducting repairs.

In order to facilitate the design of car shops where their construction may be necessary or desirable, the Committee has collected a considerable amount of data to which it has devoted careful study, and as a result presents general drawings of several plants actually in service and several proposed for the future, as an outline of actual possibilities in construction as experienced at this time. It is to be noted that, in general, the layout of many plants has been governed by existing property and trackage limits, and this condition is one which will probably be encountered even more seriously in the future, except where very extensive plants in new localities are contemplated.

In reviewing freight car repair layouts throughout the country, we find that they divide themselves into two general classes: light repairs and heavy repairs. The first-named group consists of equipment receiving running repairs given in transportation yards with trains under blue flag protection, where the safety appliances, doors, brake equipment, lubrication, brasses and minor truck repairs receive attention. Further to this, light repairs are handled, but require switching of the cars out of trains. Under this heading, cars are spotted on improvised tracks, where wheels are changed, brake rigging repaired, draft rigging and couplers replaced, and cars necessitating more extensive attention are temporarily strengthened and put in shape to meet Safety Appliance requirements, so as to be moved to heavy repair points having facilities and forces to do whatever is required.

Sheds or shops are not to be recommended as practicable at this time for the light repair work mentioned above, because of the frequent switching necessary and the further fact that many hundreds of cars in this class are worked upon each day, depending upon the amount of business handled through any territory, and the number requiring repairs has little fixed relation to a road's ownership.

In the case of heavy repairs, however, shops may be desirable at certain points, especially when considered in conjunction with the power, tool and handling equipment necessary to intensive production. There are three subdivisions into which heavy repairs may be classed, namely: Medium repairs, consisting of moderate attention to trucks, underframes and superstructure with entire repainting; heavy repairs, occasioned by severe wreck damage or extreme deterioration; and rebuild, where cars are strengthened and made modern in construction through the application of steel underframes, ends, roof, etc. Where it is possible, most railroads prefer to do heavy repair work on their own cars, due to having suitable standard material, and the further fact that cars can be segregated by series and the work standardized. There are practical reasons requiring the rebuilding of foreign cars occasioned by the handling lines' responsibility, but this only represents a small percentage of the total.

Where a railroad owns a sufficient number of steel cars to justify the expense, a special shop should be given consideration for this purpose. From what the Committee can observe, based on experience throughout the country, it recommends:

(1) Track Centers: In cases where material tracks are employed, 24 ft. centers are recommended and in cases where material tracks are not used, 18 ft. centers as a minimum.

(2) Space Allowance per Car: With the track centers named in section No. 1, it is desirable, considering present and future practice, to allow 60 ft. per car. Railroads using wider track centers, such as 30 ft. with material tracks, and 22 ft. without, usually only employ 50 ft. per car due to rearrangement of work.

(3) Supply Tracks: Standard gage seems to be preferred throughout the country, due to the ease in handling wheels and the usual design of section push car upon which material can be carried. Further to this, erecting shops can be supplied with standard freight car loads of heavy material, such as underframes, sills, etc., which is not possible with narrow-gage tracks.

(4) Clearances: It is recommended that a minimum clearance of 10 ft. from center of track to face of pilasters and 12 ft. from center of track to face of wall.

(5) Headroom: Measuring from top of rail, overhead clearance in shops where cranes are not employed should be 20 ft. minimum, 22 ft. desirable. Where cranes are used, clearance should be not less than 25 ft. unless careful study of local operating conditions should dictate a smaller dimension advisable. In mentioning clearance, it is the purpose

to define it as the exact clearance possible either from the crane hook or crane cage or girder, whichever forms the limiting element and the farthest downward projection. Shops designed with cranes should be limited to include bays not to exceed four repair tracks.

(6) Doors: The minimum dimension for end doors in car shops, which the Committee recommends, is 13 ft. wide and 17 ft. high, obtaining as large a door on supply tracks as clearance and general construction will permit.

(7) Paint Shops: Separate accommodation in line with the normal movement of cars through shops should be provided and installed in such a way so that equipment can be handled expeditiously and prevent blocking repair tracks.

(8) Expected Increase: Committee wishes to point out that in constructing any shop, full consideration should be given to expected increases in demand and future extensions which can be foreseen. In cases where shops are constructed with traveling cranes, it is felt advisable to recommend that runways be advanced beyond the covered space which will provide for flexibility of operation and permit men to work either out-doors or in-doors as local conditions may govern; also will assist in the handling of material and the adjustment of loads in cars.

(9) Handling Material for Effective Service: Every possible means should be provided for a prompt and economic handling of material through the application of necessary cranes, hoists, mono-rails, supply tracks, runways, and storage space, all located with the single purpose of concentrating work and materials into definite groups.

(10) Lighting: Ample lighting is essential. Construction of roof and walls should be such as to admit the maximum amount of natural light and ample artificial light should be provided, which, in a general way, should amount to just as much as is required in usual locomotive shop practice. Interior walls and ceilings should be painted and maintained as nearly white as possible.

(11) Heating: The question of proper heating should be carefully studied out so as to maintain a temperature of between 40 deg. and 50 deg. Fahr. in the shop itself, whereas in adjacent machine sections and other points requiring operators remaining stationary at tools, etc., a temperature of 60 deg. to 70 deg. is preferable. The expense permissible in providing a heating plant will be governed largely by the form of construction to be employed. During cold weather it should be remembered, that equipment has to be thawed out when brought into the shop in order to facilitate repairs, so that the heat should be delivered as near the floor line as practicable and well distributed so as to avoid drafts.

For next year, the Committee will attempt to study and give definite recommendations on some features governing economics of freight car shop operation as well as a partial or complete report on the design and construction for passenger car shops. The submissions for designs of various shops can be briefly stated as follows:

Fig. 1: Freight Car Repair Shops, Grand Trunk Railway, Elsdon, Chicago, Ill.

This plant was formerly constructed for the construction of new cars and was known as the Whipple Car Works. We have had occasion to personally observe the operation of this plant several times and it is very well equipped throughout.

Fig. 2: Freight Car Repair Shop, New York Central Railroad, East Buffalo, N. Y.

Figs. 3 and 19: Freight Car Repair Shop, Atchison, Topeka & Santa Fe Railway, Topeka, Kan.

This layout is worked into a large freight car and passenger facility and therefore has no direct connection with the blacksmith shop, which would be difficult to provide on account of two freight car shops being included; one of old standing and the other more recently installed.

Fig. 4: Car Repair Shops, National Transcontinental Railway, Winnipeg, Man., Canada.

This is a fairly new plant and material is handled on the transverse plan.

Fig. 5: Proposed A. R. A. Freight Car Repair Shop.

Fig. 6: Car Erecting Shop of the Bettendorf Axle Company, Bettendorf, Iowa.

This layout is particularly included to indicate the location of various facilities and transmission.

Various railroads have had considerable steel car repair work done at this plant, for which they are adequately adapted.

Fig. 7: Car Erecting Shop, Pacific Car & Foundry Company, Renton, Wash.

This plant is very well adapted to repair work, except painting facilities are not sufficient. However, this has since been corrected. The construction of the building is nicely adapted to the service.

Fig. 8: Typical Layouts Car Repair Facilities, Austin Company, Cleveland, Ohio.

We had copies made of print which the above company furnished.

Fig. 9: Proposed Car Repair Shed, Wabash Railway, Moberly, Mo.

This is simply a covering over existing tracks to comply with the state law.

Figs. 10 and 11: Wooden Shed for Light Freight Car Repairs, Baltimore & Ohio Railroad, Connellsville, Pa., and Locust Point.

This simply provides a covering over existing train yard tracks, which is advisable where climatic conditions justify.

Figs. 12 and 23: Car Repair Shed, Northern Pacific Railway, Watertown, N. D., Car Repair Shed, Chicago, Milwaukee & St. Paul Railway, Marmarth, N. D.

Both repair sheds were apparently erected to meet requirements of the state law and are similar. A covering existing on repair tracks intended to accommodate the normal run of medium classified repairs both for system and foreign cars such as require attention on a heavy trans-continental division.

Fig. 13: Car Repair Facilities, Canadian Pacific Railway, Calgary, Alta.

The layout is not unusual and is worked out to operate in conjunction with coach and locomotive repairs, besides providing for extension.

Fig. 14: Freight Car Repair Facilities, Illinois Central Railroad, Centralia, Ill.

The layout is quite typical as used by the railroad mentioned, as well as others in adjacent territory.

Fig. 15: Freight Car Repair Shop, Delaware, Lackawanna & Western Railroad, Scranton, Pa.

This simply gives the style of construction employed and indicates the use of traveling cranes, which is advisable considering the high price of labor at this time.

Fig. 16: Car Repair Shed, Baltimore & Ohio Railroad.

Proposed standard construction on one of the large trunk lines is shown herein which indicates considerable use of wire glass.

Fig. 17: Steel Car Repair Shop, New York Central Railroad, Ashtabula, Ohio.

This provides one of the most extensive layouts in this country and is adequately adapted for the work intended.

Fig. 18: Car Shop, Wabash Railway, Decatur, Ill.

The style of construction employed is indicated in the drawing herein mentioned.

Fig. 20: Car Repair Shops, Delaware, Lackawanna & Western Railroad, Keyser Valley, Pa.

A very good layout is indicated in this plant and shows adequate painting facilities.

Fig. 21: Car Repair Shop, Canadian Pacific Railway, North Bay, Ont.

The layout indicated herein shows considerable study and is adapted to cold climatic conditions, also provision for future extension is possible. Everything is kept convenient and under cover as far as possible to preserve heating facilities, etc.

Fig. 22: Steel Freight Car Shop, Baltimore & Ohio Railroad, Mt. Clair, Md.

This layout, while quite extensive, only provides service for a limited number of units.

Fig. 24: Car Repair Shed, Boston & Maine Railroad, Boston, Mass.

This shows style of construction proposed by above company and indicates installation of lighting through the use of corrugated wire glass laid similar to the practice employed with roof tile.

Fig. 25: Car Repair Shed, Chicago, Milwaukee & St. Paul Railway, Tacoma.

This unit was hurriedly constructed and forms part of installation which is expected to be increased 475 ft. over its present size. The additional length to be equipped with traveling cranes.

Fig. 26: Car Repair Shop, proposed by Chicago, Milwaukee & St. Paul Railway, Milwaukee, Wis.

The plan submitted is the result of study given by all of the practical talent the railroad had available in making the best recommendation to the management for the class of service intended. The longitudinal type of shop was selected, since it permits whole strings of cars to be pulled at a time and does not make it very difficult to classify repairs so that cars which may be in shop a longer time than others can be assigned to individual sections. Six repair tracks are provided in a building 500 ft. long, giving a capacity of approximately 50 cars. Overhead crane service in conjunction with jib cranes on two tracks is provided for lifting underframes, metal superstructures, steel ends and other heavy repair parts. As a matter of economy, cinder floor is recommended since it is fireproof, which is necessary where so many heating operations are carried on. A good floor, but one much more expensive, would be that composed of a 9-in. concrete base with some plastic surface about 2 in. thick on top, since concrete is entirely too hard for men to stand and work upon all day. Provision is made for all operations to be performed in connection with the repairs considered, such as drilling, threading bolts and rods, blacksmithing, reclaiming brake beams and equipment, straightening structural steel, wood machine work, etc., all in conjunction with necessary washrooms, rest rooms, and locker rooms. It is felt that these operations can be best carried on at the sides of the main shop in the form of low bays, 24 ft. wide, which not only cheapen the construction, but makes it possible to deliver raw material with greater ease and leaves the main shop space available for reconstruction purposes. It is proposed that vises and drills in the general shop will be found very useful and provide considerable saving in time by avoiding having the men travel to machine department. Also, grinding wheels can be used for rough work of various kinds. An electric winch at each end of the shop, centrally located, is contemplated by a system of snatch blocks. Any track can be drawn or filled with little effort, as well as permit individual cars to be handled.

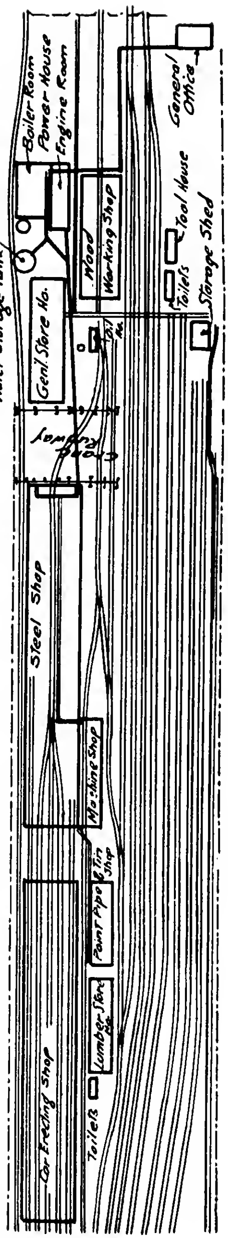


FIG. 1—CAR REPAIR SHOPS, GRAND TRUNK RAILWAY, CHICAGO, ILL.

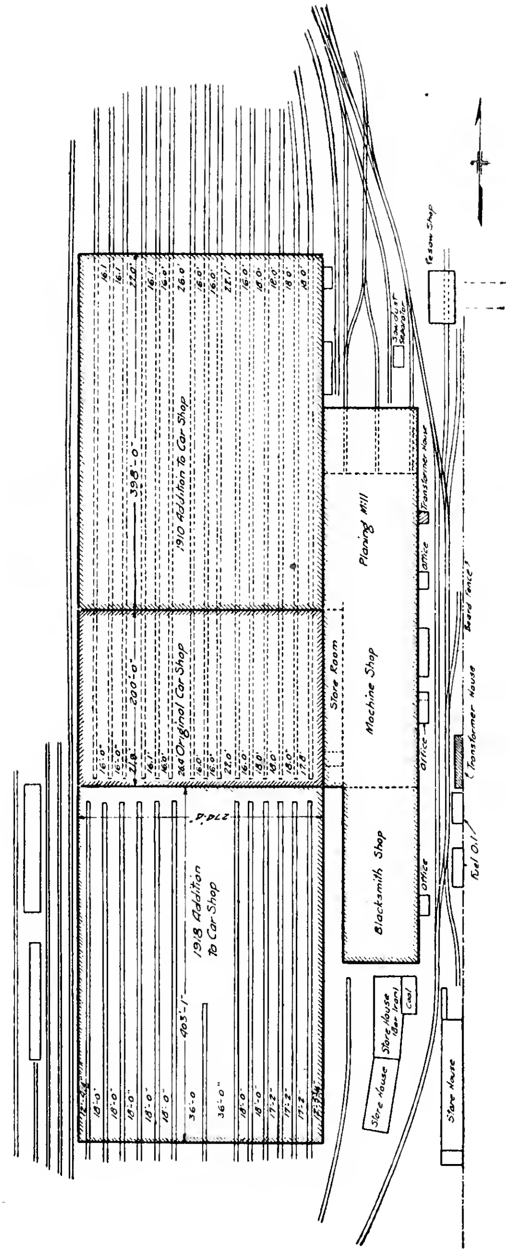


FIG. 2—FREIGHT CAR REPAIR SHOPS, NEW YORK CENTRAL RAILROAD, EAST BUFFALO, N. Y.

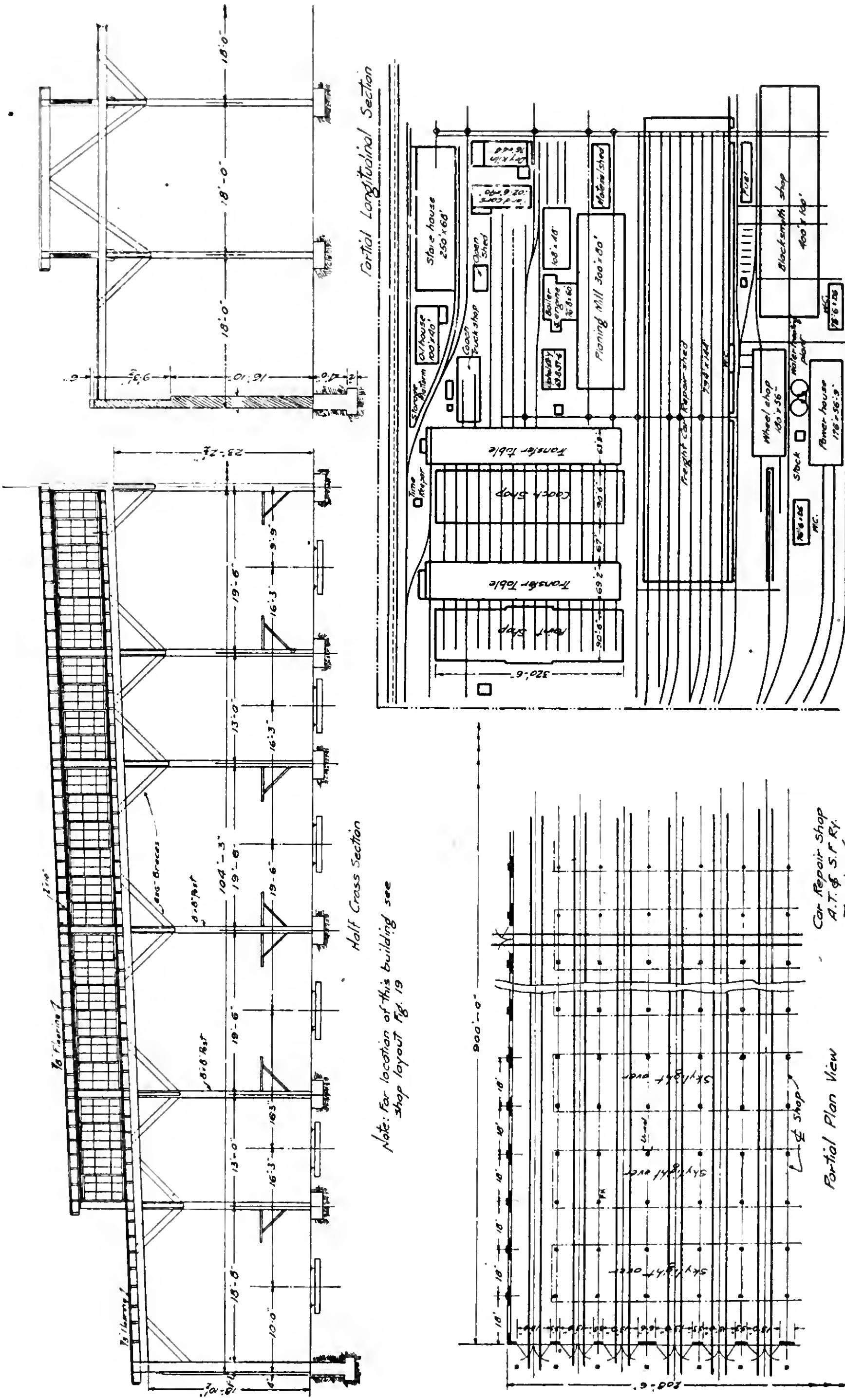


Fig. 3—Car Repair Shops, Atchison, Topeka & Santa Fe Railway, Topeka, Kansas.

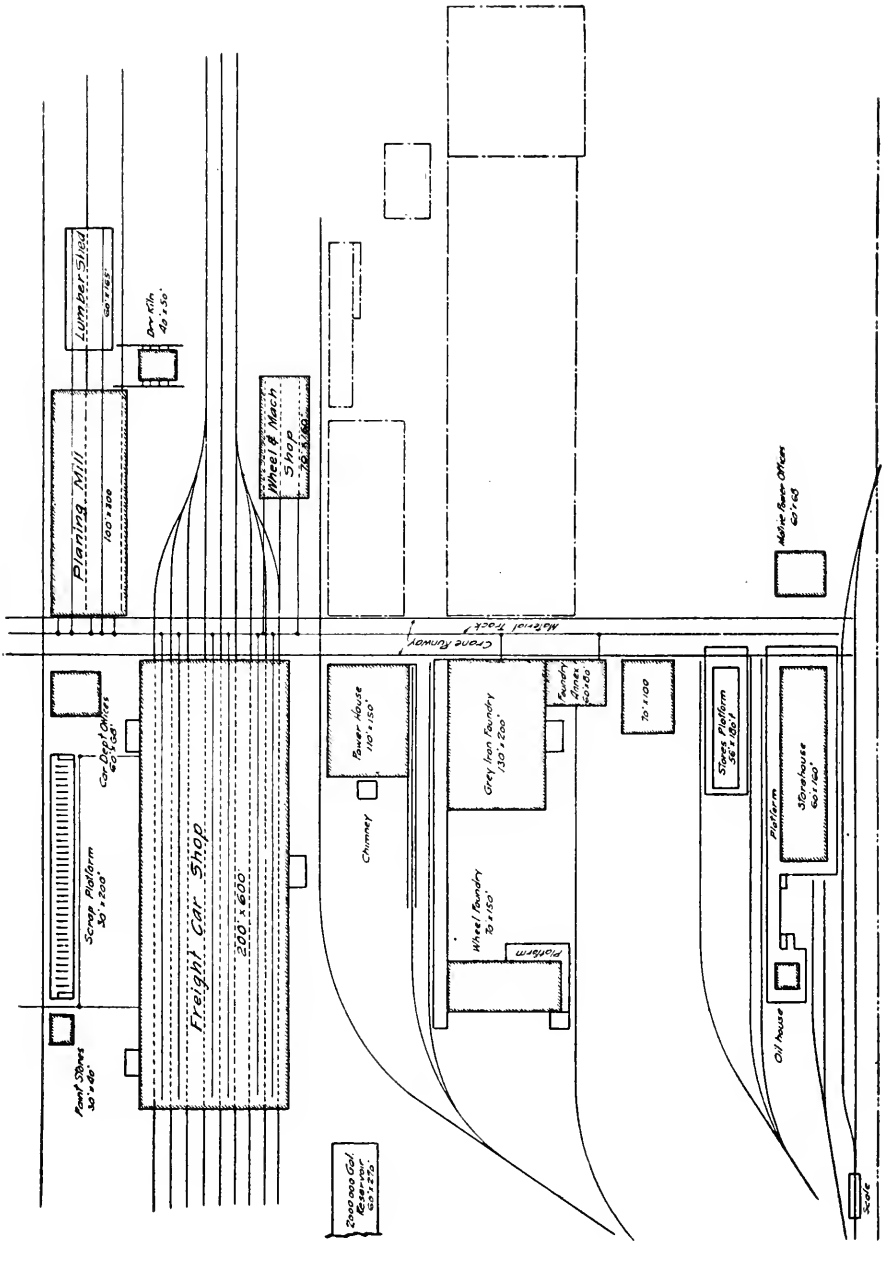


FIG. 4—CAR REPAIR SHOPS, NATIONAL TRANSCONTINENTAL RAILWAY, WINNIPEG, MANITOBA.
(Note.—Buildings and Tracks in full lines are Car Department Facilities.)

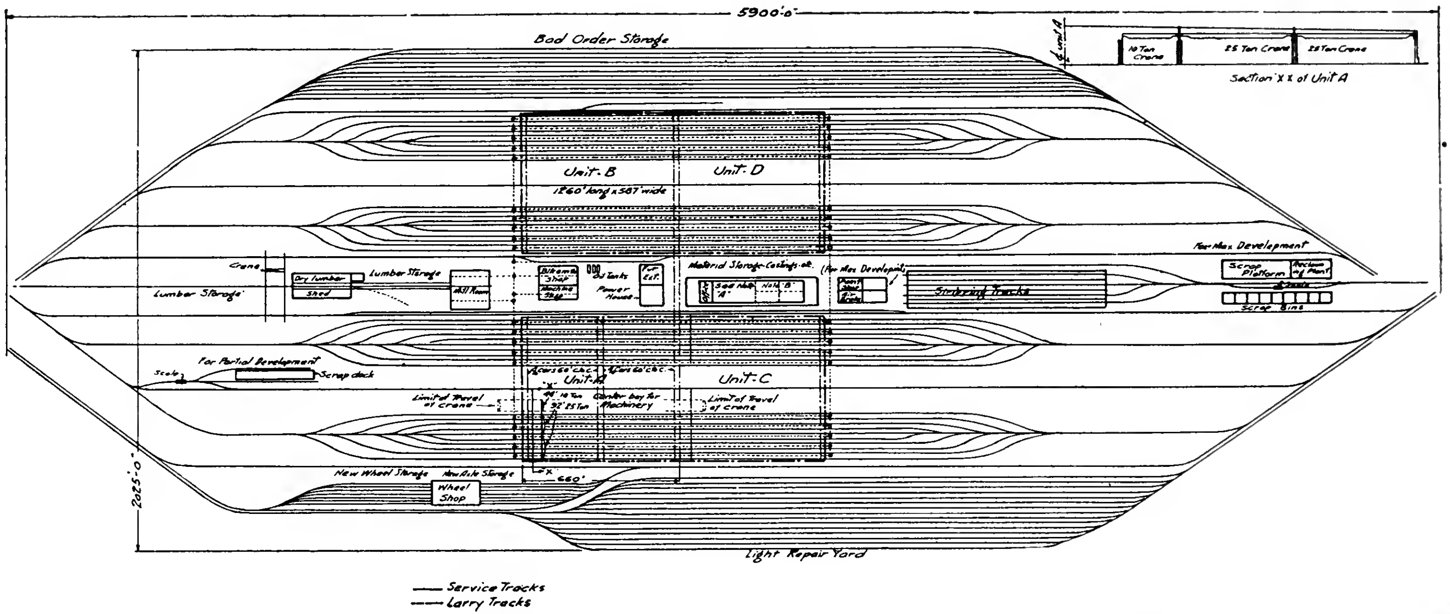


FIG. 5—PROPOSED A. R. A. FREIGHT CAR REPAIR SHOP—PLAN OF BUILDINGS AND TRACKS.

(Note A—Storage Room. Other shops, such as Tin Shop, located on second floor.)
(Note B—This space for partial development.)

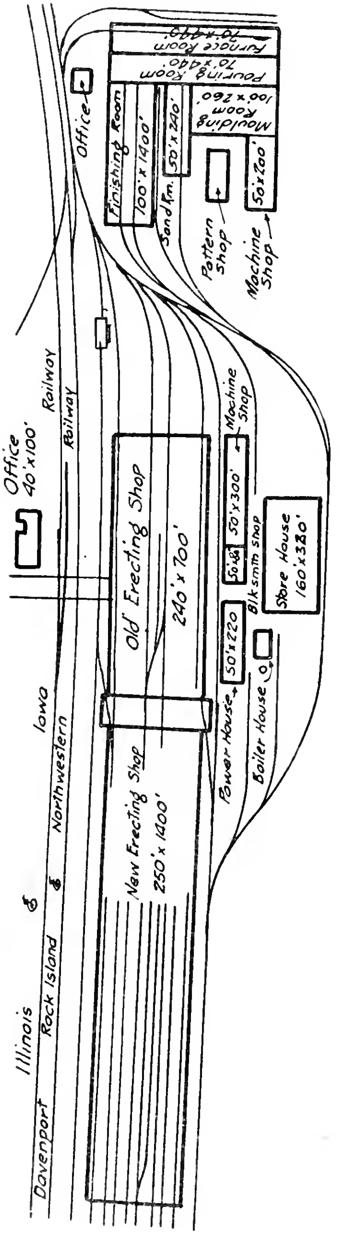


Fig. 6—New Car Shop and Steel Foundry, Bettendorf Axle Company, Bettendorf, Iowa.

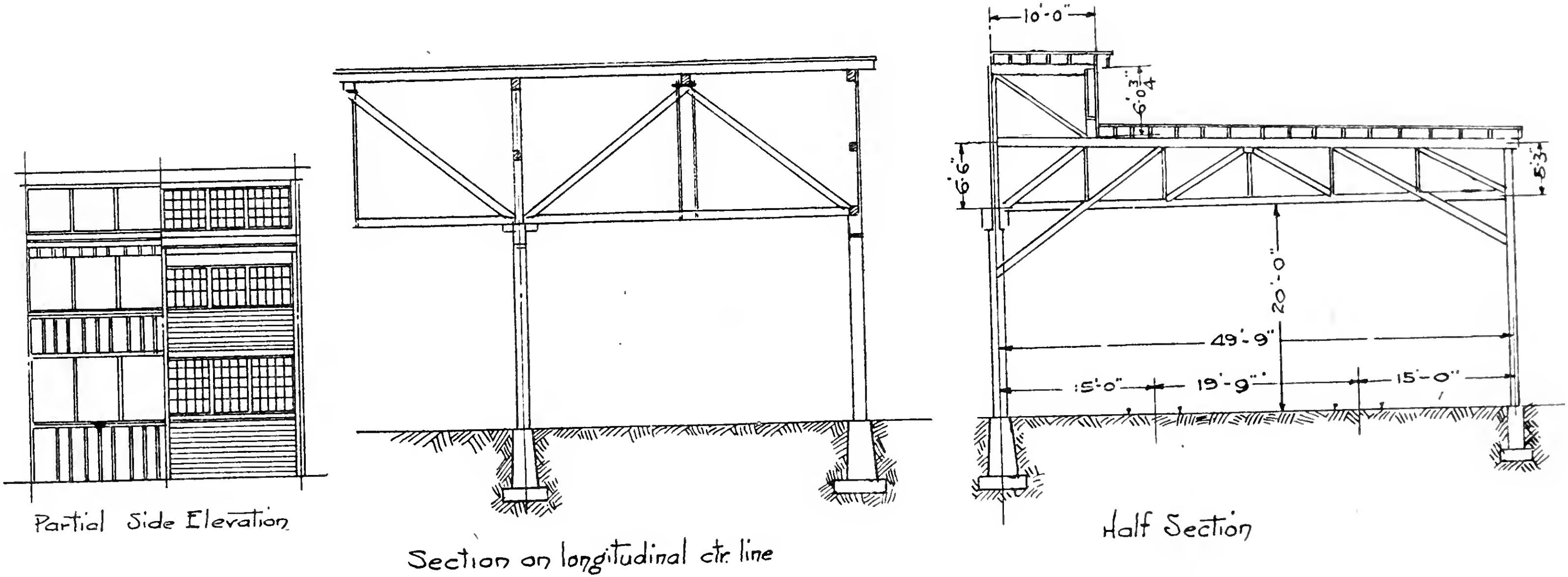


FIG. 7—100 FT. BY 300 FT. CAR ERECTING SHOP, PACIFIC CAR & FOUNDRY COMPANY, RENTON, WASHINGTON.

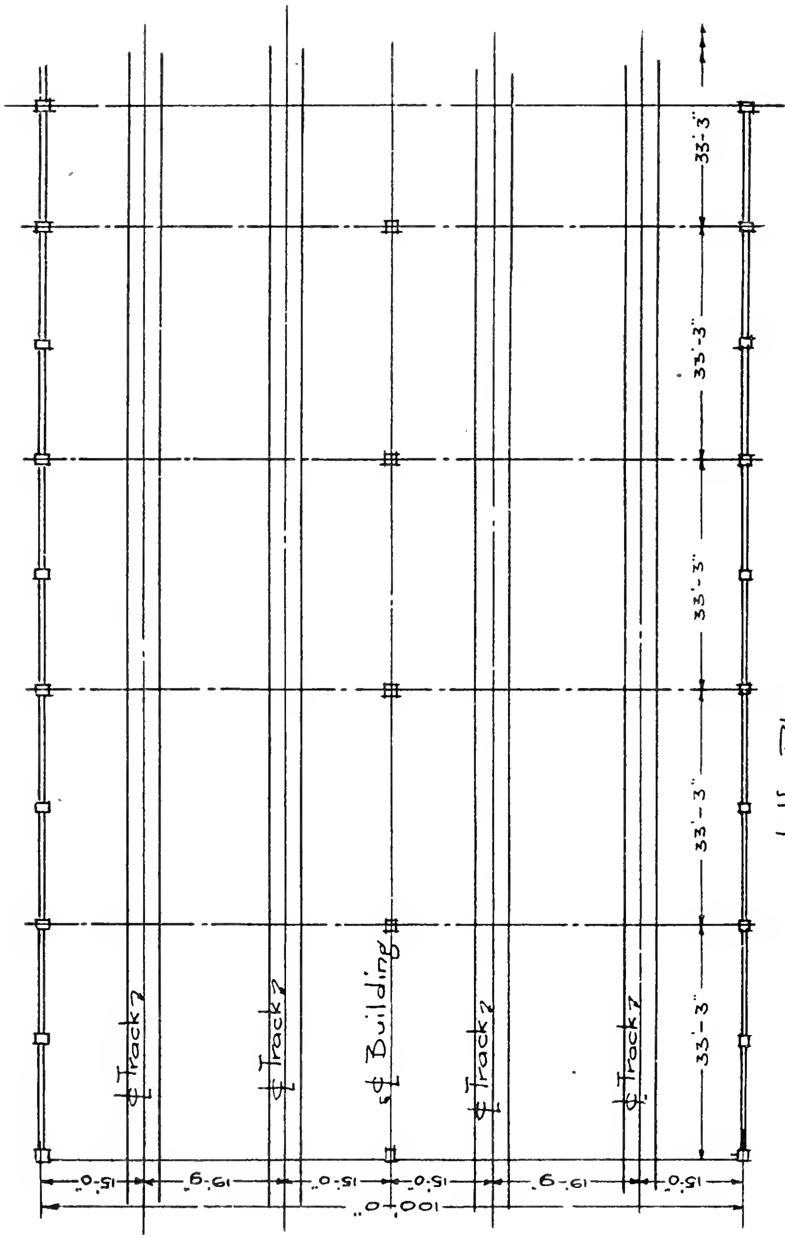


FIG. 7A—100 FT. BY 300 FT. CAR ERECTING SHOP, PACIFIC CAR & FOUNDRY COMPANY, RENTON, WASHINGTON.

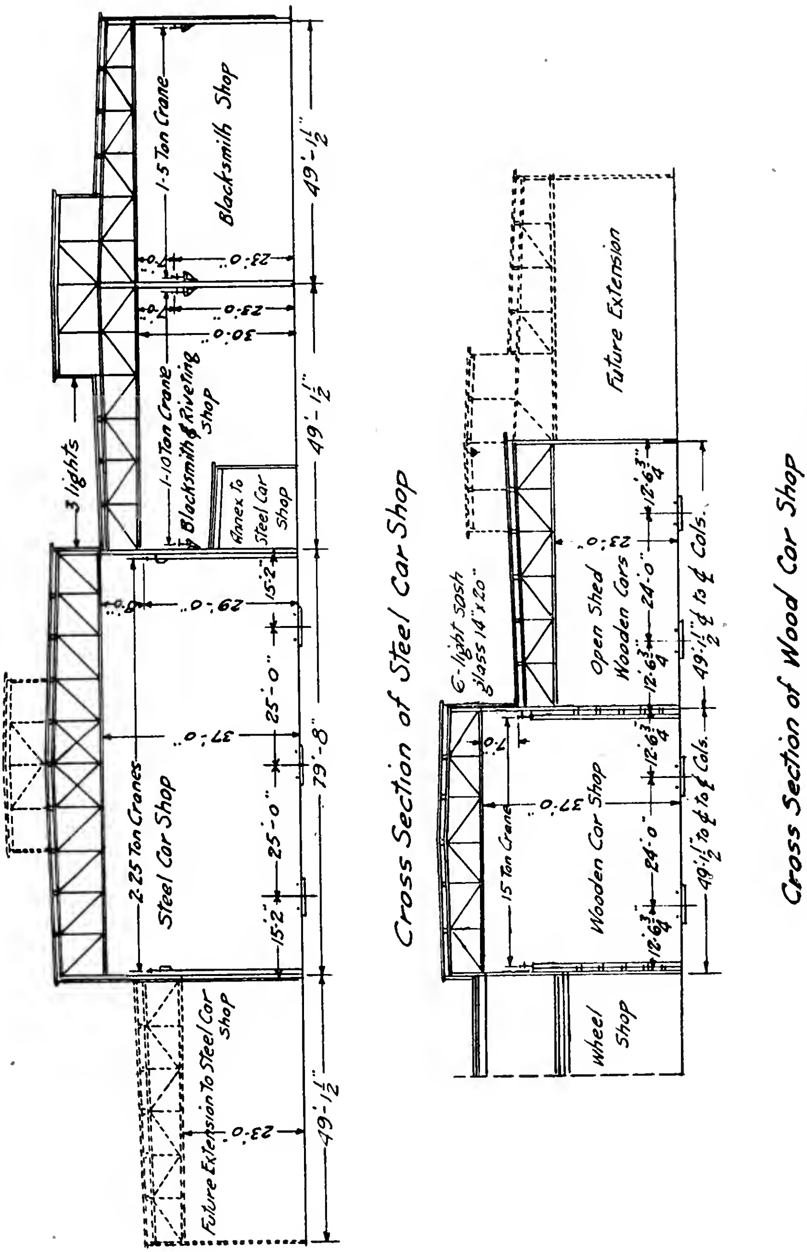


Fig. 8—Typical Layouts—Car Repair Facilities, Yards and Shop Buildings.

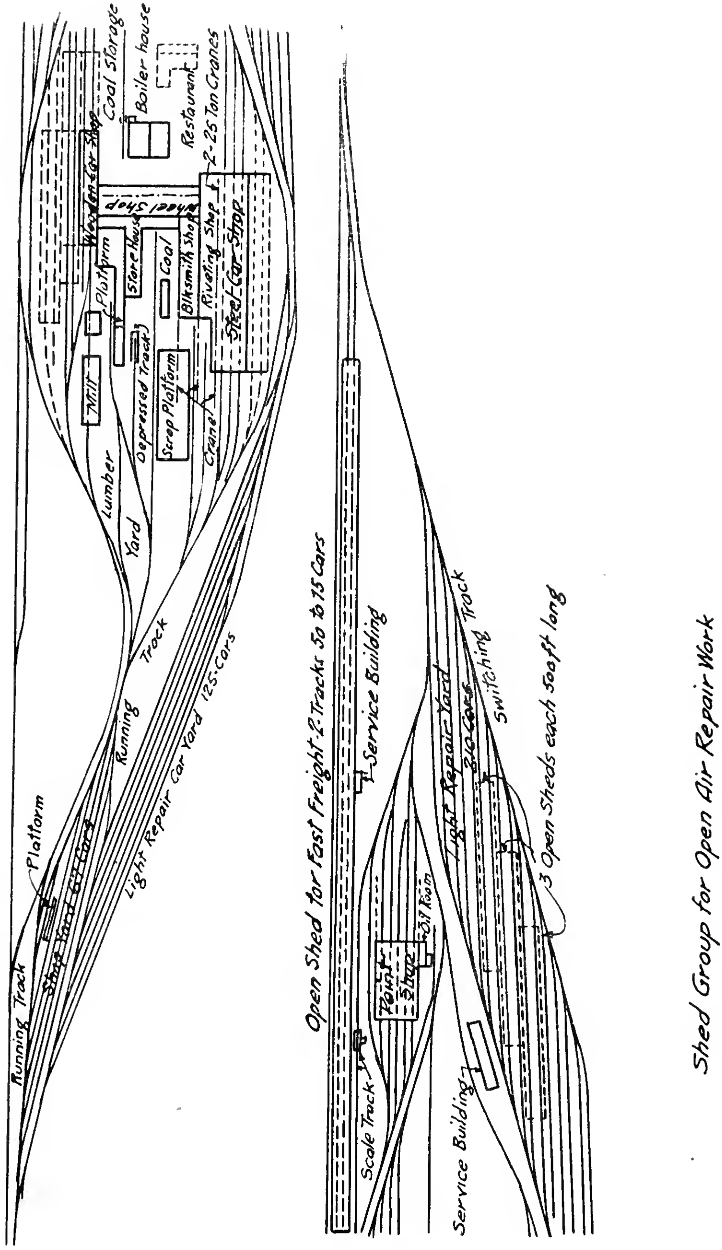


Fig. 8a—Typical Layouts—Car Repair Facilities, Yards and Shop Buildings.

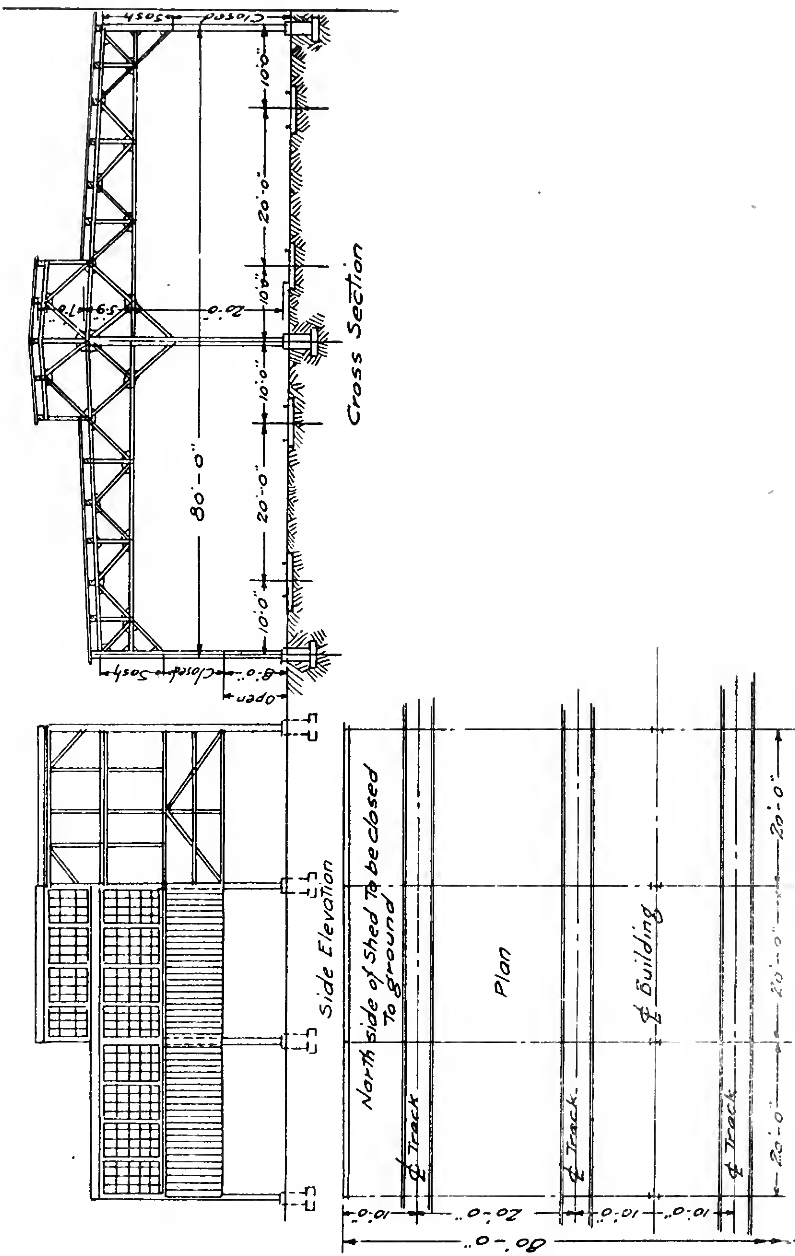


FIG. 9—PROPOSED CAR REPAIR SHED, WABASH RAILWAY, MOBERLY, MO.

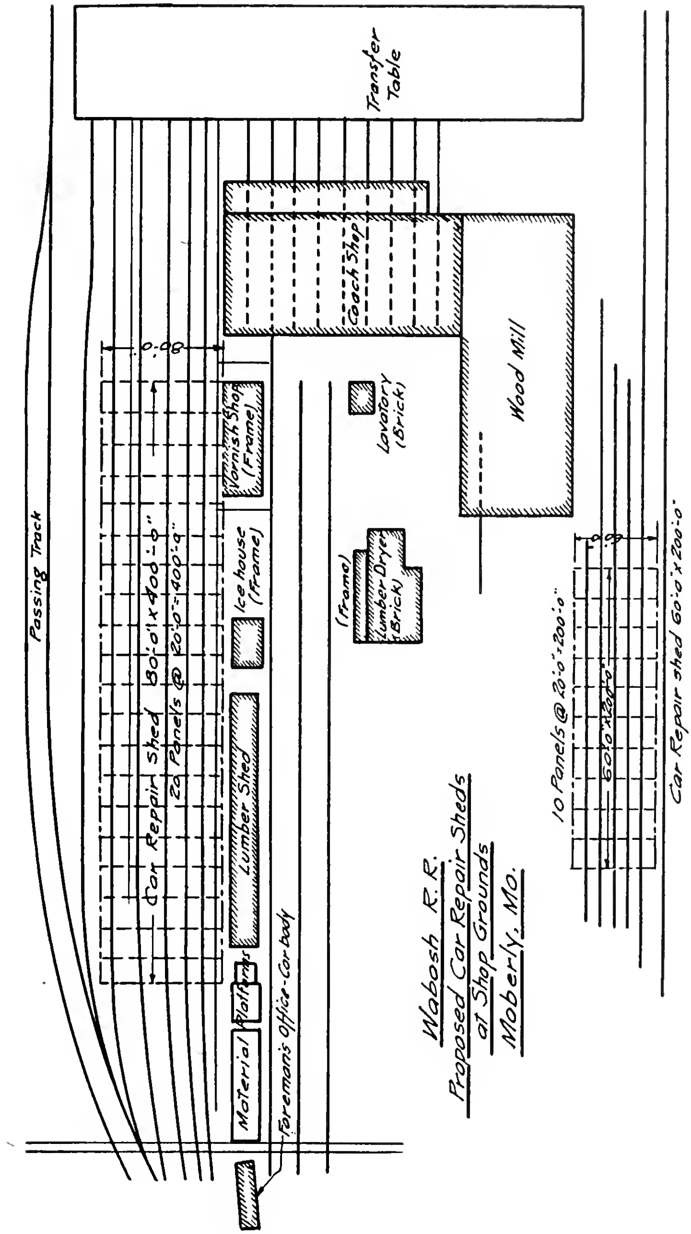


Fig. 9a—Proposed Car Repair Shed, Wabash Railway, Moberly, Mo.

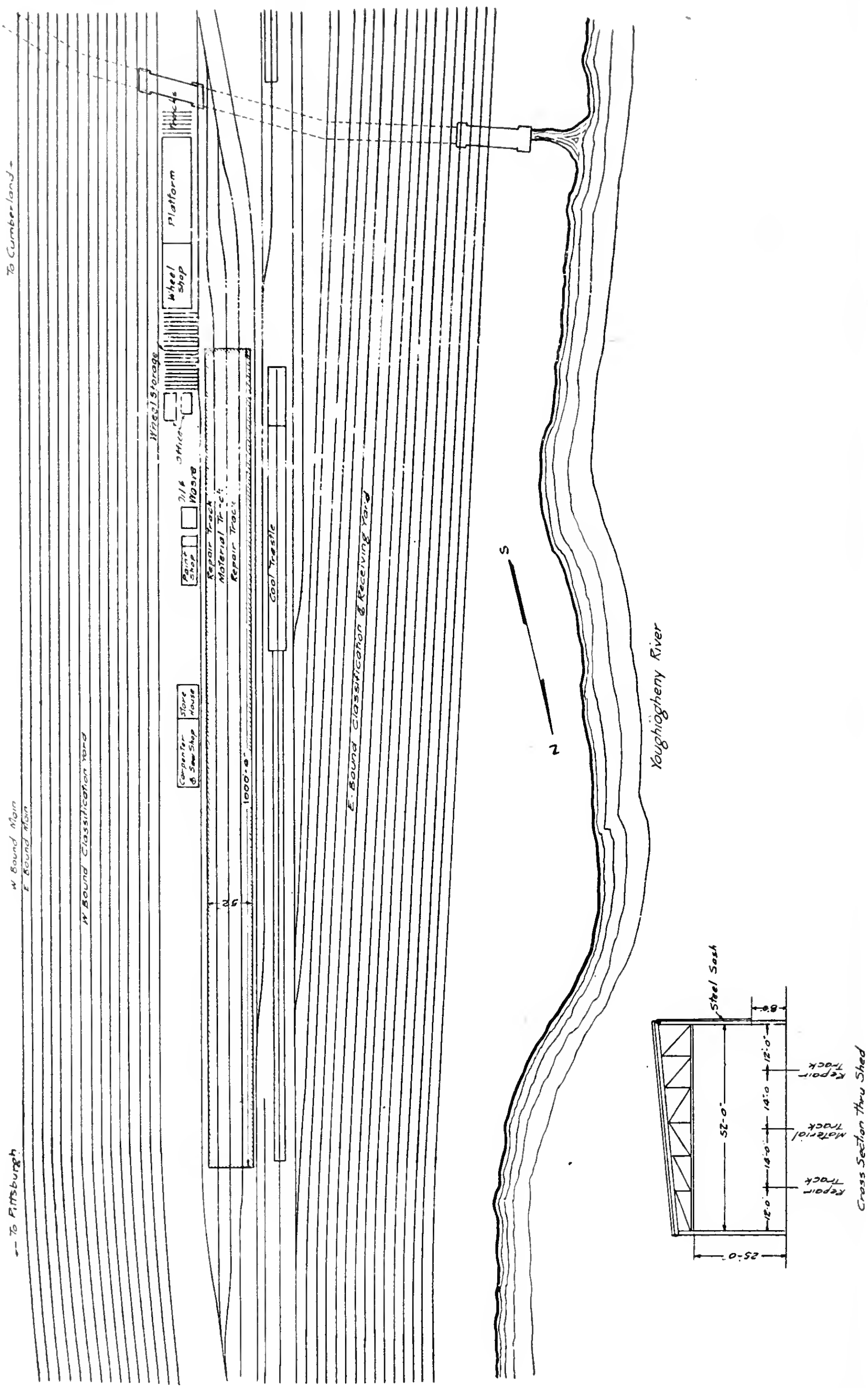


FIG. 10—WOODEN SHED FOR LIGHT FREIGHT CAR REPAIRS, BALTIMORE & OHIO RAILROAD, CONNELLSVILLE, PA.

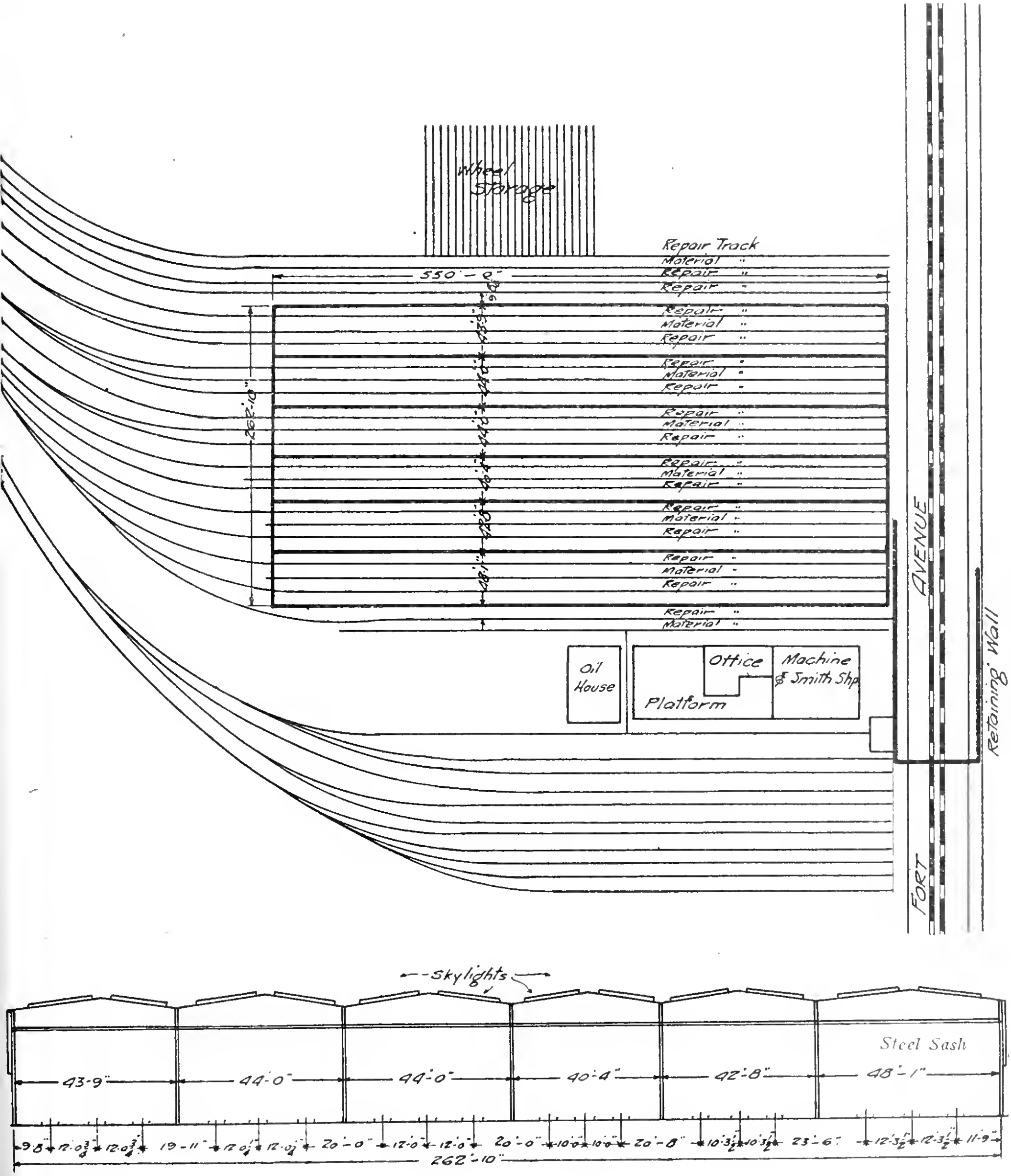


Fig. 11—Wooden Shed for Light Freight Car Repairs, Baltimore & Ohio Railroad, Locust Point, Md.

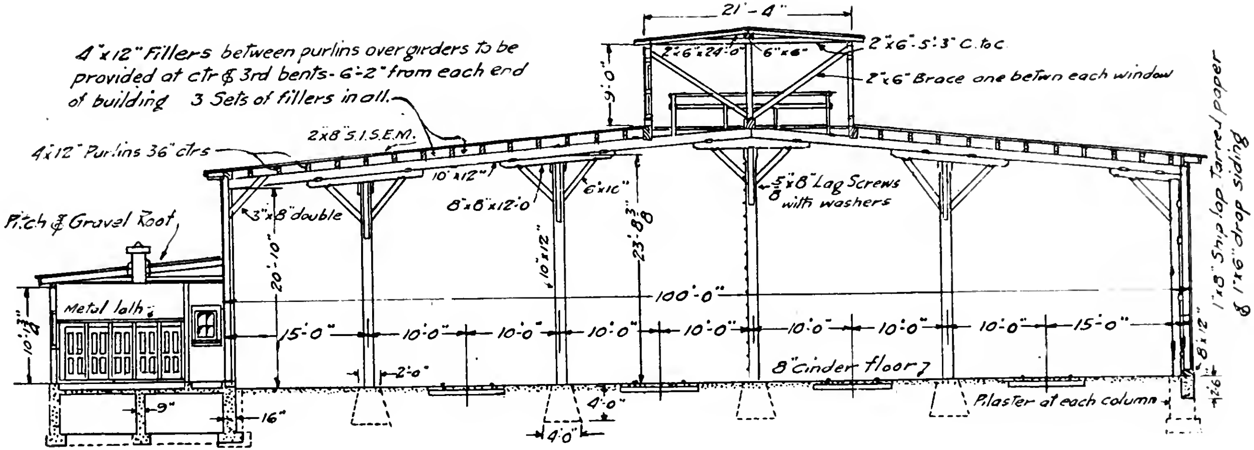


Fig. 12—Cross-Section of Car Repair Shed, 100 Ft. by 250 Ft., Northern Pacific Railway, Watertown, North Dakota.

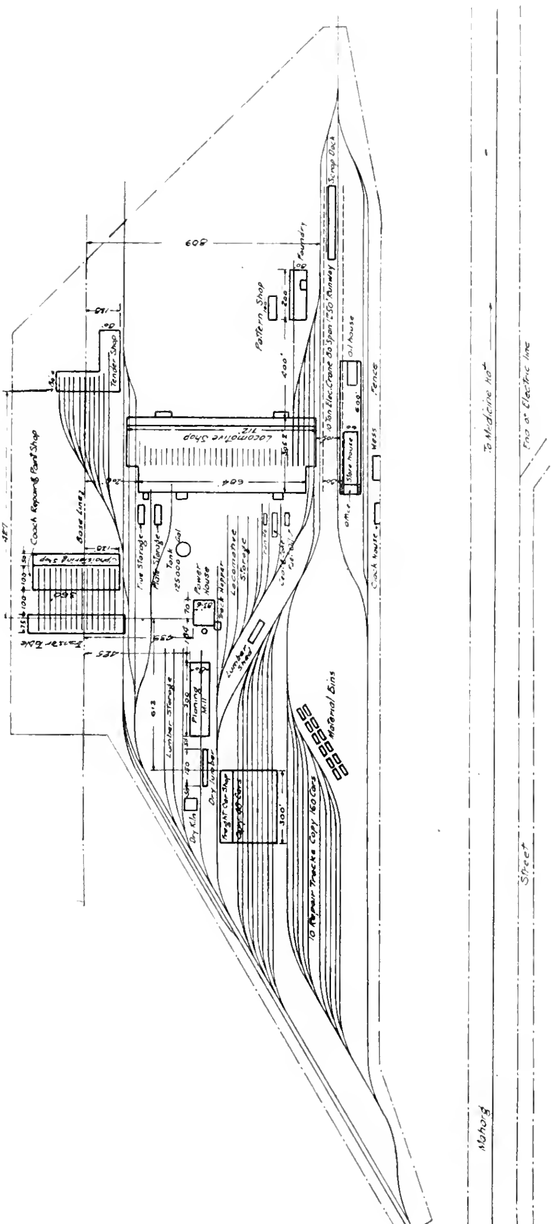


FIG. 13—GENERAL PLAN OF SHOPS, CANADIAN PACIFIC RAILWAY, CALGARY, ALBERTA, CANADA.

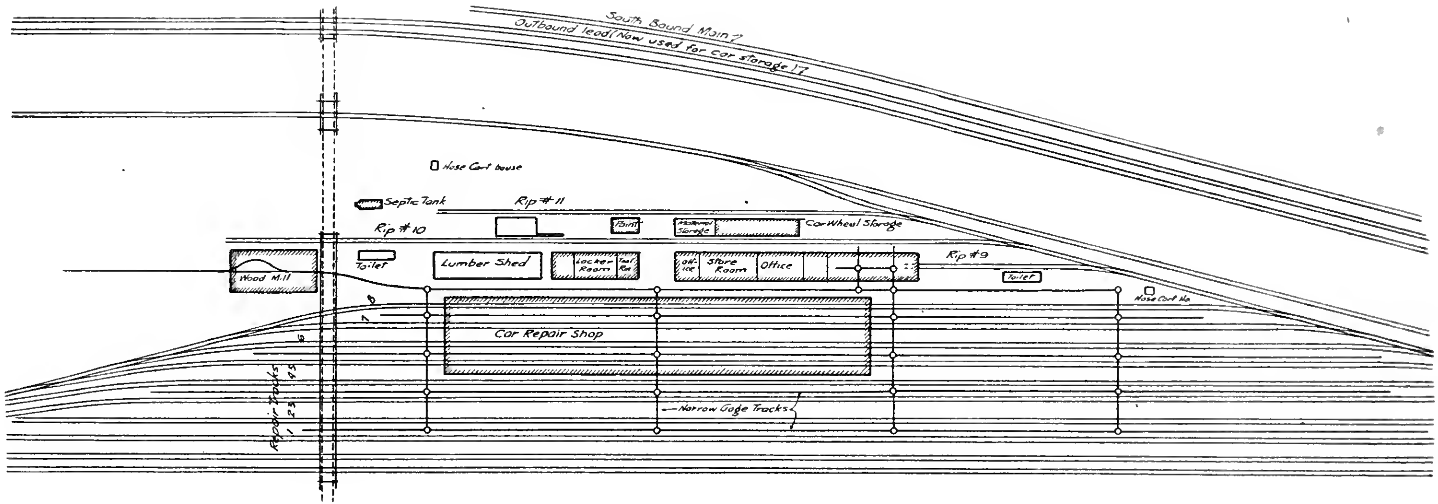


Fig. 14—Freight Car Repair Yard, Illinois Central Railroad, Centralia, Ill.

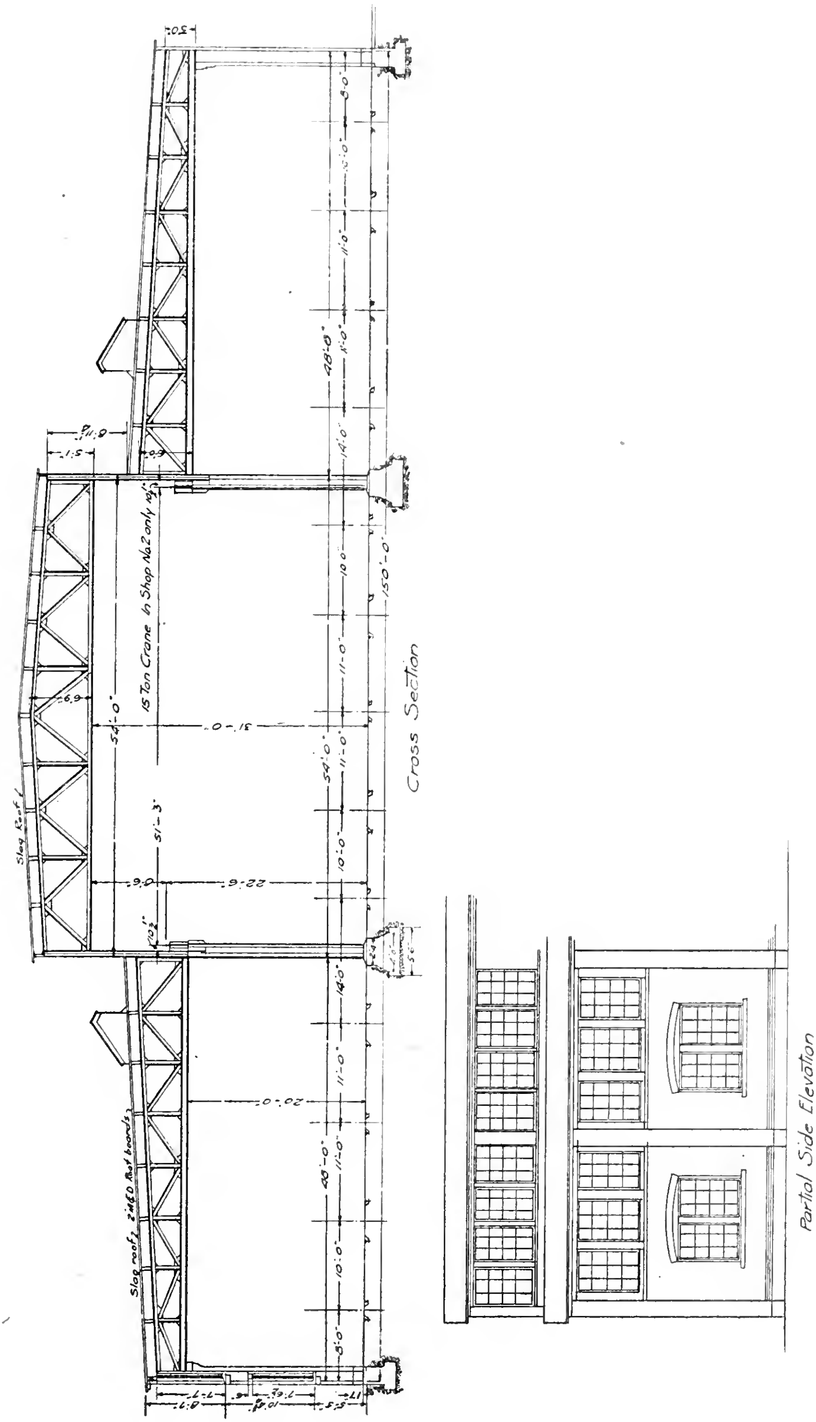


FIG. 15—FREIGHT CAR REPAIR SHOP, DELAWARE, LACKAWANNA & WESTERN RAILROAD, SCRANTON, PA.

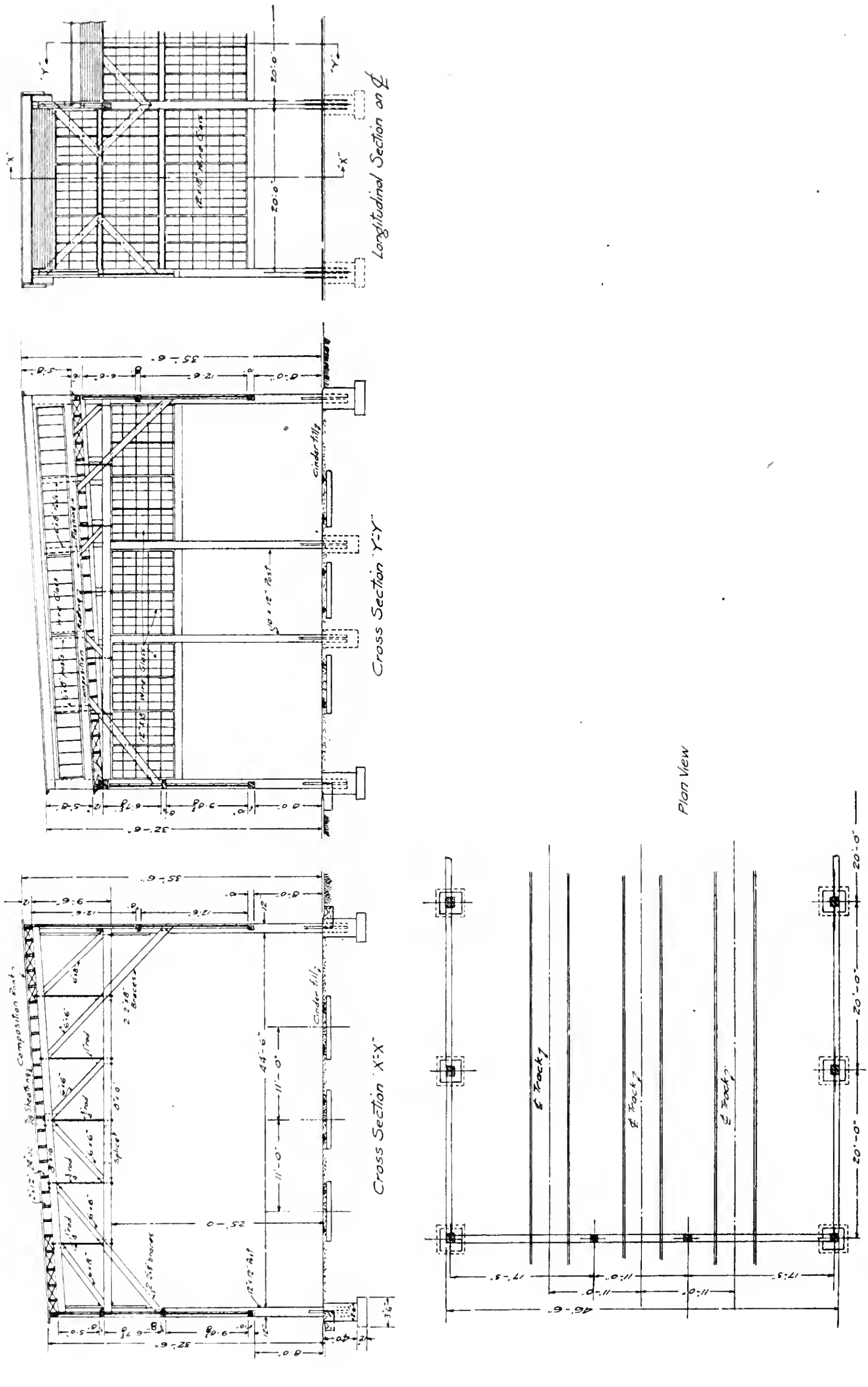
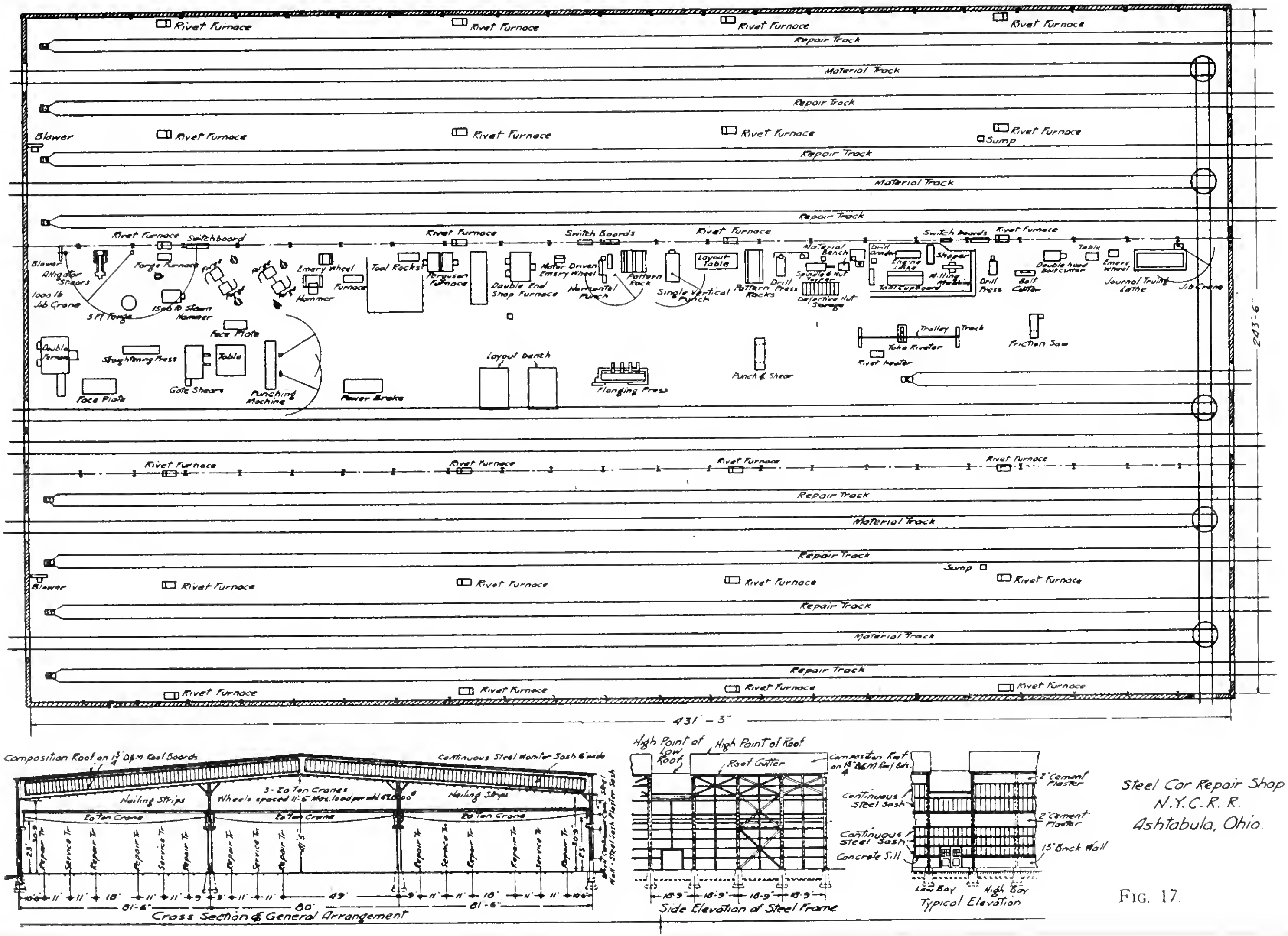


FIG. 16—PROPOSED STANDARD WOOD CAR REPAIR SHED; BATTIMORE & OHIO RAILROAD.



Steel Car Repair Shop
N. Y. C. R. R.
Ashtabula, Ohio.

FIG. 17.

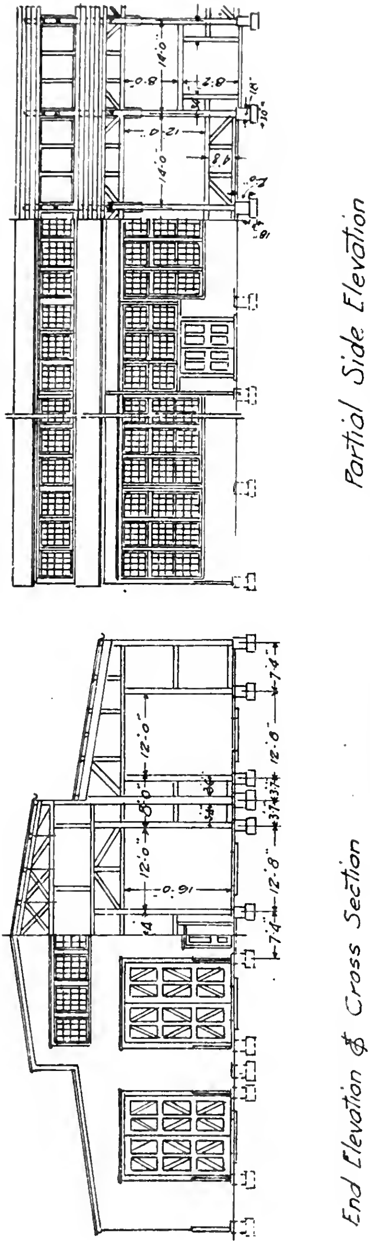


FIG. 18—CAR SHOP, WABASH RAILWAY, DECATUR, ILL.

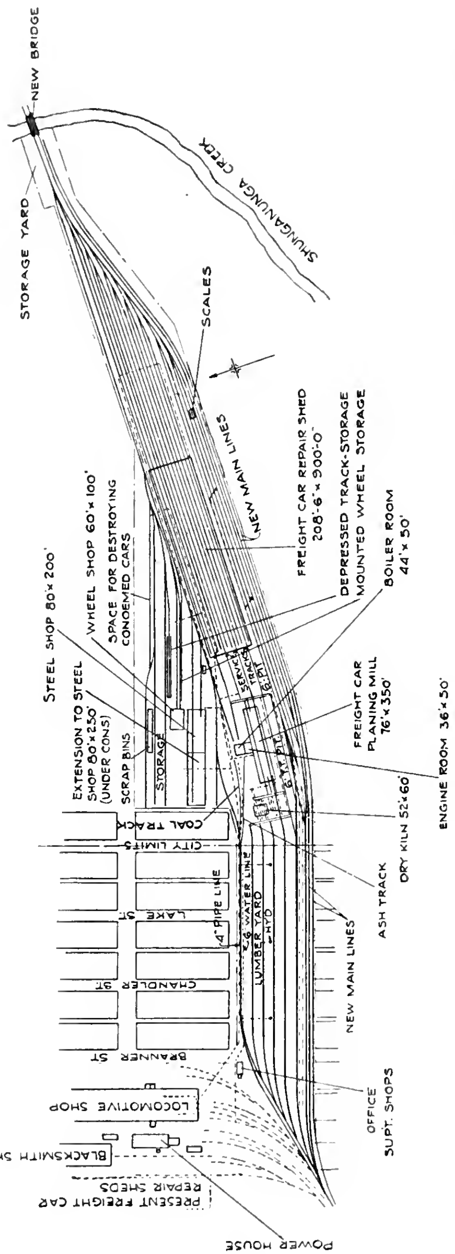


FIG. 19—FREIGHT CAR REPAIR SHOPS AND YARDS, ATCHISON, TOPEKA & SANTA FE RAILWAY, TOPEKA, KANSAS.

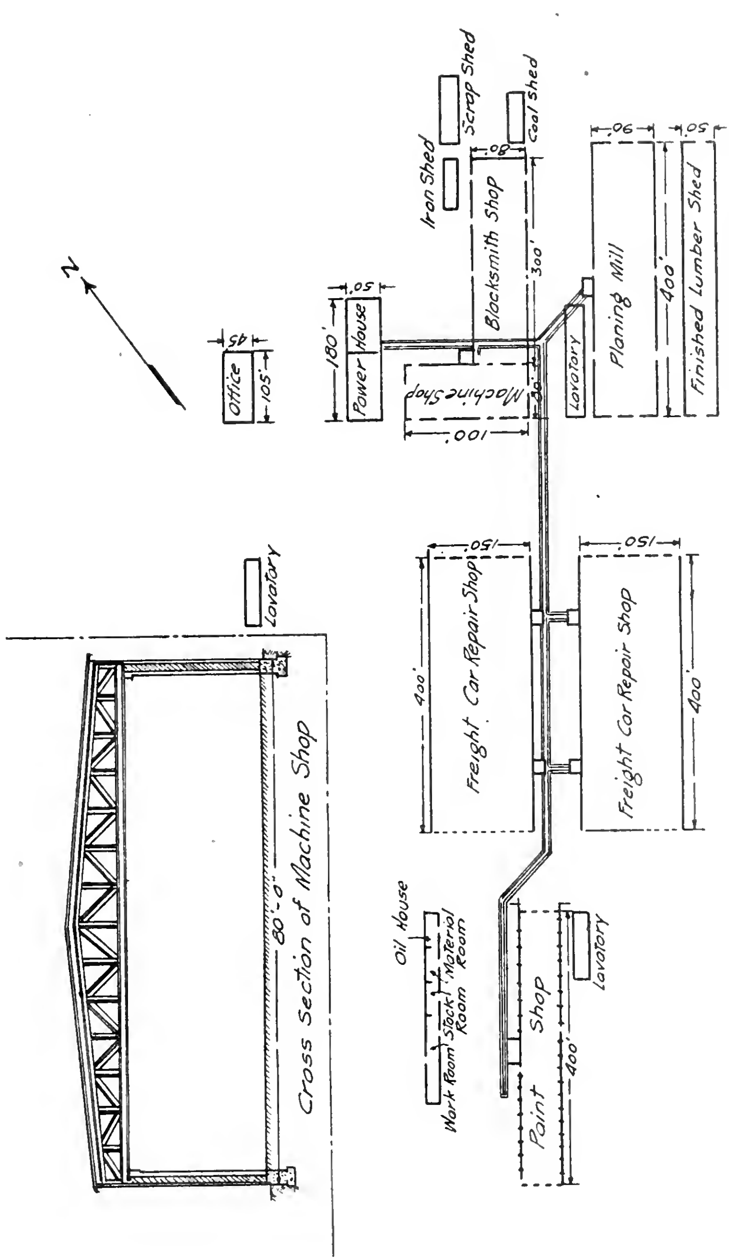


FIG. 20—CAR REPAIR SHOPS, DELAWARE, LACKAWANNA & WESTERN RAILROAD, KEYSER VALLEY, PA.

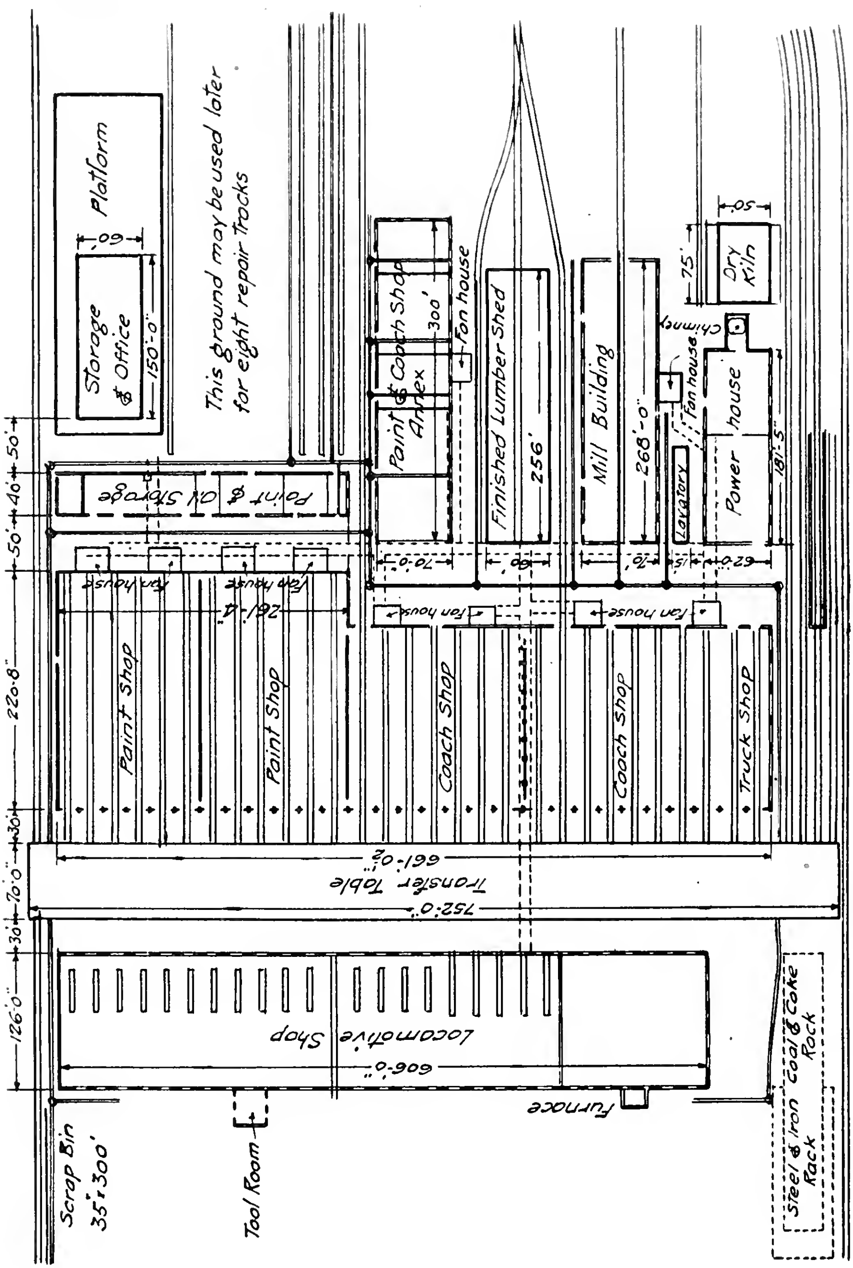


Fig. 20a—Car Repair Shops, Delaware, Lackawanna & Western Railroad, Keyser Valley, Pa.

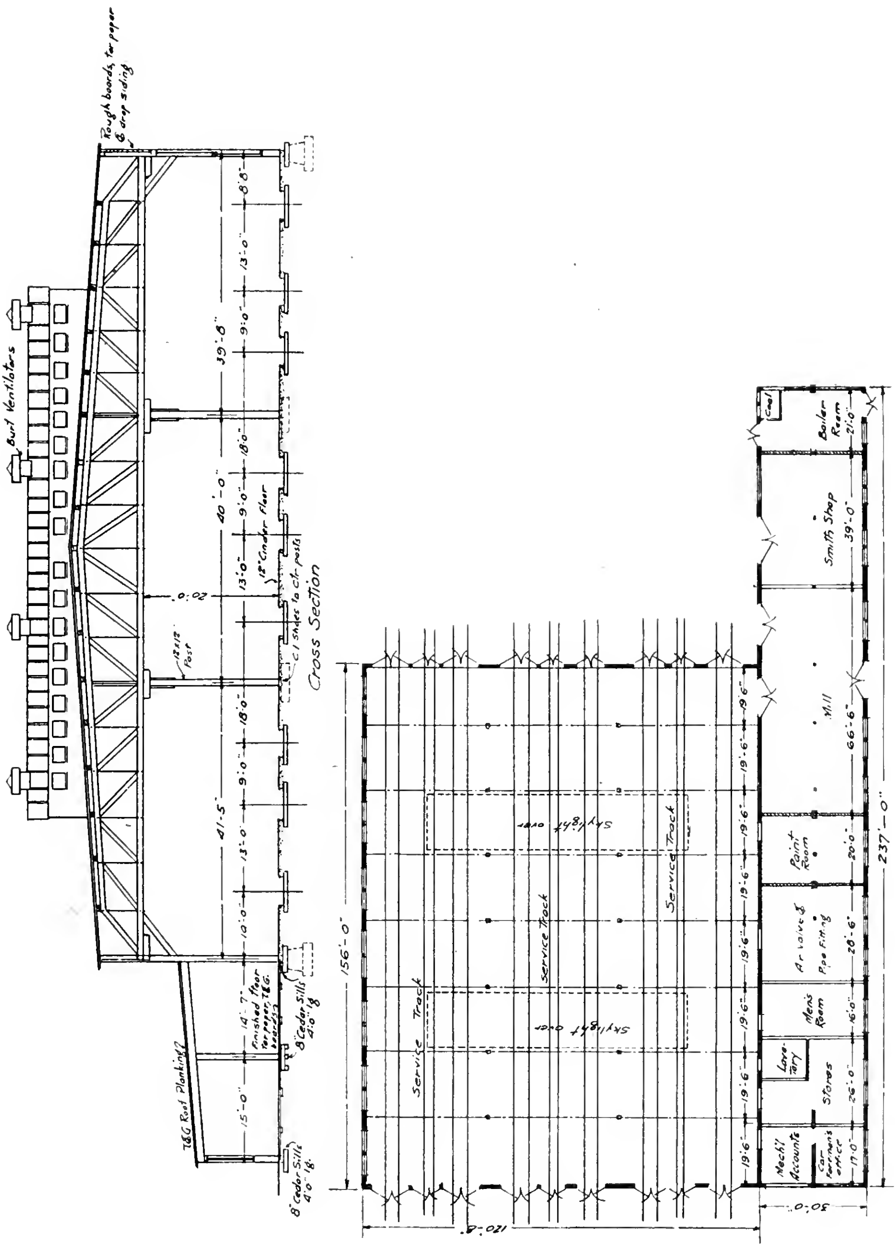


Fig. 21—Proposed Car Repair Shop, Canadian Pacific Railway, North Bay, Ontario, Canada.

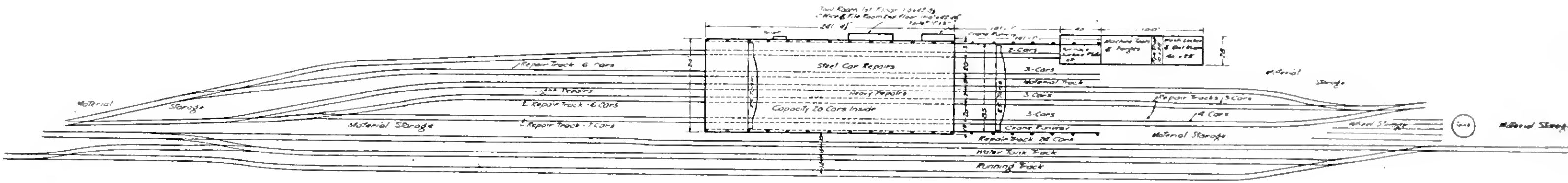
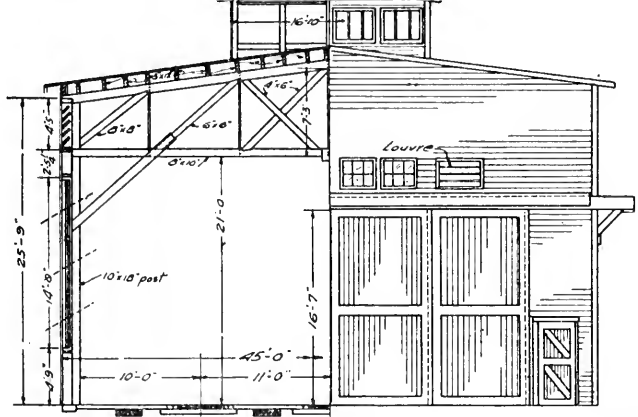


FIG. 22—STEEL FREIGHT CAR REPAIR SHOP, BALTIMORE & OHIO RAILROAD, MOUNT CLARE, MD.



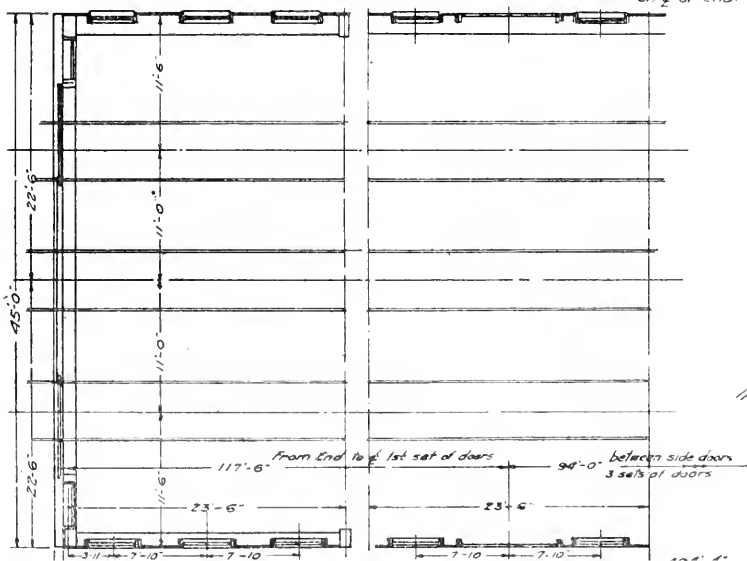
Half Cross Section

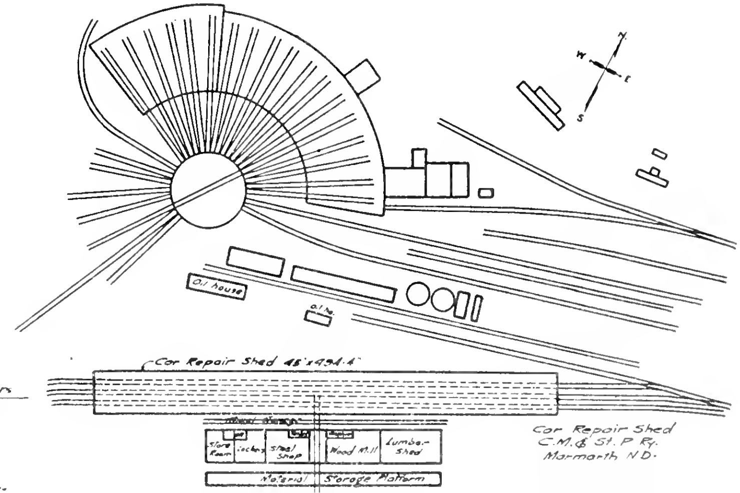
Half End Elevation

Longitudinal section on ℄ at end.

Side Elevation showing Monitor

Side Elevation between Monitors showing side doors





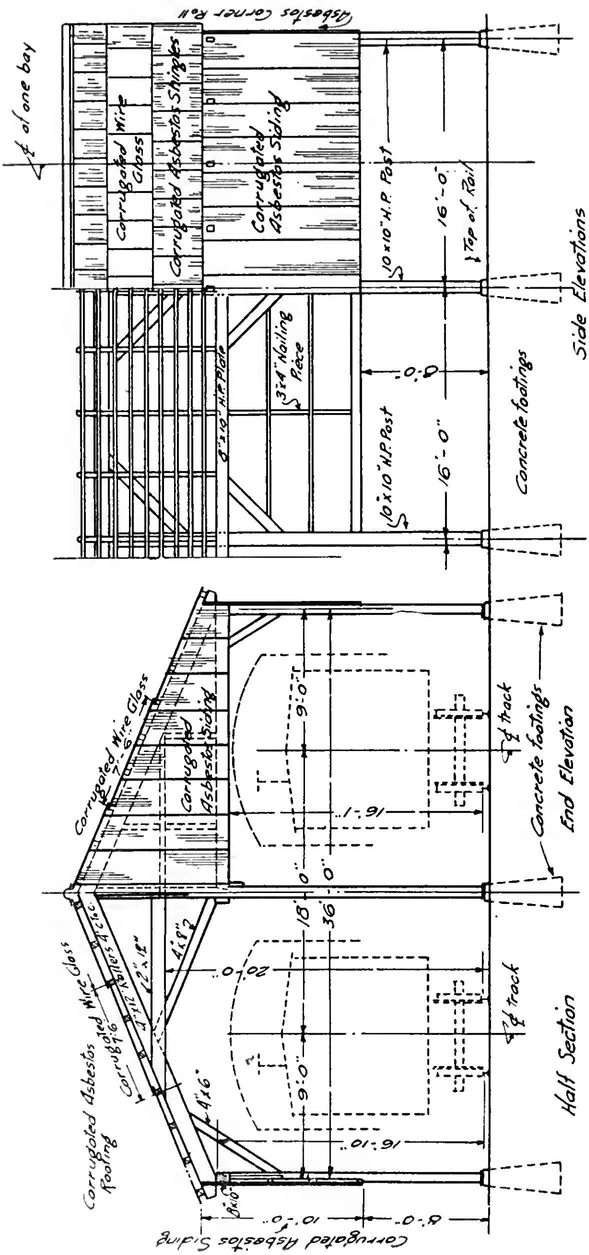


FIG. 24—PROPOSED STANDARD CAR REPAIR SHED, BOSTON & MAINE RAILROAD.

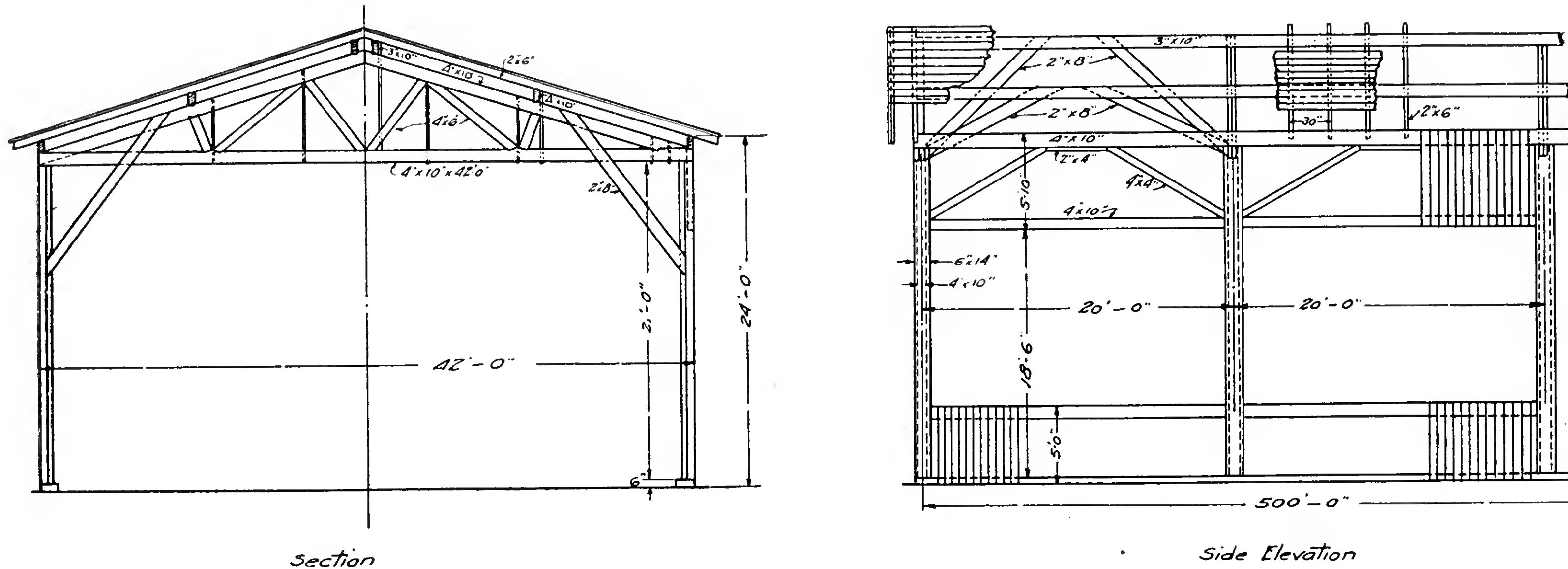


Fig. 25—Car Repair Shed, Chicago, Milwaukee & St. Paul Railway, Tacoma, Washington.

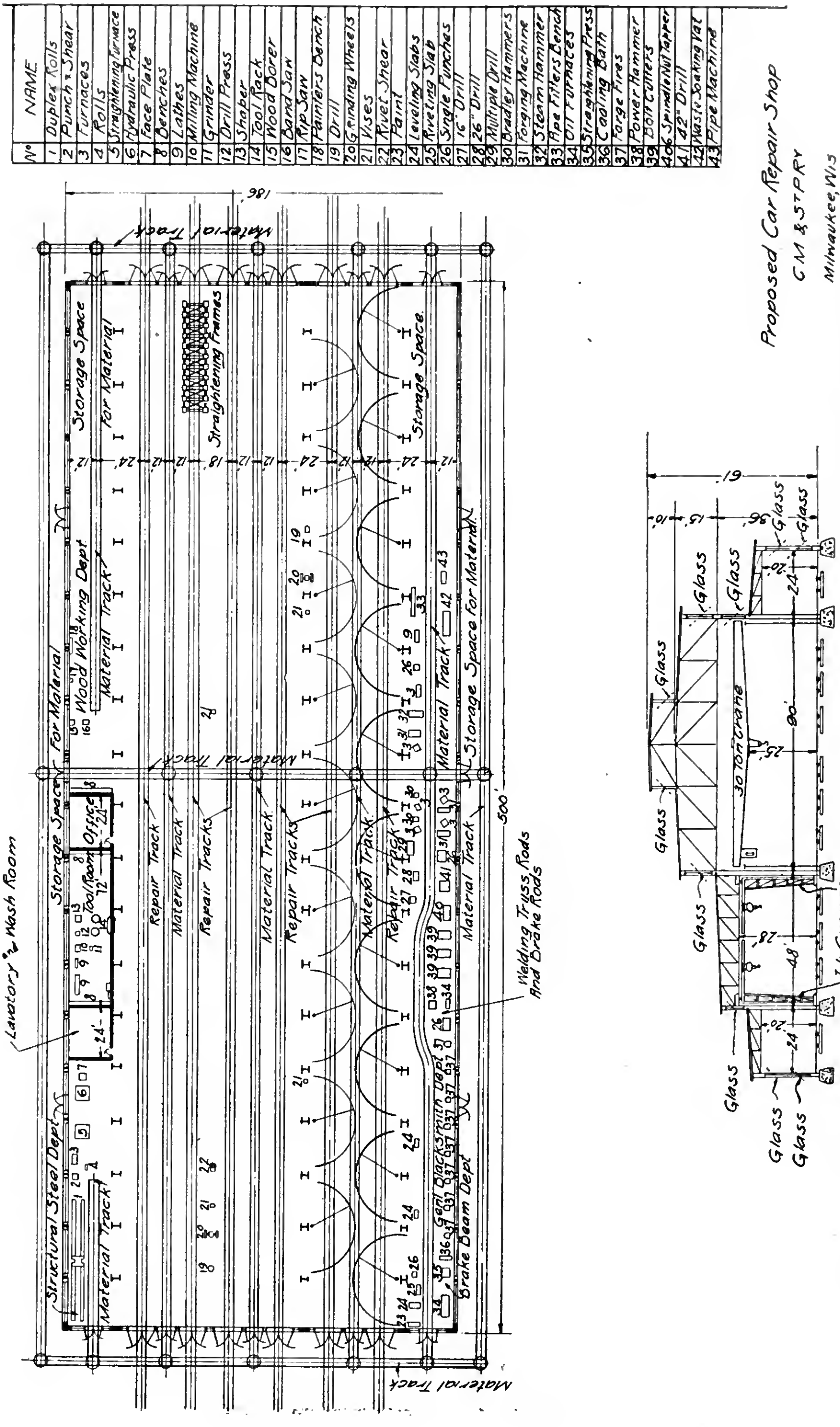


FIG. 26—PROPOSED CAR REPAIR SHOP, CHICAGO, MILWAUKEE & ST. PAUL RAILWAY, MILWAUKEE, WISCONSIN.

Appendix B

ASHPITS

G. H. Gilbert, *Chairman;*
C. N. Bainbridge,
Leland Clapper,
C. G. Delo,
R. J. Hammond,
J. L. Haugh,
F. E. Morrow,
Sub-Committee.

Practically all railroads of the United States and Canada were requested to furnish the following information regarding ashpits:

1. Essential description of types used, with blueprints showing cross-section, length and track layout.
2. Statement regarding number of locomotives handled over such pits per day and per rush period of two hours, together with statement regarding normal forces employed day and night, with rates of pay.
3. Approximate estimates of cost of construction at 1919 prices and average cost of maintenance per annum.
4. Statement of advantages and disadvantages of each type, with recommendations as to its use in new construction.

The replies received from the railroads failed to develop a deal of information sought by the Committee. It did show the use of many different kinds of ashpits. Nearly every type in common use was very favorably recommended by some roads and adversely criticized by other roads. The essential information obtained is shown below in tabulated form, grouped as to:

(a) Depressed track pits, where ashes are shoveled into cars.

(b) Water pits, both shallow and deep, where ashes are removed by buckets operated from various kinds of cranes.

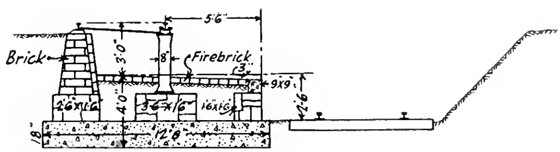
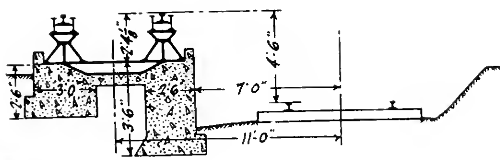
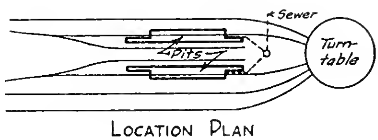
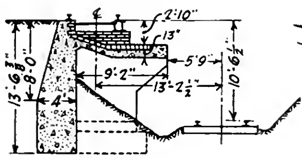
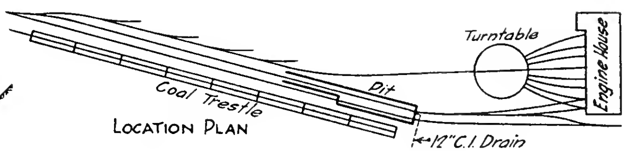
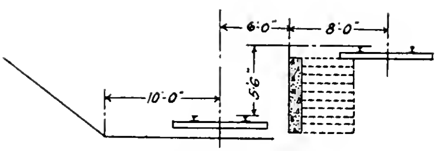
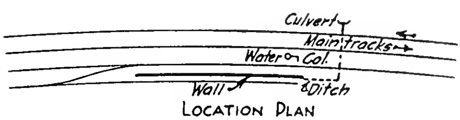
(c) Miscellaneous pits, where ashes are removed by various mechanical means.

Your Committee is still investigating various features of ashpit design and operation and expects to complete its report and present conclusions next year. The tabulation of data obtained from the various railroads, is submitted this year merely as information and progress.

Depressed Track Ashpits.

Railroad	Location	Description	Length of Pit	Number of Tracks over Pit	Number of Engines Handled			Force Employed Giving Day and Night Separately
					At once	In 24 Hrs.	In Rush Period of 2 Hrs.	
Algoma Central & Hudson Bay....	Sault Ste. Marie, Ont...........	Single-track concrete pit with openings next to a depressed track..........	75′	1	(50	to 60 engi	nes per W	EEK)...........
Ann Arbor........	Manhattan.......	Single-track pit. One rail carried on retaining-wall, other being carried on two rails and filler blocks supported by iron pedestals.......	60′	1	1	30	3	1 man 10 hours daily...........
Atchison, Topeka & Santa Fe..... (Coast Lines)	Winslow, Ariz.....	Two single pits served by independent depressed tracks. Tracks carried on I-beams supported by piers 9 ft. on centers..	84′	1 each	2	30	16	3-8-hr. shifts, 1 man per shift...
Baltimore & Ohio.	Flora, Ill.........	Single-track concrete pit. One rail supported on retaining-wall, other carried on I-beams supported by piers spaced 10′-1½″ on centers......	150′	1	....	....	....	....
Boston & Albany.	East Chatham, N. Y..........	Engines dump on running track and cinders shoveled onto cars from track..	....	1	2	40	6	17 man-hours daily........... 6 man-hours Sundays........ These men being used balance of time on other work...........

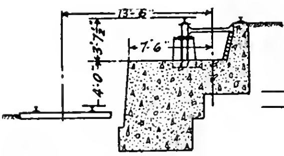
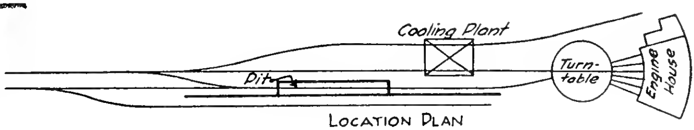
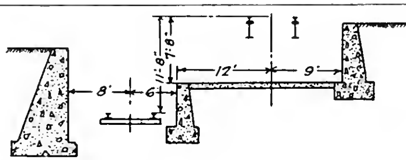
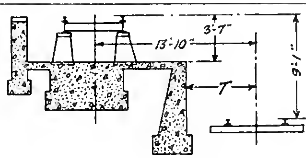
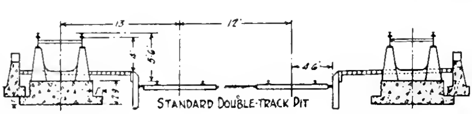
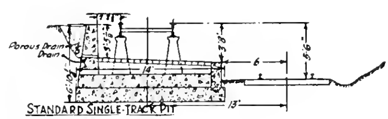
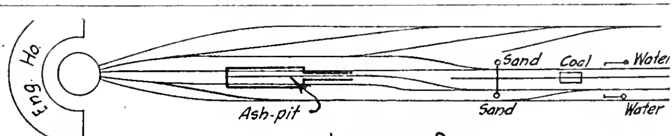
Depressed Track Ashpits.

Advantages	Disadvantages	DIAGRAM
....	Depressed track not considered advisable on acct. heavy snowfall. Would recommend handling cinders mechanically.	None
Considered desirable for new construction.......	None.	
		
Would not recommend this type pit for new construction......	....	
		
		
....	Capacity limited.	

Depressed Track Ashpits.

Railroad	Location	Description	Length of Pit	Number of Tracks over Pit	Number of Engines Handled			Force Employed Giving Day and Night Separately
					At once	In 24 Hrs.	In Rush Period of 2 Hrs.	
Boston & Maine..	Dover, N. H.....	Single-track pit. One rail carried on retaining-wall, other on I-beams supported by piers spaced 10′-2½″ on centers......	200′	1	3	25	4	2 men 8 hours each 1 each trick.....
Central of Georgia	Albany, Ga......	Open top shallow pit. Depressed track on side. Cinders shoveled by hand.....	80′-6″	1	1	24	4	Days 2 men...... Nights 2 men.....
Central of Georgia	Industry.........	Open top shallow pit. Depressed track on side. Cinders shoveled by hand.....	81′	1	1	26	4	Days 2 men...... Nights 2 men.....
Central Railroad of New Jersey..	Phillipsburg, N.J.	Single-track "dry" pit. Reinforced concrete walls and floor. Steel girders encased in concrete........	140′	1	2	60	10	8 A. M.-4 P. M., 11 men......... 4 A. M.-12 M., 3 men.......... 12 M.-8 A. M., 3 men..........
Chicago, Indianapolis & Louisville............	La Fayette, Ind..	Single-track concrete pit. Rails supported on I-beams carried on cast-iron posts spaced 7′ on centers.......	50′	1	1	12	6	2 men, 6 hours.... Days only
Chicago, Milwaukee & St. Paul...	Standard pits....	Single and double-track concrete pits. Rails supported on I-beams carried on pedestals spaced 10′-9″ on centers.........	....	....	....	....	....	....
Chicago, Milwaukee & St. Paul..	Bensenville, Ill....	2 single-track pits with one track between. Rails supported on I-beams carried on pedestals	165′	2	6	70		Shift No. 1-6 men, 8 hours......... Shift No. 2-6 men, 8 hours......... Shift No. 3-6 men, 8 hours.........

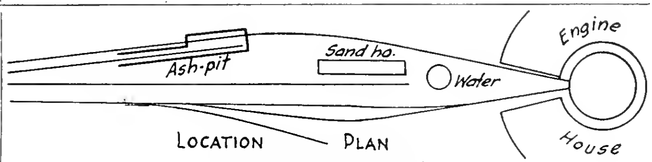
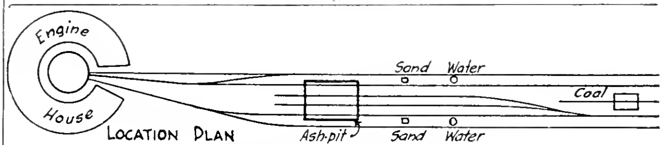
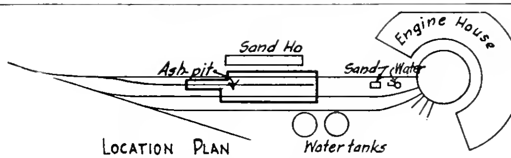
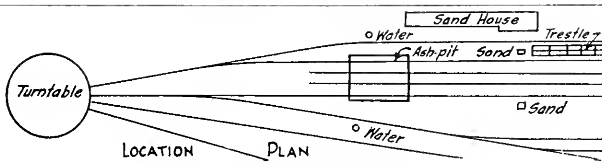
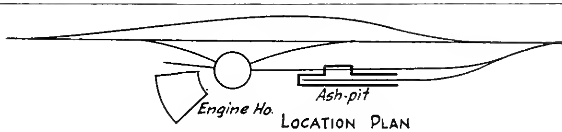
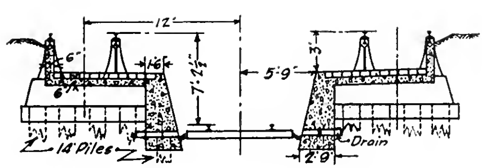
Depressed Track Ashpits.

Advantages	Disadvantages	DIAGRAM
Cost of installation for minor terminals, capacity to store cinders for several hours......	Hand shoveling.	 
Would recommend this type pit for new construction	Limited capacity.	None
Would recommend this type pit for new construction	Limited capacity.	None
Efficient at points where installation of machinery is not advisable............	Excessive corrosion due to hot gases and violent changes in temperature.	
		
		 
Not considered desirable for new construction at similiar locations.		 Two Standard Single-Track Pits

DEPRESSED TRACK ASHPITS

Railroad	Location	Description	Length of Pit	Number of Tracks over Pit	Number of Engines Handled			Force Employed Giving Day and Night Separately
					At once	In 24 Hrs.	In Rush Period of 2 Hrs.	
Chicago, Milwaukee & St. Paul..	Dubuque, Iowa...	Single-track pit. Rails supported on I-beams carried on pedestals	60′	1	1	30-40	4-5	Shift No. 1–2 men, 8 hours......... Shift No. 2–2 men, 8 hours......... Shift No. 3–2 men, 8 hours.........
Chicago, Milwaukee & St. Paul..	Galewood........	Double-track pit. Rails supported on I-beams carried on pedestals	64′	2	3	40	18	Shift No. 1–4 men, 8 hours .... Shift No. 2–2 men, 8 hours......... Shift No. 3–2 men,
Chicago, Milwaukee & St. Paul..	Savanna, Ill......	Double-track pit. Rails supported on I-beams carried on pedestals	112′	2	4	75-80	4	Days–6 men, 11 hours........ Nights–5 men, 11 hours........
Chicago, Milwaukee & St. Paul..	Western Avenue, Chicago, Ill...	Double-track pit. Rails supported on I-beams carried on pedestals	64′	2	1	95	15	Days–12 men, 10 hours........ Nights–8 men .... 10 hours
Chicago, Milwaukee & St. Paul..	Yankton, S. D....	Single-track pit. Rails supported on I-beams carried on pedestals....	44.5′	1	1	15	4	Days–2 men...... Nights–1 man....
Chicago, Rock Island & Pacific	....	Two single-track pits with depressed track between. Outside rail carried on reinforced concrete wall; inside rail carried on inverted rail supported by cast-iron pedestals............	129′-6¾″	2	....	....	....	....

Depressed Track Ashpits.

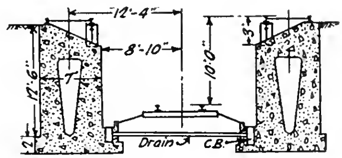
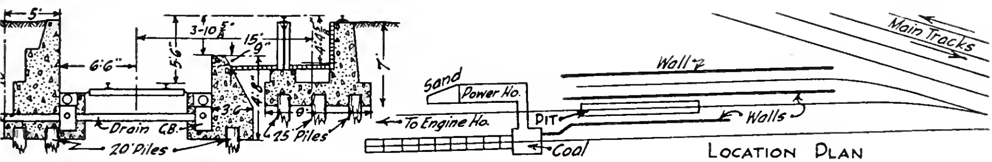
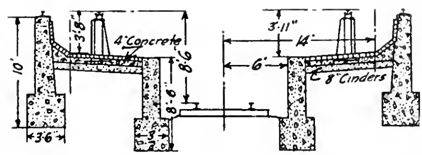
Advantages	Disadvantages	DIAGRAM
Not considered desirable for new construction at similar locations..........	Pit too short	 Standard Single-Track Pit
Not considered desirable for new construction at similar locations..........	....	 Standard Double-Track Pit
Not considered desirable for new construction at similar locations..........	Pit not deep enough	 Standard Double-Track Pit
Not considered desirable for new construction at similar locations..........	Not long enough for two passenger engines	 Standard Double-Track Pit
	None	 Standard Single-Track Pit
....	....	

Depressed Track Ashpits.

Railroad	Location	Description	Length of Pit	Number of Tracks over Pit	Number of Engines Handled: At once	Number of Engines Handled: In 24 Hrs.	Number of Engines Handled: In Rush Period of 2 Hrs.	Force Employed Giving Day and Night Separately
Cleveland, Cincinnati, Chicago & St. Louis.......	Brewster, Ohio...	Two single-track pits served by depressed track located between pits. One rail carried on retaining-wall, other on inverted rail supported by steel pedestals 4′-2¾″ on centers......	151′-6″	2	6	100–120	....	....
Cleveland, Cincinnati, Chicago & St. Louis......	Norwalk, Ohio...	Single-track pit. One rail carried on retaining-wall, other on inverted rail supported by steel pedestals 4′-2¾″ on centers.	60	1	1	15–20		
Cleveland, Cincinnati, Chicago & St. Louis.......	Sharonville, Ohio.	Two single-track pits served by one depressed track located between them. Outside rails carried on retaining-walls. Other on rails supported by pedestals 5′-6″ on centers.........	136′-6″	2	4	42	....	2 men each 8-hour shift, on piece-work basis.
Delaware, Lackawanna & Western............	Standard pit for small terminals.	* Single-track pit. Track supported by cast-iron chairs with concrete platform for shoveling....	140′	1	2	30	4–8	Shift No. 1–2 men, Shift No. 2–2 men, Shift No, 3–1 man.
Delaware, Lackawanna, & Western	Gravel Place, Pa.	Two single-track pits. Track supported by pedestals 2′ high and spaced 3′ on centers......	140′	2	4	40	4–6	Shift No. 1– 2 laborers ...... 1 fire cleaner ... Shift No. 2– 1 fire cleaner ... Shift No. 3– 1 fire cleaner ... (8-hour shifts)

*Built entirely of concrete and will need resurfacing in about a year.

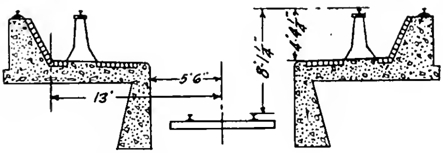
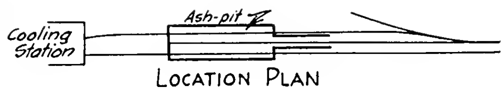
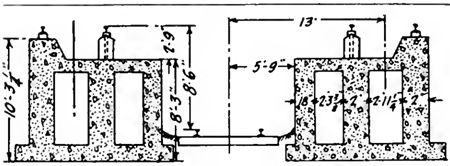
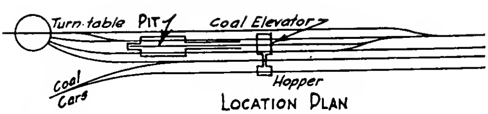
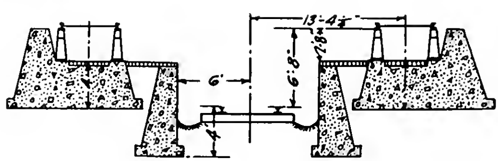
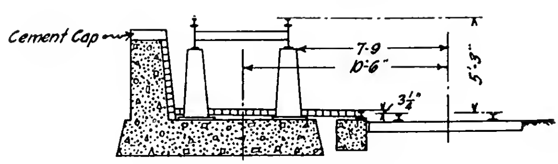
Depressed Track Ashpits.

Advantages	Disadvantages	DIAGRAM
Safe, and cannot be congested or blocked when labor is available............	Inability to switch cinder-cars promptly	
Safe, and cannot be congested or blocked when labor is available............	Inability to switch cinder-cars promptly	
Safe, and cannot be congested or blocked when labor is available.............	Inability to switch cinder-cars promptly	
....	Difficult to obtain efficient labor	None
....	Difficult to get laborers, especially in cold weather	None

Depressed Track Ashpits.

Railroad	Location	Description	Length of Pit	Number of Tracks over Pit	Number of Engines Handled: At once	Number of Engines Handled: In 24 Hrs.	Number of Engines Handled: In Rush Period of 2 Hrs.	Force Employed Giving Day and Night Separately
Elgin, Joliet & Eastern........	Rossville, Ill.....	Concrete pit......	127′-10½″	1	2	12	3	Days-2 men...... Nights-2 men ....
Georgia..........	....	....	99′-3½″	1	2	20-30	4	Days 1 man cleaning clinkers .... 3 men cleaning fires and helping hostlers..... Nights-same
Long Island......	Morris Park, N Y.	Two single-track concrete pits with depressed track between. Outside rail carried on wall. Inside rail carried on pedestals spaced 3′-6″ on centers.........	198′	2	12	100	20	Days-18 men 12 hours........ Nights-8 men 12 hours........
Michigan Central.	Niles, Mich.......	Two single-track concrete pits with depressed track between..	125′	2	4	....	....	....
Minneapolis & St. Louis...........	Cedar Lake......	Twin pits, track between........	1-47′ 1-90′	2	3	8	....	Days-4 men Nights-4 men
	Marshalltown.....	Twin pits, track between........	1-48′ 1-88′	2	3	8	....	Days-5 men Nights-3 men
	Oskaloosa........	Twin pits, track between........	1-47′ 1-90′	2	2	6	....	Days-4 men Nights-2 men
Minneapolis, St. Paul & Sault Ste. Marie......	Shoreham........	Single-track concrete pit. Rails carried on I-beams supported by pedestals spaced 9′-4⅛″ on centers.........	68′	1	....	....	....	....

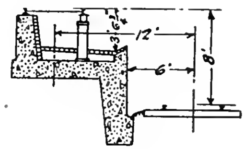
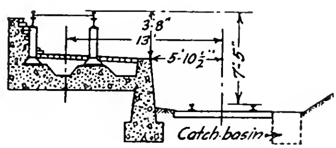
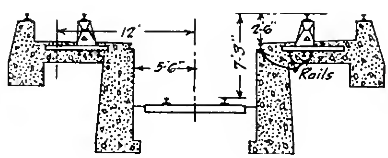
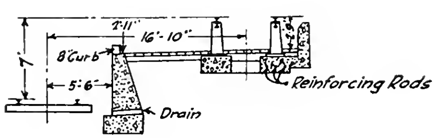
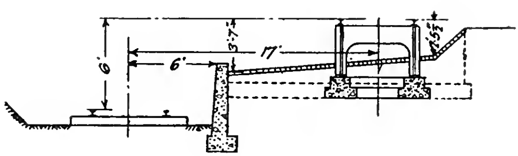
DEPRESSED TRACK ASHPITS.

Advantages	Disadvantages	DIAGRAM
Satisfactory only where small number of engines are handled........	Expensive and slow loading by hand. Pit burns out	None
Does not consider this type desirable for new construction........	Cinders have to be handled by hand	None
		
Would recommend this type pit for new construction	Hand shoveling of cinders	
		
Considered desirable for new construction on similar locations..........	Concrete walls break down under heat and pedestals burn out	
....	....	

DEPRESSED TRACK ASHPITS.

Railroad	Location	Description	Length of Pit	Number of Tracks over Pit	Number of Engines Handled: At once	Number of Engines Handled: In 24 Hrs.	Number of Engines Handled: In Rush Period of 2 Hrs.	Force Employed Giving Day and Night Separately
Missouri Pacific..	Standard pit......	Single-track concrete pit. Outside rail carried on wall. Inside rail carried on two inverted rails supported by pedestals spaced 6 feet on centers.........	Multiple of 30′	....	....	....	....	....
Missouri Pacific..	Falls City, Neb..	Single-track concrete pit. Rails carried on I-beams supported by pedestals spaced 7′-6″ on centers.	225′	1	....	....	....	....
New York Central............	Gardenville.....	Double-track concrete pit. Outside rails carried on wall. Inside rails carried on pedestals spaced 3′ on centers....	200′	2	....	115	24	Shift No. 1-12 men 8 hours......... Shift No. 2- 7 men 8 hours......... Shift No. 3- 7 men 8 hours.........
Norfolk Southern.	Charlotte, N. C..	Single-track concrete pit. Each rail carried on inverted rail supported by pedestals spaced 5′ on centers....	70′	....	....	....	....	....
Seaboard Air Line	Cayce, S. C......	Single-track concrete pit. Rails carried on C. I. pedestals spaced 2′-3″ on centers.	61′	....	....	....	....	....

Depressed Track Ashpits

Advantages	Disadvantages	DIAGRAM
....	....	
....	....	
....	Difficulty in obtaining and high cost of labor. Small amount of storage space	
Very satisfactory	....	
....	....	

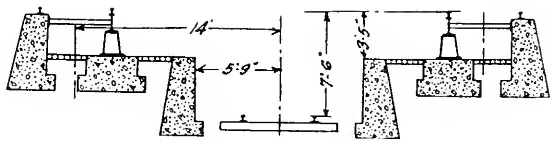
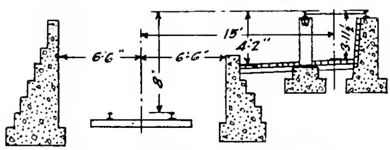
Depressed Track Ashpits.

Railroad	Location	Description	Length of Pit	Number of Tracks over Pit	Number of Engines Handled: At once	Number of Engines Handled: In 24 Hrs.	Number of Engines Handled: In Rush Period of 2 Hrs.	Force Employed Giving Day and Night Separately
Union Pacific	Hugo Sharon Springs Northport La Salle	Twin concrete pits with one depressed track between. Outside rails carried on walls. Inside rails carried on I-beams supported by pedestals spaced 12′ centers	34′-4″					
Wheeling & Lake Erie	Pine Valley, Ohio.	Single-track concrete pit. Outside rail carried on inverted rail supported by pedestals spaced 5′ on centers	119′	1				

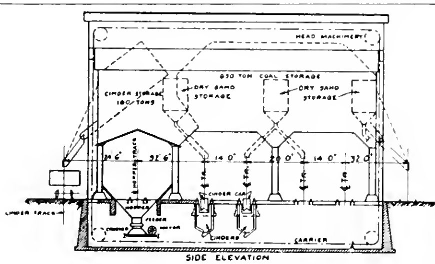
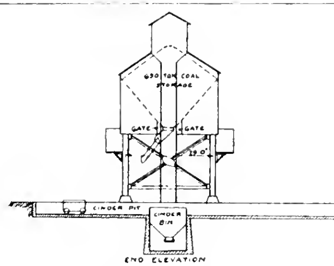
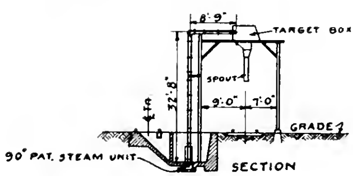
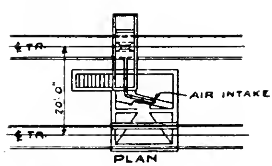
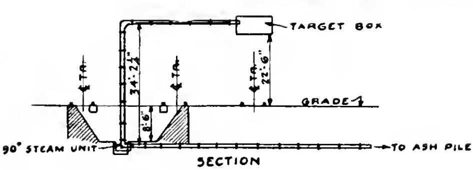
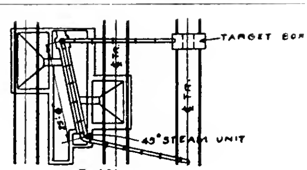
Miscellaneous Mechanical Ashpits.

Railroad	Location	Description	Length of Pit	Number of Tracks over Pit	At once	In 24 Hrs.	In Rush Period of 2 Hrs.	Force Employed Giving Day and Night Separately
U. P.	Pullman, Col.	Combination coal, ash and sand handling plant		2				
A. C. Y.	Akron, Ohio	Steam conveyor system		1				
D. R. G.	Soldier Summit, Utah	Steam conveyor system		2		45		

Depressed Track Ashpits.

Advantages	Disadvantages	DIAGRAM
....	....	
....	....	

Miscellaneous Mechanical Ashpits.

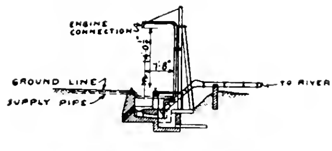
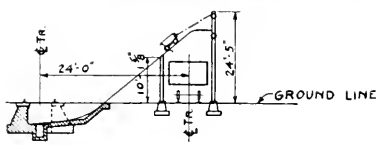
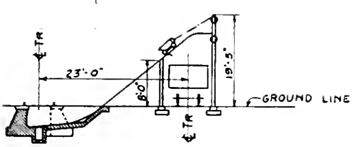
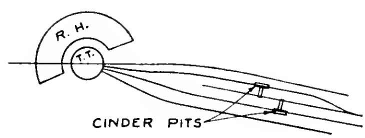
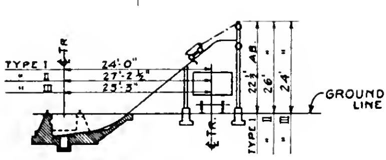
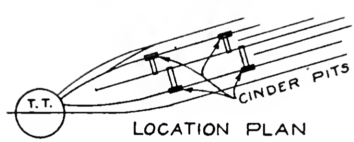
Advantages	Disadvantages	DIAGRAM
....		 
....	....	 
....		 

Miscellaneous Mechanical Ashpits.

Railroad	Location	Description	Length of Pit	Number of Tracks over Pit	Number of Engines Handled: At once	In 24 Hrs.	In Rush Period of 2 Hrs.	Force Employed Giving Day and Night Separately
B. & O.	Clarksburg, W.Va.	Steam ejector system	150′-0″	1	....	....	....	....
C. R. I. & P.	Joliet, Ill.	Robertson Mfg. Co. 1 unit, 2 conveyors	25′-0″ About	1	1	28	4	Nights-2 men Days-none
A. T. & S. F.	Gallup, N. M.	*Robertson Mfg. Co. 2 units, 2 conveyors	24′-0″	1	1	35	5	6 men, 3 shifts
L. V.	Wilkes-Barre, Pa.	Robertson Mfg. Co. Pneumatic type ash pit, 2 conveyors	14′-0″	1	1	40	4	6 fire cleaners 5 laborers (3 shifts)
L. E. & W.	....	Robertson Mfg. Co. single and double conveyor pits	....	1	....	....	5	3 men, 3 shifts
Mo. Pac.	....	†Robertson Mfg. Co. 2 conveyors	14′-3″	1	....	....	....	....

*Now have under way removal of motors and installation of air.
†Location plan for Ewing Avenue, St. Louis, where 4 pits 6′ long each having single conveyors were used.

Miscellaneous Mechanical Ashpits.

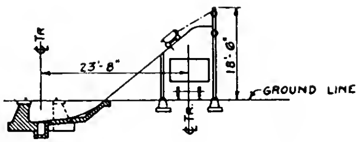
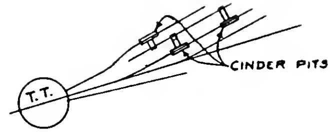
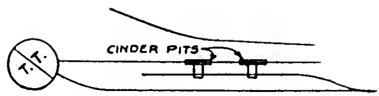
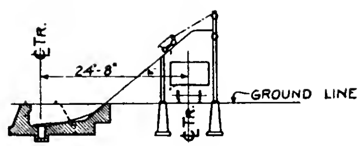
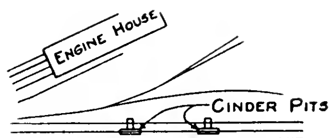
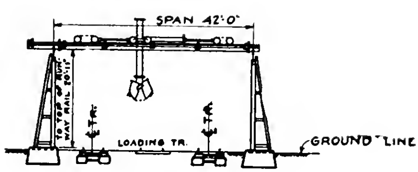
Advantages	Disadvantages	DIAGRAM
...	...	
...	Difficulty of properprotection on account one track. Also air operation cost.	
...	None	 
...	...	
...	No elasticity in case of elevating machinery failing as no space for dumping and holding cinders is provided	
...	...	 

Miscellaneous Mechanical Ashpits.

Railroad	Location	Description	Length of Pit	Number of Tracks over Pit	Number of Engines Handled: At once	In 24 Hrs.	In Rush Period of 2 Hrs.	Force Employed Giving Day and Night Separately
C. M. & St. P....	Milwaukee, Wis...	*Robertson Mfg. Co. 3 units, 9 conveyors......	39′-6″	1	3	100	40	6 men, 3 shifts.....
C. M. & St. P....	No. McGregor, Ia.	Robertson Mfg. Co. 2 units, 8 conveyors......	52′-6″	1	2	48	8	9 men, 3 shifts.....
S. Ry. System...	Memphis, Tenn...	Robertson Mfg. Co. 1 unit, 2 conveyors......	....	1	....	30	....	3 men, 3 shifts.....
B. & A..........	No. Adams Jct., Mass...........	Robertson Mfg. Co. 2 units 1 conveyor.......	13′-0″	1	2	36	12	3 fire cleaners..... 3 laborers......... (3 shifts)
C. of G..........	Savannah, Ga....	Robertson Mfg. Co. 1 unit, 2 conveyors......	32′-3″	1	1	30-35	8	1 man day........ 1 man night......
C. of G..........	Macon, Ga.......	Robertson Mfg. Co. 1 unit, 2 conveyors......	32′-3″	1	1	34	6	1 man day........ 1 man night......
C. of G..........	Columbus, Ga....	Robertson Mfg. Co. 1 unit, 2 conveyors......	32′-3″	1	1	39	3-6	1 man day........ 1 man night......
D. & I. R........	....	Traveling crane with air hoist...	50′-0″	2	2	70	8	4 laborers, 3 shifts.

*Capacity based on switch engines.

Miscellaneous Mechanical Ashpits.

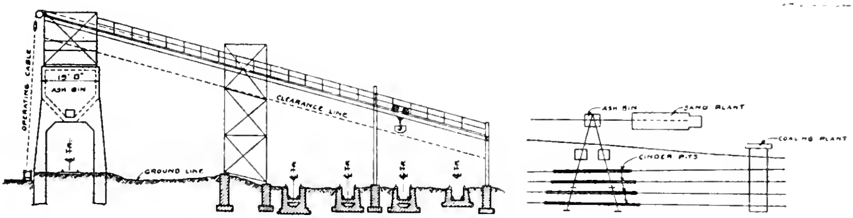
Advantages	Disadvantages	DIAGRAM
....	Air fails in cold weather	 
....	....	 Same as for Milwaukee, Wis.
....	....	
....	None:	 
....	....	
Satisfactory; very economical	....	
....	....	
....	....	

Miscellaneous Mechanical Ashpits.

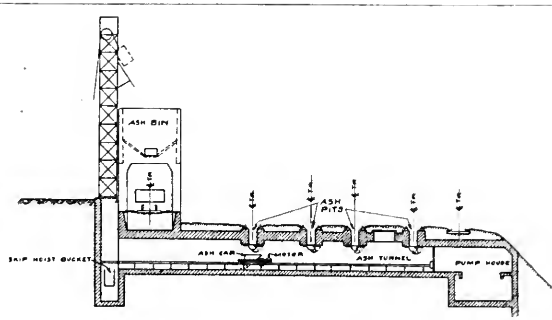
Railroad	Location	Description	Length of Pit	Number of Tracks over Pit	Number of Engines Handled			Force Employed Giving Day and Night Separately
					At once	In 24 Hrs.	In Rush Period of 2 Hrs.	
P. & L. E.	Haselton, Ohio...	Trolley on inclined runway for handling cinder buckets........	125′-0″ 135′-0″ 142′-6″ 152′-6″	4	4	120	12	3 men nights...... 3 men days.......
P. & L. E	Brightwood, Pa..	Ash car in tunnel and skip hoist system.........	14′-0″	4	4	....	24	....
Penn. Lines.......	....	Traversing bucket and trolley system...........	70′-0″	3	3	....	....	....

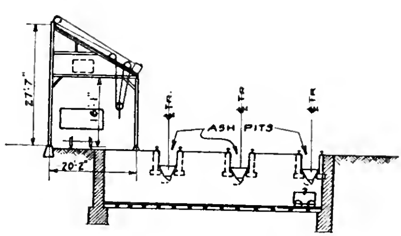
Miscellaneous Mechanical Ashpits.

Advantages	Disadvantages	DIAGRAM



Advantages	Disadvantages
	Difficulty in pushing the ash buckets in the pit in severe winter weather.



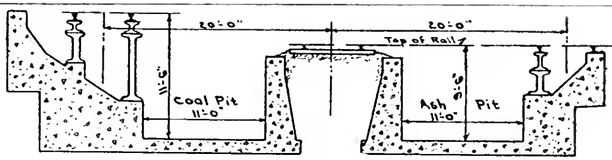
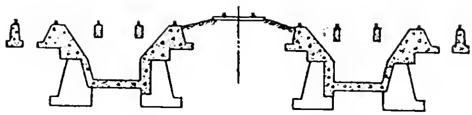
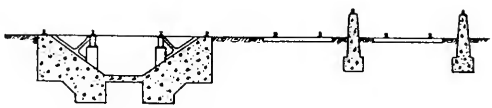
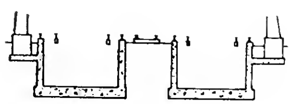
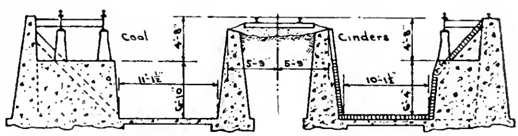
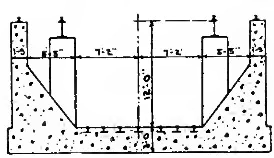


Water Ashpits.

Railroad	Location	Description	Length of Pit	Number of Tracks over Pit	Number of Engines Handled			Force Employed Giving Day and Night Separately
					At once	In 24 Hrs.	In Rush Period of 2 Hrs.	
Ann Arbor........	Manhattan Yard..	Single-track pit, adjacent and parallel to coal pit, with a common crane track between........	100′	1	2	50	4	3 men days....... 3 men nights......
Boston & Albany.	West Springfield, Mass...........	Twin pits. Wet ash loading track between them on same level. Ashes handled by gantry crane	240′	4	12	164	72	6 fire cleaners days........... 6 fire cleaners nights.......... 1 crane operator 8 hours.........
Boston & Maine...	East Deerfield, Mass...........	Double-track pit. Wet ash loading track on side. Ashes handled by gantry crane	343′	2	10	140	18	12 men days...... 9 men nights....
Central of New Jersey..........	Jersey City, N. J..	Twin pits. Wet ash loading track between them on same level. Ashes removed by overhead crane. Reinforced concrete walls and floor............	200′	4	12	275	70	23 men days...... 20 men nights....
Chicago, Indianapolis & Louisville...........	Bloomington, Ind.	Single-track ash pit, adjacent and parallel to coal pit with a common crane track between...	100′	1	1	23	6	....
C. M. & St. P....	Sioux City, Iowa..	Double-track pit. Loading track on one side. Ashes handled with clam shell......	100′	2	4	60	8	*3 men days....... 3 men nights.....

*Only 10 hours days and 10 hours nights chargeable to cleaning fires and handling ashes.

Water Ashpits.

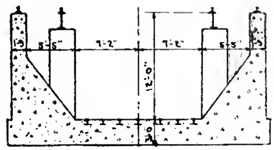
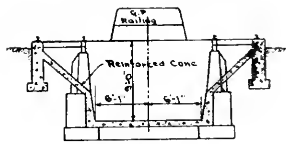
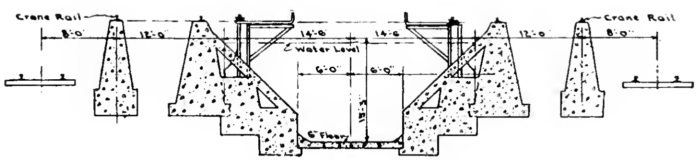
Advantages	Disadvantages	DIAGRAM
.....	High maintenance	
....	None.	
For large terminals	Original cost and cost to operate.	
Compact arrangement for congested points...	Necessity of handling wet ashes in cold weather. High initial cost	
....	....	
....	....	

Water Ashpits.

Railroad	Location	Description	Length of Pit	Number of Tracks over Pit	Number of Engines Handled: At once	Number of Engines Handled: In 24 Hrs.	Number of Engines Handled: In Rush Period of 2 Hrs.	Force Employed Giving Day and Night Separately
C. M. & St. P....	Ottumwa, Iowa..	Double-track pit. Loading track on one side. Ashes handled with clam shell.	100′	2	4	35	8	*3 shifts, 2 men each... ....
C. R. I. & P. .	Burr Oak, Ill.....	Double-track pit..	205′	2	6	127	11	5 men nights..... 2 men days....... 8 hours each......
Del., Lack & West.	Scranton, Pa......	Twin pits. Wet ash loading track between them. Ashes handled by gantry crane	400′	2	12	150	22	6 men days....... 6 men nights..... 1 crane operator days...
E. J. & E.........	Kirk Yard.......	Double-track pit. Loading track over center, with gantry crane to remove cinders.........	155′	2	4	80	12	12 men days ... 12 men nights.....
E. J. & E.	East Joliet, Ill....	Double-track pit. Loading track over center, with gantry crane to remove cinders	152′	2	4	115	24	15 men days .... 15 men nights. ..
Lehigh Valley....	Coxton, Pa..	†Double-track pit. Ashes removed by electric traveling crane.....	400′	2	12	110	15	9 men on each 8-hour shift..... 1 crane operator 8 hours
L. & N..........	Latonia, Ky......	Double-track pits. 100 feet long, 30 feet wide, and 12 feet deep. Ashes removed by locomotive crane..........	100′	2	....	Approx. 1900 per mo.	....	3 men each 8-hour shifts. Locomotive crane for 1 hour per day..

*Pit is cleaned once a week with a clam shell at a cost of 5 hours' labor.
†A special feature is the construction of the ashing platform between the engine tracks over pit.

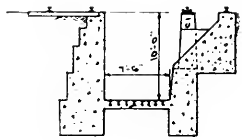
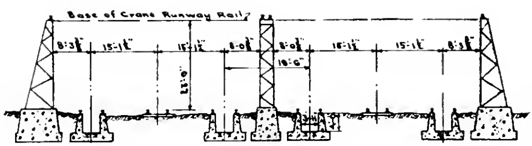
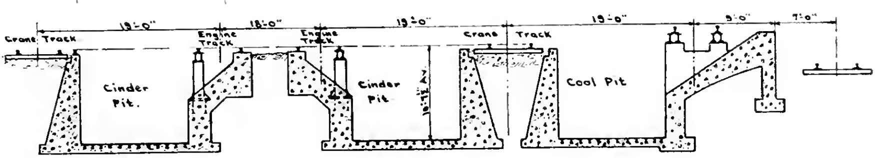
Water Ashpits.

Advantages	Disadvantages	DIAGRAM
Cinders drop into the water, eliminating gases		
Advantageous for large terminals.	Difficult to protect when placed between tracks.	
....	Hot ashes. Kink rails.	No Diagram
... .	....	No Diagram
....	... .	No Diagram
... .	..	
....	....	No Diagram

Water Ashpits.

Railroad	Location	Description	Length of Pit	Number of Tracks over Pit	Number of Engines Handled			Force Employed Giving Day and Night Separately
					At once	In 24 Hrs.	In Rush Period of 2 Hrs.	
N. Y. C. & St. L.	....	Rectangular water pit. Ashes loaded by crane...	150′	1	3	40	5	3 men, 8-hour shifts... ...
N. Y., N. H. & H.	Cedar Hill, Conn.	Twin pits with gantry crane between. Ashes removed by clam shell shovel..........	145′	2	4	114	Depends on class engine and number of fires dumped	2 foremen........ 18 men......... 1 crane operator...
Southern	Birmingham, Ala.	Duplicate installation. Each unit consists of 2 cinder pit tracks and a center loading track. Ashes removed by electric crane	160′	2 each	....	130 to 150	....	5 men each 12-hour shifts... 1 crane operator 2 hours per day.
Southern	Atlanta, Ga......	Double-track pits. 90 feet long, 22 feet wide, 12 to 13 feet deep. Ashes are removed by locomotive crane...	90′	2	....	45 to 50	....	4 men each, 8-hour period.......... Also engineer and fireman for locomotive crane, which is also used for coaling engines.........
C. & W. I.......	Chicago, Ill......	Double-track pits. adjacent and parallel to coal pit, with a common crane track between. Also a crane track for cinders only....	1–200′ 1–250′	2	7	104	30	9 men days ...... 9 men nights.....

Water Ashpits.

Advantages	Disadvantages	DIAGRAM
All fire is put out by water. No burning of cinder cars. No handling of cinders by laborers....	....	
Very satisfactory.	None	No Diagram
....	..	
... .	...	No Diagram
Very satisfactory.	Coal sometimes drops into the water when coaling from cars alongside of pits	

COMMITTEE V—ON TRACK

W. P. WILTSEE, *Chairman;*	J. V. NEUBERT, *Vice-Chairman;*
L. B. ALLEN,	J. B. JENKINS,
V. ANGERER,	H. A. LLOYD,
W. G. ARN,	J. DE N. MACOMB,
J. B. BAKER,	F. H. MCGUIGAN, JR.,
R. A. BALDWIN,	F. L. NICHOLSON,
G. H. BREMNER,	R. M. PEARCE,
H. G. CLARK,	H. T. PORTER,
E. A. HADLEY,	J. H. REINHOLDT,
G. W. HEGEL,	G. J. SLIBECK,
E. T. HOWSON,	J. B. STRONG,
T. T. IRVING,	J. R. WATT,

Committee.

To the American Railway Engineering Association:

The following subjects were assigned the Committee on Track for study and report:

1. Make thorough examination of the subject-matter in the Manual, and submit definite recommendations for changes.
2. Report on typical plans of turnouts, crossovers, slip switches, double crossovers, and railroad crossings, and prepare detail plans for such work, including necessary fixtures, etc., conferring with Committee on Signals and Interlocking. Submit complete plans for clamped frogs.
3. Make final report, if practicable, on reduction of taper of tread of wheel to 1 in 38, and on canting the rail inward, conferring with Committee on Rail.
4. Make final report, if practicable, on (a) tests of tie plates subject to brine drippings; (b) on the effect of brine drippings on track appliances.
5. Submit plans and specifications for track tools.
6. Study and report on the limit of wear on frogs, including, if possible, rules for determining when frogs are sufficiently worn to warrant removal from track.
7. Submit plans and specifications for switch stands, switch lamps and switch locks.
8. Submit plans and specifications for tie plates, derailers and anti-creepers, conferring with Committee on Ties and on Rail.
9. Study and report on specifications and piece work schedules for contracting track maintenance work.

Committee Meetings

Meetings of the Committee were held in North Asbury Park, N. J., June 21st, 1920; in St. Louis, Mo., September 20th, 1920, and in Chicago, Ill., November 17th, 1920. The names of the members in attendance have been given in the minutes of the meetings which have been forwarded to the Secretary.

(1) Revision of Manual

Proposed changes in the Manual, items I, II, III, are given in Appendix A.

(2) Typical Plans of Turnouts, Crossovers, Slip Switches, Double Crossovers, and Railroad Crossings, and Detail Plans for Such Work, Including Necessary Fixtures, Etc.

In Appendix B the Committee reports on this subject, and its recommendations are given under Conclusions.

(2a) (Special Committee) Gages and Flangeways for Curved Crossings

In Appendix C the Committee submits a progress report on this subject.

(7) Submit Plans and Specifications for Switch Stands, Switch Lamps and Switch Locks

In Appendix D the Committee submits a progress report on this subject.

(8) Submit Plans and Specifications for Tie Plates, Derailers and Anti-Creepers

In Appendix E the Committee submits a progress report on this subject.

(9) Study and Report on Specifications and Piece Work Schedules for Contracting Track Maintenance Work

In Appendix F the Committee submits a progress report on this subject.

The Committee also reports progress on subject (3) Make Final Report on Reduction of Taper of Tread of Wheel 1 in 38, and on Canting the Rail Inward; on subject (4) Make Final Report on (a) Tests of Tie Plates Subject to Brine Drippings, and (b) on the Effect of Brine Drippings on Track Appliances; on subject (5) Submit Plans and Specifications for Track Tools, and on subject (6) Study and Report on Limit of Wear on Frogs, including Rules for Determining When Frogs Are Sufficiently Worn to Warrant Removal.

CONCLUSIONS

1. The Committee recommends the changes in the Manual as submitted in Appendix A be approved and the revised matter be substituted for the present subject matter in the Manual.

2. In Appendix B the Committee submits detail plans as per instructions, recommending certain of them for adoption and others to be received as information. These plans are the result of the study and co-operation of your Committee and the Frog and Switch Manufacturers of the Manganese Track Society. Appendix B also covers Progress Report on uncompleted work, and the Committee recommends reassignment of the subject.

2a. In connection with subject 2, a special subcommittee was appointed to make an investigation on the subject of Gages and Flangeways for Curved Crossings. In Appendix C a theoretical study is submitted on the subject, which the Committee recommends be accepted as information. The Committee also recommends that the subject be reassigned.

3. The Committee reports progress and recommends the subject be reassigned.

4. On account of delay in getting tie plates for tests the Committee has no report to make and recommends the subject be reassigned.

5. Plans of various track tools have been prepared, but more time is desired to get answers from questionnaires as to the extent of use of the alternate details, etc. The Committee recommends the subject be reassigned.

6. The Committee has this subject under investigation and recommends that the subject be reassigned.

7. The Committee recommends that the Progress Report, being Appendix D, be accepted as information, and the subject be reassigned.

8. The Committee recommends that the Progress Report, being Appendix E, be accepted as information, and the subject be reassigned.

9. The Committee recommends that the Progress Report, being Appendix F, be accepted as information, and the subject be reassigned.

Recommendations for Future Work

The Committee recommends in addition to continuing the above assignments the subject of Gages and Flangeways for Curves and for Curved Crossings be assigned as a separate subject.

Respectfully submitted,

THE COMMITTEE ON TRACK,

W. P. WILTSEE, *Chairman.*

Appendix A

(1) REVISION OF MANUAL

W. P. Wiltsee, *Chairman;*
J. V. Neubert,
R. A. Baldwin,
G. W. Hegel,
E. T. Howson,
T. T. Irving,
J. De N. Macomb,
F. H. McGuigan, Jr.,
H. T. Porter,

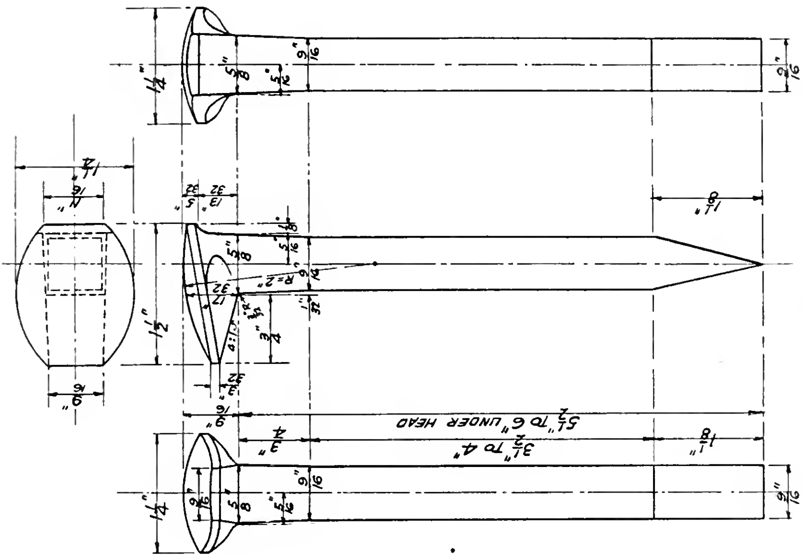
Sub-Committee.

Item I.

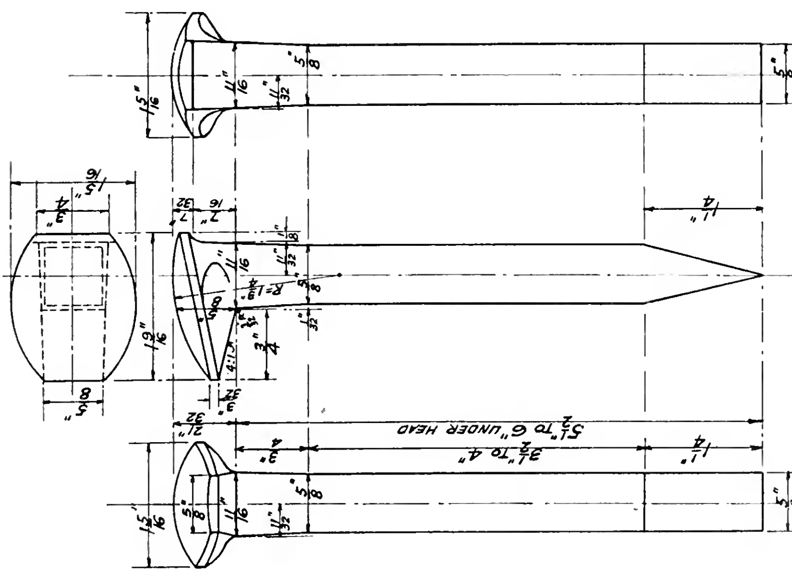
The Committee recommends that the design of the Cut Track Spike shown on page 22 of the 1918 Supplement to the Manual be withdrawn, and the designs for ⅝-in. and $\frac{9}{16}$-in. Cut Track Spikes submitted herewith be substituted therefor, as the present design in the Manual does not correctly show the slope of the underside of the head of the spike to agree with the slope of the top of the rail base. The accompanying designs fit the rail base most commonly in use.

The accompanying design of ⅝" Cut Track Spike is the same as that submitted last year and as published in Vol. 21, Bulletin 221, except the width at the toe end has been changed to ½" instead of ⅝", and the curve under the head has been changed for greater strength and better contact of the jaw of a claw bar.

Reports as to the practicability of this design for manufacture in automatic machines have been received from various steel companies and samples have been submitted to this Committee.



DESIGN OF 9/16" CUT TRACK SPIKE.



DESIGN OF 5/8" CUT TRACK SPIKE.

Item II.

Omit pages 168 to 186 inclusive, commencing with article "Length of Switches" and ending with and including article "Crossovers," and substitute the following:

SPECIFICATIONS FOR SWITCHES, FROGS, CROSSINGS AND GUARD RAILS

General Instructions

1. The Purchaser will furnish the Manufacturer specifications and drawings, giving rail sections, splice drilling, angles, alinement and general dimensions, and such special details as may be required.

2. Unless otherwise specified the construction, design and details shall conform to the plans adopted by the American Railway Engineering Association as recommended practice. For track structures for which no such plans have been adopted, the Manufacturer shall, when requested, submit for approval detail drawings.

3. The detailed drawings shall be on sheets 22 in. wide between outside border lines, with inside border lines ½ in. from the top and bottom. The standard length of the sheet shall be 30 in. between outside border lines with inside border lines ½ in. from the right-hand edge and 1½ in. from the left-hand edge. When longer sheets are necessary they shall be in multiples of 6 in. and folded back to the standard length.

Drawings shall be confined to one subject. The title shall be placed in the lower right-hand corner. The scale of the general drawings shall be 1½ in. equals one foot, where practicable. Details not less than 3 in. equals one foot wherever practicable. Dimensions and distances under 2 ft. should be shown in inches; 2 ft. and over in feet and inches. Cross-sections shall be section lined for the material to be indicated in accordance with standard sections as shown in the A.R.E.A. Manual. Manganese steel section to be indicated by heavy single lines.

4. The drawings shall be part of the specifications. Anything that is not shown on the drawings, but which is mentioned in the specifications, or vice versa, or anything not expressly set forth in either, but which is reasonably implied, shall be furnished, the same as if specifically shown and mentioned in both. Should anything be omitted from the drawings or specifications that is necessary for a clear understanding of the work, or should any error appear in either the drawings or specifications affecting the work, the Manufacturer shall notify the Purchaser and shall not proceed with the work until instructed to do so.

Material

Rail.

5. The rail used shall be first quality open-hearth steel of the section called for, manufactured according to A.R.E.A. specifications or to Rail Manufacturers' standard specifications, unless otherwise specified.

Grey Iron Castings.

6. Grey iron castings shall be of a good commercial grade of medium grey iron.

Steel Castings.

7. Steel castings shall be of good commercial grade manufactured in accordance with standard specifications of the American Society for Testing Materials for steel castings class "B"; except that steel castings exposed to wheel wear shall have a hardness approximately that of rail steel.

Cast Manganese Steel.

8. The cast manganese steel shall conform to the standard specifications of the Manganese Track Society (Page 410, Volume 18, A.R.E.A. Proceedings).

Malleable Iron Castings.

9. Malleable iron castings shall be of a good commercial grade, properly annealed.

Rolled or Forged Steel.

10. Rolled or forged steel parts shall be of a medium grade of commercial mild steel. Parts exposed to wheel wear shall be equal in hardness to rail steel.

Fillers.

11. Fillers shall be of rolled or forged steel, wrought iron or of good quality grey cast iron as called for on plans and as specified.

Heel Risers.

12. Heel risers shall be as called for on plans and provide wearing surface equal in hardness to rail steel.

Foot Guards.

13. Metal foot guards as shown on plans shall be of rolled steel or malleable iron. Wooden foot guards shall be good quality hard wood. Filler blocks when acting as foot guards may be of grey iron.

Bolts.

14. Bolts, other than where heat treated bolts are called for on plans or specified, shall be of mild carbon steel and shall have a tensile strength of not less than 50,000 lb. per square inch and an elongation of not less than 15 per cent. in 8 in.

Heat treated or high tensile bolts shall be of carbon or alloy steel and conform to the following minimum requirements:

Tensile Strength	100,000 lb.
Yield Point	70,000 lb.
Elongation in 2 in.	15 per cent.
Reduction of Area	40 per cent.

Full-size bolts shall bend cold without cracking through 180 deg. around a pin of the same diameter as the bolt. The yield point, elongation, and reduction of area may be determined from a finished bolt or from a test piece ½ in. by 2 in. turned from a finished bolt. Nuts may be Bessemer or open-hearth carbon steel not heat treated and shall be of sufficient thickness to develop the full strength of the bolt.

Rivets.

15. Rivets shall be made of steel manufactured in accordance with the standard specifications of the American Society for Testing Materials for rivet steel for ship or structural work.

Reinforcing Bars.

16. Reinforcing bars shall be of wrought iron or mild open-hearth steel.

Plates.

17. Switch plates, special frog tie plates, and bearing plates shall be of mild open-hearth steel.

Switch Clips.

18. Switch clips shall be of mild open-hearth steel, except special designs which may be of cast steel or malleable iron.

Switch Rods.

19. Switch rods shall be of mild rolled steel or wrought iron.

Stops and Hold-Downs.

20. Stops and hold-downs shall be of mild rolled steel or wrought iron.

Anti-Creeping Device.

21. Anti-creeping devices shall be of mild rolled steel or wrought iron.

Braces.

22. Braces shall be of mild rolled steel, malleable iron or cast steel.

Washers.

23. Washers shall be of mild rolled steel, malleable iron or cast steel.

Nut Locks.

24. Nut locks shall be of good strong spring steel.

Switch Heel Blocks.

25. Switch heel blocks shall be of grey iron, cast or forged steel as specified.

Springs.

26. The steel in springs shall conform to the standard specifications of the American Society for Testing Materials for carbon steel bars for

railway springs. Springs when forced down solid and held in the compressed position for thirty seconds, upon release, must not vary from their original free length.

Spring Housings.

27. Spring housings shall be of grey cast iron, malleable iron or cast steel.

Forged Crossing Knees.

28. Forged crossing knees shall be of mild rolled open-hearth steel or wrought iron.

Special Splice Bars.

29. Special splice bars shall be of mild rolled steel or cast steel.

Workmanship

Workmanship.

30. Workmanship shall be first-class and in accordance with best current practice. The assembly of the several parts shall be such that uniformity of detail and finish will result.

Alinement and Surface.

31. The alinement and surface of all finished work shall be even and true and conform to the angles specified.

Length.

32. Length of frogs and crossing arms shall not vary more than ¼ in. from lengths specified. Switch-point rails and guard rails shall not vary more than ½ in. from length specified. Rail ends shall be cut square to the axis of the rail, unless otherwise required.

Flangeways.

33. The width of flangeways shall not be less than nor more than $\frac{1}{16}$ in. greater than the width specified, when measured on the level of gage line ⅝ in. below tread surface. Flangeways shall not be less than 1⅞ in. deep measured from top of the tread surface, unless otherwise specified.

Bending.

34. Bends shall be made accurately in arcs of circles and without injury to the material. It is desired that rails be bent cold. If heating of the rails is resorted to it must be done in a manner so as not to injure the metal.

Planing.

35. All planing must be true and all abutting surfaces must fit accurately.

Grinding.

36. Running surfaces of the manganese steel parts shall be ground to practically as good a surface as that of the rolled rail. Manganese steel portions fitting into rails or other parts shall be ground to a good fit.

Drilling and Punching.

37. All holes in carbon steel rails must be drilled. In other parts all holes for turned pins or bolts and for tight fit of rough bolts must be drilled. Drilling to be done accurately, on bevel where necessary. Punching will be permitted only in wrought iron or mild steel parts for rivets, loose rough bolts and spikes, except when such holes come so close together or close to the edge of the piece that the metal between holes or between hole and edge is less in width than the thickness of the material, in which case holes must be drilled.

Fit of Bolts.

38. Main or body bolts in frogs and crossings shall have a tight fit in straight true holes. Heads and nuts shall have a square bearing. Other bolts not requiring a tight fit, unless otherwise specified, shall have a clearance of not more than 1/16 in. in drilled or punched holes and not more than 1/8 in. in cored holes. Threads must be U. S. Standard, accurately cut within tolerance of best practice for cut threads. Nuts must have a tight fit.

Rivets.

39. Rivets shall be of full diameter called for on plans and rivet holes shall not be more than 1/16 in. greater in diameter. When not otherwise called for by plans or specifications, rivets shall have standard button or cone heads of uniform size for the same size rivet. The heads shall be concentric with the holes. Countersunk rivets shall be flush with the surface and fill the countersink.

Fit of Fillers, Braces and Reinforcing Bars.

40. Fillers, except as otherwise called for or permitted by plans and specifications, shall fit closely into the fishing space of the rail and into the fillets of the web for not less than 1/2 in. below the head and above the base flange. When the raised brand of the rail interferes with fit of filler the brand shall be removed. Fillers shall be grooved or cut to clear rivet heads and bolt heads.

Switch braces shall fit the fishing space of the rail when the brace is tight against the shoulder of the switch plate.

Reinforcing bars shall fill the height of the fishing space of the rail.

Plates and Bars.

41. All plates must be flat and true to surface. Bars must be straight and of the full size called for.

Painting.

42. No paint, tar or other covering shall be used unless specified, and, in any case, shall not be applied before final inspection.

Welding.

43. No welding shall be permitted on rails or on surfaces of other parts exposed to wheel wear. Welding in other portions may be permitted if in the judgment of the inspector the strength of the piece is not impaired.

Marking.

44. The finished articles shall be plainly stamped with ¾ in. figures and letters for indentification. The manufacturers' name or initials, section and weight of rail and month and year of manufacture must be stamped on a rail portion of the sctructure not exposed to wheel wear and where marking can be plainly seen, or may be stamped on a separate rust-proof plate, riveted to the web of the rail, in which case smaller letters may be used. Frogs must be marked with the frog number. All loose parts or fixtures shall be similarly stamped with suitable size letters and figures, the stamping also to show the numbers of the parts appearing on the plan and detail number, where established. On cast parts all or part of the lettering may be cast on the piece. All heat-treated bolts shall be marked on the head with letter or symbol indicating the manufacturer.

Inspection

45. Material and workmanship shall be at all times subject to inspection by a duly authorized representative of the purchaser. The inspector shall have all reasonable facilities afforded to him by the manufacturer to examine the work during its progress, as well as the finished product, to satisfy himself that the work is manufactured and finished in accordance with these specifications.

46. All inspection shall be made at the place of manufacture. Tests of material may be made at the expense of the manufacturer if the amount of any particular kind of material is 50 tons or more. If less than 50 tons, the manufacturer shall certify that it is furnished in accordance with this specification; however, if the purchaser desires that a test be made he shall bear the expense of same, unless the material fails to meet the specifications, in which case the manufacturer shall stand the expense of such test. For the rails used in the work the manufacturer, when requested, shall supply the purchaser with a certificate of inspection from the rail manufacturer.

47. The acceptance of any material by an inspector shall not prevent subsequent rejection if found defective after delivery, and such defective material shall be replaced by the manufacturer at his own expense.

FROG DESIGNS

Data for laying out Bolted Rigid Frogs, Railbound Manganese Steel Frogs and Solid Manganese Frogs as given below will aid in laying out frogs of different angles and number from those covered by plans submitted by this Committee. Several railroads have asked for this information.

Bolted Rigid Frogs—For data for laying out see Plan No. 320.

Railbound Manganese Steel Frogs—The rules given below for designs of Railbound Manganese Steel Frogs are applicable for all rail sections from 80 lb. per yard up, and from 2⅝ in. to 3 in. width of head. Design A is applicable to all angles of from No. 4 to No. 20, both inclusive. Design B is applicable to angles of from No. 16 to No. 20, both inclusive.

Sections and other details are to conform to those for similar angles shown on Plans 601 to 607, inclusive. Lengths shall conform to A.R.E.A. standard lengths for Bolted Rigid Frogs.

Rules for Laying Out Design A

Applicable to All Frogs from No. 4 to No. 20, Inclusive.

1. **Heel.**

The heel end of manganese point is placed where the spread between gage lines is 4¾ in.

2. **Heel Block Extension.**

The heel block extension running out from the heel of manganese point between the heel rails to be 23 in. long for frogs Nos. 4, 5 and 6 and 26 in. long for No. 7; above No. 7, the heel extension is to run 6 in. beyond the point where spread between gage lines is 7¼ in. The heel block extension is integral with the manganese body casting on all frogs up to and including No 15; for frogs No. 16 to No. 20, inclusive, the integral part is made 10½ in. long from the heel of manganese point and a separate heel block casting forms the balance. The riser at the end of all heel blocks is to have a slope from ½ in. below the level of the head of rails at the end to tread level in a length of 6 in.

3. **Heel Rails.**

The heel rails are offset horizontally toward the gage line by a short bend at the end of the heel block extension and a reverse bend 15½ in. from the point end of the rails on all frogs up to and including No. 15, and 20½ in. from the point end of the rail for frogs No. 16 to No. 20, inclusive, so as to bring the center line of web ⅞ in. (+ 1/16 in.) from gage line of frog and running parallel to gage line from point end to reverse bend. Head on gage line is planed to straight line conforming to side contour of head. Back of head is planed to a straight taper with a vertical side from 1½ in. net width of head at point to full section at end of heel block extension.

The point end of rail is cut at an angle of 45 deg. to the gage line and the back of head at point end is rounded by 5 in. radius.

4. **Wing Rail.**

Wing rail laps heel rail from point end to reverse bend or for a length of 15½ in. for all frogs up to and including No. 15, and 20½ in. for No. 16 to No. 20, inclusive, and is parallel to gage line with a width of flangeway of 2¼ in. using a standard section filler made for a 1¾ in. flangeway with full rail heads, but producing a width of 2¼ in. between the line of head of wing rail and the planed away head of heel rail. The side of the head of wing rail is planed for a straight flare on the guard side running on a line from the 1¾ in. width flangeway opposite to a 2¼ in. spread of the gage lines (except for No. 4 and No. 5 frogs) to a 3½ in. flare opening at the end of a flare measured ⅝ in. below tread level. The side of flare planing on the wing rail commencing at the end of the manganese wing to be on a bevel of 25 deg. from vertical. For No. 4 and No. 5 frogs the beginning of the flare line is placed at opposite spread between gage line of 1⅝ in. instead of 2¼ in.

Where the flare line intersects the side of the head of wing rail at the 2¼ in. width of flangeway measured ⅝ in. below tread level, head of wing rail is notched to a radius of ⅝ in. for the reception of the manganese steel wing and rail is bent outward on a straight line so as to bring side of full head 4 in. from gage line opposite theoretical point. Opposite theoretical point wing rail is bent back on a line running to a gage line toe spread of 3 in., but on an angle of not less than 1 in 8 with gage line (frogs No. 4 to No. 10, inclusive). If angle comes out smaller than 1 in 8, reduce toe spread (2.91 in. for No. 11 frog and 2.67 in. for No. 12 frog) to make the angle 1 in 8 until a minimum toe spread of 2½ in. is reached (frogs No. 14 to No. 20, inclusive) when such minimum spread and minimum angle of 1 in 8 are kept and the middle bend of wing rail moved toward the toe end of the frog by extending the line of wing rail running from the notch to the point 4 in. out at theoretical point until such line meets the line drawn from 2½ in. toe spread on the 1 in 8 angle. Head is planed with vertical side from notch to full section of head at middle bend.

5. **Manganese Steel Body and Wings.**

From the heel end of the manganese point at the 4¾ in. spread the manganese is carried across the flangeway on an angle of 30 deg. to the gage line to the web of the wing rail. It then follows the web of bent wing rail to the bend at toe, where the manganese body ends. The back of the manganese wing fits into the notch in the wing rail and follows the planed and bent head of the wing rail to the toe end, where it lies up against the side of the full head section of the wing rail, the end being sloped and rounded. Manganese wing is flared to follow flare line from 1¾ in. width of flageway to 2¼ in. opening at notch to meet flare planed in wing rail. Bottom bearing of the manganese steel casting on top of base of wing rail to be continuous throughout except at bends. Bearing under head and against web of wing rail to be 3 in. long at every other through bolt commencing with the second bolt from the manganese heel towards the toe down to the first bolt from the theoretical point towards the heel and then at every bolt to the toe end; and for a length of 4 in. at the last bolt through the toe end of manganese body.

Heel extension to have continuous bearing on the top of base of heel rails and to bear against the web and under head continuous from the point end of heel rails for same length as flangeway filler, then for 3 in. at each bolt beyond end of filler and 4 in. at end of heel block extension.

6. **Fillers and Toe Blocks.**

Fillers between heel rails and wing rails are of a constant length of 14¼ in. for frogs No. 4 to No. 15, inclusive, and 19¼ in. for frogs No. 16 to No. 20, inclusive, measured on gage line, being cut on an angle of 30 deg. to correspond to angle of manganese steel body carried across flangeway and square on outer end, except when wing rails are beveled, when filler is cut flush with end of the same angle as the wing rail.

Toe blocks are placed 2 in. from the toe end of the manganese body and are 7 in. long, with one bolt for all frogs up to and including No. 15, and 12 in. long with two bolts for frogs No. 16 to No. 20, inclusive.

7. **Bolt Spacing.**

At heel end spacing of bolts through heel rails, wing rails and fillers is constant; 3 in.-5 in.-5 in. for all frogs from No. 4 to No. 15, inclusive, and 3 in.-5 in.-5 in. for frogs No. 16 to No. 20, inclusive, measured on gage line from point end of heel rail. Bolt at end of heel block extension is placed 2 in. from extreme end of all frogs. In 26 in. long heel block extension one additional bolt is placed midway between end bolt and last bolt through filler (No. 7 and No. 8 frogs). In longer extensions (No. 9 frog and above) first bolt outside of end of wing rails is placed 6½ in. from last bolt through flangeway fillers and additional bolts (No. 11 frog and above) are spaced between this bolt and the end bolt in least number of equal spaces not exceeding 10 in. from c. to c. At toe end position of bolts through toe block is constant, being 6 in. measured on gage line from toe end of manganese body for 7 in. toe block and 4 in.-8 in. for 12 in. toe block. Position of first two bolts through manganese body at toe end is constant 2 in.-7 in. for all frogs, measured on gage line from toe end of casting. Body bolts between fixed positions of bolts at heel and toe ends are spaced in least number of equal spaces not exceeding 12 in. from c. to c.

Rules for Laying Out Design B

Applicable to All Frogs from No. 16 to No. 20, Inclusive.

The rules for the laying out of Design B are the same as given for Design A for frogs No. 16 to No. 20, inclusive, with the following modifications:

8. **Heel.**

The heel end of manganese point is placed where the spread between gage lines is 4¼ in. instead of 4¾ in.

9. **Heel Block Extension.**

To correspond with rules for Design A.

10. **Heel Rails.**

To correspond with rules for Design A.

11. **Wing Rail.**

To correspond with rules for Design A, from heel down to opposite theoretical point at 4 in. out from gage line. The wing rail is then bent back on a straight line to meet guard line at opposite the point where the toe spread between gage line is 1 in. (equals 2½ in. wide throat). Angle of this line with guard line to be not smaller than 1 in 8 (1 in 7.1 for No. 16 frog). In No. 18 and No. 20 frogs run line on angle of 1 in 8 from guard line from opposite the 1 in. toe spread and extend line of wing from notch to 4 in. from gage line at theoretical point until the two lines meet. Toe end of manganese wing is placed at opposite the 1 in. toe spread. Wing rail then follows a straight line through throat to a 2⅛ in. spread between gage line, where it is again bent to the line of the frog angle.

12. **Manganese Steel Body and Wings.**

To correspond with rules for Design A, commencing at the 4¼ in. heel spread to toe end of manganese wing at throat. Manganese body is extended beyond end of manganese wing toward toe asa filler between wing rails a distance of 10 in. with continuous bearing on top of base and under head and against web of rail from toe end of casting to second bolt through manganese wing.

13. **Flangeway Fillers and Toe Blocks.**

Fillers between heel rail and wing rail same as Design A. Toe blocks are placed 2 in. from end of manganese steel body—1 block 20 in. long for No. 16 frog—2 blocks 2 in. apart, outer one 16 in. long—inner one 6 in. long for No. 18 frog; and 2 blocks 2 in. apart—outer one 16½ in, long—inner one 9½ in. long for No. 20 frogs.

14. **Bolt Spacing.**

Rules for bolt spacing at the heel and heel block extension are the same as for Design A.

At the toe end the position of the first four bolts through the manganese steel body is constant: 2 in.-5 in.-6 in.-7 in. from end of body extension between wing rails. Bolts through toe block are spaced as follows: From first toe bolt through manganese body towards toe end of from—No. 16 frog, 8 in.-12 in.; No. 18 frog, 7 in.-7 in.-12 in.; No. 20 frog, 8¾ in.-9 in.-12 in.

Body bolts between fixed position of bolts at heel and toe ends are spaced in the least number of equal spaces not exceeding 12 in. from c. to c. same as Design A.

SOLID MANGANESE STEEL FROGS

The rules given below for the design of solid manganese steel frogs are applicable to all frogs from a No. 4 to a No. 20, inclusive, and for all connecting rail sections from 80 lb. per yard up, and from $2\frac{3}{8}$ in. to 3 in. (inclusive), width of head.

Abbreviations and Definitions: Base = Base of rail connecting from; Head = Head of rail connecting frog; Minimum Width of Head = width of head of rail at a point $\frac{5}{8}$ in. below top; Design 1 = Type of frog without easer extensions; Design 2 = Type of frog with easer extensions.

Sections shall conform to those shown on Plans 651 to 655, inclusive.

Typical details of heel-ends, toe-ends and flare are appended.

Grouping of Rails. To establish a minimum of different standard lengths of frogs, rails are grouped as follows, and composite standard lengths for each group tabulated as per appended tables of "Standard Dimensions."

Class "A."—Rail with a base of $5\frac{3}{4}$ in. down, but not including $5\frac{1}{2}$ in. and head $2\frac{7}{8}$ in, to $2\frac{5}{8}$ in. wide, inclusive; or rail head at or exceeding $2\frac{7}{8}$ in. when head and base do not exceed $8\frac{5}{8}$ in.

Class "B."—Rails with a base of $5\frac{1}{2}$ in. down, but not including $5\frac{1}{4}$ in. and head $2\frac{13}{16}$ in. to $2\frac{9}{16}$ in. wide, inclusive; or rail head at or exceeding $2\frac{13}{16}$ in. when head and base do not exceed $8\frac{5}{16}$ in.

Class "C."—Rails with a base of $5\frac{1}{4}$ in. down, but not including 5 in. and head $2\frac{11}{16}$ in. to $2\frac{7}{16}$ in. wide, inclusive; or rail head at or exceeding $2\frac{11}{16}$ in. when head and base do not exceed $7\frac{15}{16}$ in.

Class "D."—Rails with a base of 5 in. down, but not including $4\frac{1}{2}$ in. and head $2\frac{11}{16}$ in. to $2\frac{7}{16}$ in. wide, inclusive; or rail head at or exceeding $2\frac{11}{16}$ in. when head and base do not exceed $7\frac{11}{16}$ in.

1. Lengths. (General Rule.)

For Design 1, Toe Lengths. Toe Lengths from theoretical $\frac{1}{2}$ in. point = (maximum base minus minimum width of head plus $\frac{1}{2}$ in.) times frog number. Minimum toe length for 15 in. maximum splicing = $2\frac{1}{4}$ in. times frog number plus 13 in. (below a No. 11 frog, class "A"; a No. 12 frog, class "B"; a No. 14 frog, class "C," and a No. 18, class "D").

For Design 2, Toe Lengths. Toe Lengths from theoretical $\frac{1}{2}$ in. point = (maximum base minus minimum width of head plus $\frac{1}{2}$ in.) times frog number. Minimum toe length = $2\frac{1}{4}$ in. times frog number plus 6 in. (below a No. 5 frog, class "A"; a No. 6 frog, class "B"; a No. 7 frog, class "C," and a No. 8 frog, class "D").

For Designs 1 and 2, Heel Lengths. Heel Lengths from theoretical ½ in. point = (maximum base plus maximum width of head minus ½ in.) times frog number. Minimum heel length for 15 in. maximum splicing and 15 in. length of flare = 3 ft. 6 in. (frogs No. 4 and 5 all classes).

All lengths to be taken to the even inch (lower for fractions up to but not including ½ in., higher for fractions ½ in. or more).

2. Heights.

Heights of frog casting to be (both designs):

4⅝ in. high for connecting rails of 4⅜ in. to 4$\frac{11}{16}$ in. high, inclusive.
5 in. high for connecting rails of 4¾ in. to 5$\frac{1}{16}$ in. high, inclusive.
5⅜ in. high for connecting rails of 5⅛ in. to 5$\frac{7}{16}$ in. high, inclusive.
5¾ in. high for connecting rails of 5½ in. to 5$\frac{13}{16}$ in. high, inclusive.
6⅛ in. high for connecting rails of 5⅞ in. to 6$\frac{3}{16}$ in. high, inclusive.
6½ in. high for connecting rails of 6¼ in. to 6⅝ in. high, inclusive.

3. Heel Extension.

Heel extension to run 15 in. beyond heel joint.

For Design 1—Its top to be 1⅝ in. below tread of connecting rails. Easer to be formed in front of heel extension, between tread lines, sloping from ½ in. below at heel joint to flush with tread in 6 in.

For Design 2—Its top to be flush with tread of connecting rails, sloping to ½ in. below tread in 6 in. at extreme end.

Side walls or webs to fit fishing section of connecting rail. End walls to be ¾ in. thick.

4. Toe Extension.

For Design 1—Toe extension to run between rails for 15 in. beyond toe joint. Its top to be level with bottom of flangeway. Side walls or webs to fit fishing section of connecting rail. End wall to be ¾ in. thick. Outside splice bars and through bolts to be used for fastening rails.

For Design 2—Toe extension to run along outside of connecting rails for 15 in. beyond toe joint, forming easer; and fitting outside section of connecting rails. Its top to be flush with tread of connecting rail, sloping to ½ in. below tread in 6 in. at extreme end. Vertical web of extension to be flush with outside and ⅞ in. thick. Method of fastening toe rails by toe block and through bolts or direct independent bolting or supplementary tie plate, optional with manufacturer.

5. Width of Tread Surface.

Width of tread surface to vary with height of frog casting:

Design 1

2½ in. wide for 4⅝ in. high frog casting.
2⅝ in. wide for 5 in. and 5⅜ in. high frog casting.
2¾ in. wide for 5¾ in. high frog casting.
2⅞ in. wide for 6⅛ in. high frog casting.
3 in. wide for 6½ in. high frog casting.

Design 2

4 in. wide for 4⅝ in., 5 in. and 5⅜ in. high frog casting.
4½ in. wide for 5¾ in., 6⅛ in. and 6½ in. high frog casting.

6. Flare and Side Lines of Frog.

For Design 1—Carry full width of tread surface (see rule 5) from toe end to opposite theoretical ½ in. point, following gage, throat and guard lines.

For Design 2—Carry outer line of tread surface (see rule 5) from toe end, including toe extension, parallel to gage line to opposite theoretical point.

Then (for both designs) taper width to 1¼ in. wide guard for 1¾ in. wide flangeway, at a point opposite beginning of flare. Flare begins where spread of gage lines is 2¼ in. (except frogs Nos. 4, 5, 6, all classes, and No. 7, class "D"), and runs to a 2½ in. opening in 10 in. and then in 6 in. to a 3¾ in. opening at the end. If this brings end of flare (16 in. from point of commencement) opposite a point where spread of gage lines is less than 4 in. (above a No. 9 frog), then extend flare by placing outside end at the 4 in. spread, go back 6 in. reducing opening from 3¾ in. at extreme to 2½ in. in that distance, same as on wide end of the normal standard flare, then reduce width of opening by a straight line from the 2½ in. to the regular 1¾ in. width of flangeway at the point where spread of gage lines is 2¼ in.

Note.—For flangeways wider than 1¾ in. the length of flare will be shortened correspondingly.

If end of flare comes closer than 23 5/16 in. from heel joint, reduce 10 in. portion of the normal standard flare to a length of 6 in. and relocate end of flare at 23 5/16 in. from heel joint (for frogs Nos. 4, 5, 6, all classes, and No. 7, Class "D").

7. Joint Surfaces at Heel End.

Run web lines parallel to gage line for a length of 17 in., round off with a 3¾ in. radius to a 45 deg. line joining the regular outer wall. (Both designs.)

8. Joint Surface at Toe End.

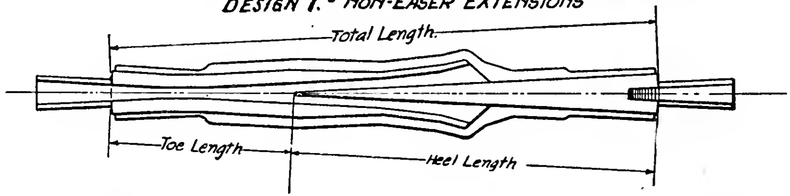
Design 1 only—Run web line from toe joint parallel to gage line without regard to top line for a length of 17 in., round off with a 3¾ in. radius to a 45 deg. line joining the regular outer wall. If this would bring outer web line closer than ¾ in. to guard line at throat, reduce joint surface from 17 in. long to necessary shorter length to make wall ¾ in. thick (Nos. 4 and 5 frogs).

9. Bolts at Joints.

Bolt spacing at joints to agree with purchaser's specifications. Bolts to be of high tensile steel. Bolt holes to be 1/4 in. larger diameter than diameter of bolts specified by purchaser. Through bolts in heel of designs 1 and 2 and toe of Design 1 to have 3/8 in. minimum to 5/8 in. maximum thick metal around bolt, extending from web to web of section.

STANDARD DIMENSIONS OF SOLID MANGANESE STEEL FROGS

DESIGN I. - NON-EASER EXTENSIONS



USE TABLE GIVING SHORTEST LENGTHS THAT WILL APPLY IN EACH CASE.

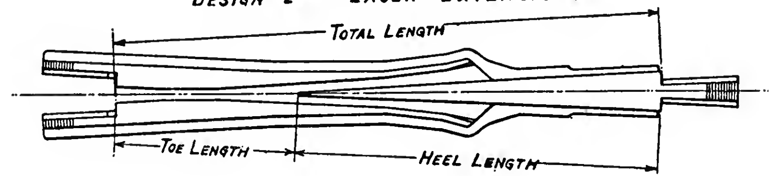
	A.			B.			C.			D.		
	Rail base 5¾" down but not incl. 5½". Rail head 2⅞" to 2⅝" incl. Or rail head at or exceeding 2⅝" when head and base do not exceed 8⅝"			Rail base 5½" down but not incl. 5¼". Rail head 2 13/16" to 2 9/16" incl. Or rail head at or exceeding 2 9/16" when head and base do not exceed 8 3/16".			Rail base 5¼" down but not incl. 5". Rail head 2 11/16" to 2 5/16" incl. Or rail head at or exceeding 2 5/16" when head and base do not exceed 7 13/16".			Rail base 5" down but not incl. 4½". Rail head 2 11/16" to 2 5/16" incl. Or rail head at or exceeding 2 5/16" when head and base do not exceed 7 1/16".		
Frog No.	Heel Length	Toe Length	Total Length	Heel Length	Toe Length	Total Length	Heel Length	Toe Length	Total Length	Heel Length	Toe Length	Total Length
4	3'-6"	1'-10"	5'-4"	3'-6"	1'-10"	5'-4"	3'-6"	1'-10"	5'-4"	3'-6"	1'-10"	5'-4"
5	3'-6"	2'-0"	5'-6"	3'-6"	2'-0"	5'-6"	3'-6"	2'-0"	5'-6"	3'-6"	2'-0"	5'-6"
6	4'-1"	2'-3"	6'-4"	3'-11"	2'-3"	6'-2"	3'-9"	2'-3"	6'-0"	3'-7"	2'-3"	5'-10"
7	4'-9"	2'-5"	7'-2"	4'-7"	2'-5"	7'-0"	4'-4"	2'-5"	6'-9"	4'-2"	2'-5"	6'-7"
8	5'-5"	2'-7"	8'-0"	5'-3"	2'-7"	7'-10"	5'-0"	2'-7"	7'-7"	4'-10"	2'-7"	7'-5"
9	6'-1"	2'-9"	8'-10"	5'-10"	2'-9"	8'-7"	5'-7"	2'-9"	8'-4"	5'-5"	2'-9"	8'-2"
10	6'-9"	3'-0"	9'-9"	6'-6"	3'-0"	9'-6"	6'-2"	3'-0"	9'-2"	6'-0"	3'-0"	9'-0"
11	7'-5"	3'-4"	10'-9"	7'-2"	3'-2"	10'-4"	6'-10"	3'-2"	10'-0"	6'-7"	3'-2"	9'-9"
12	8'-2"	3'-8"	11'-10"	7'-10"	3'-5"	11'-3"	7'-5"	3'-4"	10'-9"	7'-2"	3'-4"	10'-6"
14	9'-6"	4'-3"	13'-9"	9'-1"	4'-0"	13'-1"	8'-8"	3'-10"	12'-6"	8'-5"	3'-9"	12'-2"
15	10'-2"	4'-6"	14'-8"	9'-9"	4'-4"	14'-1"	9'-4"	4'-2"	13'-6"	9'-0"	3'-11"	12'-11"
16	10'-10"	4'-10"	15'-8"	10'-5"	4'-7"	15'-0"	9'-11"	4'-5"	14'-4"	9'-7"	4'-1"	13'-8"
18	12'-2"	5'-5"	17'-7"	11'-9"	5'-2"	16'-11"	11'-2"	5'-0"	16'-2"	10'-9"	4'-7"	15'-4"
20	13'-7"	6'-1"	19'-8"	13'-0"	5'-9"	18'-9"	12'-5"	5'-6"	17'-11"	12'-0"	5'-1"	17'-1"

A	110 L.V.	100 A.S.C.E.	95 B.&A.			
	105 DUD.	100 DUD.				
		100 I.R.T.				
B	107 N.H.	100 N.H.	90 A.S.C.E.			
	101 D.L.&W.	100 A.R.A."A"	90 U.P.			
		100 P.R.R.	91 D.L.&W.			
		100 P.&R.	90 N.H.			
		100 A.R.E.A.				
C		100 A.R.A."B"	90 A.R.A."A"	85 A.S.C.E.		
		100 C.&N.W.	90 A.T.&S.F.	85 C.B.&Q.		
			90 D.&R.G.	85 MO.PAC.		
			90 P.&R.	85 D.&R.G.		
			90 I.R.T.			
D		100 P.S. Penn.	90 A.R.A."B"	85 P.S. Penn.	80 A.R.A."A"	
		100 T.S.Co.	90 G. NOR.	85 P.R.R.	80 A.S.C.E.	
			90 DUD.	85 G. NOR.	80 DUD.	
				85 N.Y.C.&S.L.	80 CAN. NOR.	
				85 CAN. PAC.	80 H.V.	
				85 SOO LINE	80 CAN. #540	
				85 S.A.L.		
				85 D.&R.G.&C.S.		
				85 DUD.		

NOTE: FIGURES ABOVE THE HEAVY LINES ARE MINIMUM LENGTHS.

STANDARD DIMENSIONS OF SOLID MANGANESE STEEL FROGS.

DESIGN-2 — EASER EXTENSIONS.

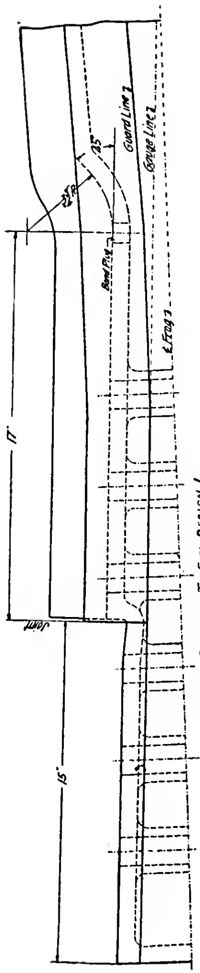


USE TABLE GIVING SHORTEST LENGTHS THAT WILL APPLY IN EACH CASE.

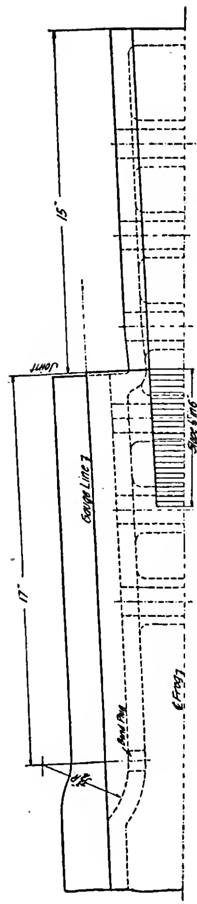
	A			B			C			D		
	Rail Base 5¾" Down But Not Incl. 5½". Rail Head 2⅞" To 2⅝" Incl. Or Rail Head At Or Exceeding 2⅞" When Head And Base Do Not Exceed 8⅝".			Rail Base 5½" Down But Not Incl. 5¼". Rail Head 2$\frac{13}{16}$" To 2$\frac{9}{16}$" Incl. Or Rail Head At Or Exceeding 2$\frac{13}{16}$" When Head And Base Do Not Exceed 8$\frac{5}{16}$".			Rail Base 5¼" Down But Not Incl. 5". Rail Head 2$\frac{11}{16}$" To 2$\frac{7}{16}$" Incl. Or Rail Head At Or Exceeding 2$\frac{11}{16}$" When Head And Base Do Not Exceed 7$\frac{15}{16}$".			Rail Base 5" Down But Not Incl. 4¾". Rail Head 2$\frac{11}{16}$" To 2$\frac{7}{16}$" Incl. Or Rail Head At Or Exceeding 2$\frac{11}{16}$" When Head And Base Do Not Exceed 7$\frac{11}{16}$".		
Frog No.	Heel Length	Toe Length	Total Length	Heel Length	Toe Length	Total Length	Heel Length	Toe Length	Total Length	Heel Length	Toe Length	Total Length
4	3'-6"	1'-3"	4'-9"	3'-6"	1'-3"	4'-9"	3'-6"	1'-3"	4'-9"	3'-6"	1'-3"	4'-9"
5	3'-6"	1'-6"	5'-0"	3'-6"	1'-5"	4'-11"	3'-6"	1'-5"	4'-11"	3'-6"	1'-5"	4'-11"
6	4'-1"	1'-10"	5'-11"	3'-11"	1'-9"	5'-8"	3'-9"	1'-8"	5'-5"	3'-7"	1'-8"	5'-3"
7	4'-9"	2'-1"	6'-10"	4'-7"	2'-0"	6'-7"	4'-4"	1'-11"	6'-3"	4'-2"	1'-10"	6'-0"
8	5'-5"	2'-5"	7'-10"	5'-3"	2'-4"	7'-7"	5'-0"	2'-3"	7'-3"	4'-10"	2'-1"	6'-11"
9	6'-1"	2'-9"	8'-10"	5'-10"	2'-7"	8'-5"	5'-7"	2'-6"	8'-1"	5'-5"	2'-4"	7'-9"
10	6'-9"	3'-0"	9'-9"	6'-6"	2'-10"	9'-4"	6'-2"	2'-9"	8'-11"	6'-0"	2'-7"	8'-7"
11	7'-5"	3'-4"	10'-9"	7'-2"	3'-2"	10'-4"	6'-10"	3'-0"	9'-10"	6'-7"	2'-10"	9'-5"
12	8'-2"	3'-8"	11'-10"	7'-10"	3'-5"	11'-3"	7'-5"	3'-4"	10'-9"	7'-2"	3'-1"	10'-3"
14	9'-6"	4'-3"	13'-9"	9'-1"	4'-0"	13'-1"	8'-8"	3'-10"	12'-6"	8'-5"	3'-7"	12'-0"
15	10'-2"	4'-6"	14'-8"	9'-9"	4'-4"	14'-1"	9'-4"	4'-2"	13'-6"	9'-0"	3'-10"	12'-10"
16	10'-10"	4'-10"	15'-8"	10'-5"	4'-7"	15'-0"	9'-11"	4'-5"	14'-4"	9'-7"	4'-1"	13'-8"
18	12'-2"	5'-5"	17'-7"	11'-9"	5'-2"	16'-11"	11'-2"	5'-0"	16'-2"	10'-9"	4'-7"	15'-4"
20	13'-7"	6'-1"	19'-8"	13'-0"	5'-9"	18'-9"	12'-5"	5'-6"	17'-11"	12'-0"	5'-1"	17'-1"

A	110 L.V.	100 A.S.C.E.	95 B.&A.			
	105 DUD.	100 DUD.				
		100 I.R.T.				
B	107 N.H.	100 N.H.	90 A.S.C.E.			
	101 D.L.&W.	100 A.R.A."A."	90 U.P.			
		100 P.R.R.	91 D.L.&W.			
		100 P.&R.	90 N.H.			
		100 A.R.E.A.				
C		100 A.R.A."B."	90 A.R.A."A."	85 A.S.C.E.		
		100 C.&N.W.	90 A.T.&S.F.	85 C.B.&Q.		
			90 D.&R.G.	85 Mo. Pac.		
			90 P.&R.	85 D.&R.G.		
			90 I.R.T.			
D		100 P.S. Penn.	90 A.R.A."B."	85 P.S. Penn.	80 A.R.A."A."	
		100 I.S.Co.	90 Gr. Nor.	85 P.R.R.	80 A.S.C.E.	
			90 DUD.	85 Gr. Nor.	80 DUD.	
				85 N.Y.C.&S.L.	80 Can. Nor.	
				85 Can. Pac.	80 H.V.	
				85 Soo Line	80 Can. #540	
				85 S.A.L.		
				85 D.&R.G.&C.&S.		
				85 DUD.		

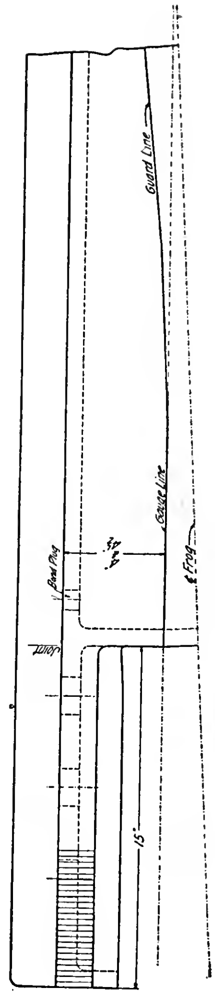
Note: Figures Above The Heavy Lines Are Minimum Lengths.



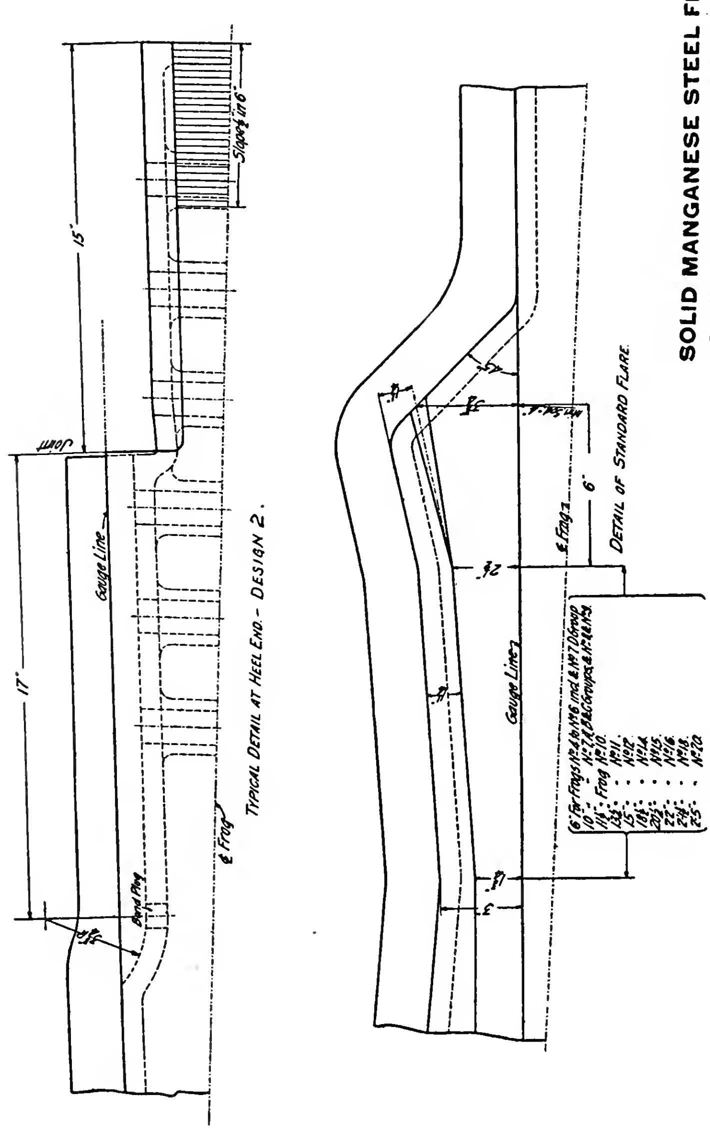
Typical Detail at Toe End.—Design 1.



Typical Detail at Heel End.—Design 1.



Typical Detail at Toe End.—Design 2.



Typical Detail at Heel End. - Design 2.

Detail of Standard Flare.

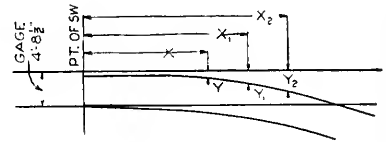
SOLID MANGANESE STEEL FROG

RULES FOR LAYING-OUT DESIGNS 1 AND 2.

TYPICAL DETAILS.

Table of Practical Turnout Leads

Frog Number	Length of Switch Rail	Lead = Distance Actual Point of Switch Rail to Frog ½ in. Point	CLOSURE RAILS Number of Rails and Lengths in Feet and Inches: Straight Rail	CLOSURE RAILS: Curved Rail	LEAD CURVE: Radius of Center Line	LEAD CURVE: Degree of Curve	GAGE LINE OFFSETS: X	X₁	X₂	Y	Y₁	Y₂	Tangent Adjacent to Switch Rail	Tangent Adjacent to Toe of Frog
	Ft. In.	Ft. In.			Feet	Deg. Min. Sec.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In	Ft.	Ft.
5	11-0	42-6½	1—28-0	1—28-3¾	175.40	33-07-28	17-11	24-10	31-9	0-11⅝	1- 8 5/16	2- 8 5/16	0.00	0.97
6	11-0	47-6	1—32-9	1—33	254.00	22-42-20	19- 2¼	27- 4½	35-6¾	1- 0 5/16	1- 9½	2- 9 15/16	0.00	2.00
7	16-6	62-1	1—26 1—14-10½	1—26 1—15-1½	361.69	15-53-30	26- 8½	36-11	47-1½	0-11¾	1- 8 11/16	2- 9⅛	0.00	0.22
8	16-6	68-0	1—30 1—16-5	1—30 1—16-7	487.37	11-46-36	28- 1¼	39- 8½	51-3¾	1- 0 1/16	1- 9 3/16	2- 9⅝	0.32	0.00
9	16-6	72-3½	1—33 1—16-5	1—33 1—16-7	605.18	9-28-42	28- 9	40-11¾	53-2¼	1- 0¼	1- 9⅛	2- 9	0.00	0.57
10	16-6	78-9	1—28 1—27-10	2—28	779.82	7-21-08	30- 3⅜	44- 0⅝	57-9¾	1- 0 7/16	1- 9 7/16	2- 9⅜	1.56	0.00
11	22-0	94-3¾	1—33 1—32-10¼	2—33	922.65	6-12-47	40- 8⅞	56- 5⅝	72-2¼	1- 0 15/16	1-10 1/16	2-10 7/16	2.99	0.00
12	22-0	100-9⅝	2—24 1—23-10⅝	3—24	1098.73	5-12-59	48-11⅞	60- 7¾	77-3⅜	1- 1 13/16	1-10 13/16	2-10 15/16	5.33	0.00
14	22-0	106-3¼	2—30 1—16-5¼	2—30 1—16-6¾	1512.14	3-47-23	41- 1¼	60- 2½	79-3¾	1- 0 15/16	1-10½	2-10 15/16	0.00	2.84
15	30-0	126-2¼	2—30 1—27-10¾	2—30 1—28	1748.29	3-16-40	52- 0	74- 0	96-0	1- 0 5/16	1- 9 11/16	2-10⅜	0.00	0.51
16	30-0	131-6¾	2—30 1—32-10¾	2—30 1—33	2019.18	2-50-16	53- 2¾	76- 5½	99-8¼	1- 0½	1- 9 15/16	2-10⅝	0.00	0.40
18	30-0	138-6	2—33 1—32-11	3—33	2380.47	2-24-26	54- 8¾	79- 5½	104-2¼	1- 0¾	1-10 5/16	2-10 15/16	0.00	6.38
20	30-0	151-5½	2—33 1—30 1—14-11½	2—33 1—30 1—15-0½	3322.13	1-43-29	57-9	85-6	113.3	1- 1 3/16	1-10 15/16	2-11 7/16	0.00	0.27



TURNOUTS AND CROSSOVERS RECOMMENDED
For Main Line High Speed Movements, No. 16 or No. 20.
For Main Line Slow Speed Movements, No. 12 or No. 10.
For Yards and Sidings, to Meet General Conditions, No. 8.

Note.—When conditions require a wider gage than 4 ft. 8½ in., the length lead as shown for 4 ft. 8½ in. gage shall be maintained and the gage widened on the inside rail back of the heel of switch.

Table of Theoretical Turnout Leads

Frog Number	Properties of Frogs: Total Length	Properties of Frogs: Toe Length to ½ in. Point	Properties of Frogs: Heel to ½ in. Point	Properties of Frogs: Frog Angle	Properties of Frogs: Toe Spread	Properties of Frogs: Heel Spread	Properties of Switches: Length of Switch Rail	Properties of Switches: Thickness of Point = ¼ in. Heel Spread = 6¼ in. Switch Angle	Leads For P. C. at Heel of Switch and P. T. at Toe End of Frog: Radius of Center Line	Leads: Degree of Curve	Leads: Distance Point of Switch to Theoretical Point of Frog	Theoretical Leads For Uniform Curve Throughout: Radius of Center Line	Theoretical Leads: Degree of Curve	Theoretical Leads: Distance P. C. to Theoretical Point of Frog
	Ft. In.	Ft. In.	Ft. In.	Deg. Min. Sec.	In.	In.	Ft. In.	Deg. Min. Sec.	Feet	Deg. Min. Sec.	Feet	Feet	Deg. Min. Sec.	Feet
5	9–0	3– 6½	5– 5½	11–25–16	7 15/16	13 9/16	11–0	2–36–19	185.59	31–15–28	42.94	235.42	24–31–28	47.08
6	10–0	3– 9	6– 3	9–31–38	7	13	11–0	2–36–19	280.48	20–32–14	48.41	339.08	16–57–34	56.51
7	12–0	4– 8½	7– 3½	8–10–16	7 9/16	13	16–6	1–44–11	364.88	15–47–19	61.94	461.43	12–26–30	65.92
8	13–0	5– 1	7–11	7–09–10	7⅛	12⅜	16–6	1–44–11	488.71	11–44–40	67.47	602.65	9–31–06	75.33
9	16–0	6– 4½	9– 7½	6–21–35	8 1/16	13 5/16	16–6	1–44–11	616.27	9–18–27	72.24	762.73	7–31–02	84.75
10	16–6	6– 5	10– 1	5–43–29	7 3/16	12⅝	16–6	1–44–11	790.25	7–15–18	77.51	941.70	6–05–14	94.17
11	17–0	6– 5½	10– 6½	5–12–18	6 9/16	12	22–0	1–18–08	940.21	6–05–48	92.06	1139.47	5–01–18	103.59
12	18–6	6–11	11– 7	4–46–19	6 7/16	12⅛	22–0	1–18–08	1136.34	5–02–38	97.25	1355.96	4–13–36	113.00
14	21–6	7–10	13– 8	4–05–27	6 3/16	12 3/16	22–0	1–18–08	1600.73	3–34–48	107.16	1845.64	3–06–18	131.83
15	22–6	8– 3½	14– 2½	3–49–06	6⅛	11⅞	30–0	0–57–18	1764.69	3–14–50	125.87	2118.70	2–42–16	141.25
16	24–0	8– 8	15– 4	3–34–47	6	12	30–0	0–57–18	2032.74	2–49–08	131.15	2410.79	2–22–36	150.67
18	26–6	9– 7	16–11	3–10–56	5⅞	11¾	30–0	0–57–18	2632.76	2–10–35	141.18	3051.10	1–52–40	169.50
20	29–0	10– 6	18– 6	2–51–51	5 13/16	11⅝	30–0	0–57–18	3334.16	1–43–06	150.77	3766.70	1–31–16	188.33

Item III.

The Committee recommends that article "Requisites for Switch Stands" on page 168 be withdrawn, and the following substituted:

"REQUISITES FOR SWITCH STANDS, INCLUDING CONNECTING RODS

1. Provision shall be made for spiking or bolting switch stands to two head blocks.

2. Classification of Switch Stands according to heights (Note.—Height of Switch Stands is measured from top of tie to bottom of taper of lamp tip):

A. High Switch Stands:

Height greater than	14′ 0″
Standard height	18′ 0″

B. Intermediate Switch Stands:

Height greater than	2′ 0″
To and including	14′ 0″
Standard Heights:	
(a) First Intermediate	7′ 9″
(b) Second Intermediate	6′ 0″
(c) Third Intermediate	4′ 0″

C. Low Switch Stands:

Height greater than	1′ 0″
To and including	2′ 0″

D. Extra Low Switch Stands:

Height	1′ 0″ or less

Note.—Extra low switch stands are for general use with target lamps without separate targets.

3. The operating lever of extra low and low switch stands shall work parallel with the track.

4. The switch stand shall be so arranged that it can easily be inspected.

5. There shall be no lost motion in the bearings. The connections between the various parts of the switch stand shall be such as to insure against movement of switch points without corresponding movement of the operating lever.

6. The connection between the connecting rod and the switch stand shall be by a turned bearing of not less than 1⅛″ diameter, and shall be so arranged that the separation cannot occur under operating conditions.

7. Provision shall be made for adjusting the throw of either or both switch points without moving the switch stand.

8. The throwing apparatus shall be so arranged that it will lock or latch in either extreme position without the use of the switch lock.

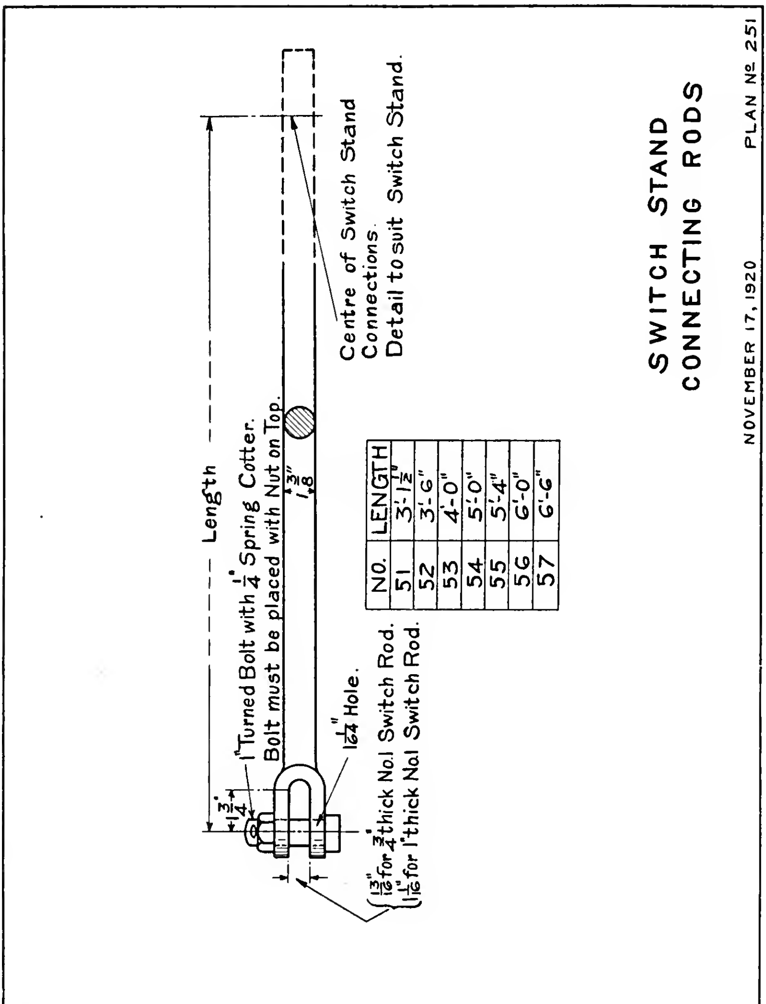
9. Lengths and details of connecting rods shall conform to plan No. 251, dated November 17th, 1920.

10. The target and lamp tip when used on a switch stand shall revolve through 90 degrees with the movement of the switch points, and indicate their position.

11. Shapes and sizes of targets shall conform to plan.......

12. Lamp tips shall conform to plan......"

On account of the variety in the detail of switch stands now on the market and the fact that many of the features are patented the Committee recommends that it would not be desirable to prepare plans nor complete specifications for switch stands, and in lieu thereof recommends the above. The requisites of switch stands have been drawn sufficiently broad to include the more efficient and complete switch stands now commercially available.



NO.	LENGTH
51	3'-1½"
52	3'-6"
53	4'-0"
54	5'-0"
55	5'-4"
56	6'-0"
57	6'-6"

Appendix B

(2) TYPICAL PLANS OF TURNOUTS, CROSSOVERS, SLIP SWITCHES, DOUBLE CROSSOVERS AND RAILROAD CROSSINGS, AND PREPARE DETAIL PLANS FOR SUCH WORK, INCLUDING NECESSARY FIXTURES, ETC.

J. V. NEUBERT, *Chairman;*
W. P. WILTSEE,
V. ANGERER,
J. B. BAKER,
E. A. HADLEY,
E. T. HOWSON,
H. A. LLOYD,
J. DE N. MACOMB,
R. M. PEARCE,
H. T. PORTER,
G. J. SLIBECK,
J. B. STRONG,
J. R. WATT,
Sub-Committee.

The Committee recommends the following plans for adoption:

Plan 901—Layout No. 6 Turnout and Crossover.
Plan 902—Layout No. 7 Turnout and Crossover.
Plan 903—Layout No. 8 Turnout and Crossover with Rigid Frogs.
Plan 904—Layout No. 8 Turnout and Crossover with Spring Frogs.
Plan 905—Layout No. 10 Turnout and Crossover.
Plan 906—Layout No. 11 Turnout and Crossover.
Plan 907—Layout No. 16 Turnout and Crossover.
Plan 908—Layout No. 20 Turnout and Crossover.
Plan 190—Diagram Preferred Names for Split Switches with Uniform Risers.
Plan 191—Diagram Preferred Names for Split Switches with Graduated Risers.
Plan 390—Diagram Preferred Names for Bolted Rigid Frogs.
Plan 490—Diagram Preferred Names for Spring Rail Frogs.
Plan 590—Diagram Preferred Names for Guard Rails.
Plan 690—Diagram Preferred Names for Rail Bound Manganese Steel Frogs.
Plan 691—Diagram Preferred Names for Solid Manganese Steel Frogs.

The plans of turnouts and crossovers, Nos. 901 to 908, inclusive, are the result of study of several railroads, and they speak for themselves. Attention is called to using short ties in the crossovers to eliminate the heavy expense of longer ties, which are used as alternates. The plans, 901 to 908, inclusive, were published as information in Supplement to Bulletin 221, and in Vol. 21 of the Proceedings. As the changes from previous publication are of a minor nature only, principally in modifying some of the tie lengths, their reprinting at this time was deemed an unwarranted expense. If approved, the corrected plans will be published in the revised Manual, to be issued after this convention. Prints from the corrected plans, if desired, can be obtained upon application to the Secretary.

The plans showing diagrams of preferred names of parts were published as information in Supplement to Bulletin 221 and in Vol. 21 of the Proceedings, and are now offered supplementary to the Definitions printed on pages 115, 116 and 117 in the 1915 Manual. The Committee has been working on a rather extensive glossary of the definitions of terms for addition and revision to those printed in the Manual on the pages above mentioned, but at present can only make a Progress Report on work done thus far.

The following changes are recommended on the plans adopted at the March convention, 1920:

Plan 501—Details of Guard Rails. (See Vol. 21, Proceedings.)

Make the following changes in Gage Line Diagram: Show dimension line between gage line of frog point and guard line of guard rail, stating this distance must be maintained 4 feet 6¾ inches instead of showing this distance as 4 feet 5 inches between guard line of wing rail and guard line of guard rail.

Plan 502—Details of Guard Rail Fixtures. (See Vol. 21, Proceedings.)

Under notes, the second item, correct to read "For 16 feet 6 inches guard rails and for congested traffic, with 11-foot guard rails, use two clamps applied in Position C-2"; and note under Alternate should be revised to read "For 16 feet 6 inches guard rails and for congested traffic, with 11-foot guard rails, use two adjustable guard rail braces applied in Position B-2."

The Committee also recommends that the following plans be accepted as information:

Plan 309—No. 4 and No. 5 Bolted Rigid Frogs.
Plan 608—No. 4 and No. 5 Rail Bound Manganese Steel Frogs.
Plan 656—No. 4 and No. 5 Solid Manganese Steel Frogs.

As these are special angle frogs and there is very little call for them, they are submitted only as information so they will be available in case they are needed.

The following plans for railroad crossings, dated November, 1920, are submitted as information and for criticism:

Bolted Rail Crossings:

Plan 701—Angle 50 to 90 deg., Three Rail Crossings.
Plan 702—Angle 50 to 90 deg., Two Rail Crossings.
Plan 703—Angle 35 to 50 deg. minus, Three Rail Crossings.
Plan 704—Angle 35 to 50 deg. minus, Two Rail Crossings.
Plan 705—Angle 25 to 35 deg. minus, Two Rail Crossings with easers.
Plan 706—Angle 25 to 35 deg. minus, Two Rail Crossings without easers.

Manganese Steel Insert Crossings:

Plan 751—Designs and dimensions of manganese steel inserts for angles 45 deg. to 14 deg. 15 min., Details A.
Plan 752—Designs and dimensions of manganese steel inserts for angles 45 deg. to 14 deg. 15 min., Details B.
Plan 753—Designs and dimensions of manganese steel inserts for angles 14 deg. 15 min. to 8 deg. 10 min.
Plan 754—Typical crossings, angles 35 deg. to 45 deg., Details A, with continuous easers.

Plan 757—Typical crossings, angles 25 deg. to 35 deg., Details A, without easers.
Plan 762—Typical crossings, angles 35 deg. to 45 deg., Details B, with continuous easers.

The following plans for clamp frogs, submitted as information last year, have been re-examined and no corrections or changes found necessary. They are resubmitted without recommendations:

Plan 331—No. 6 Clamp Frog.
Plan 332—No. 7 Clamp Frog.
Plan 333—No. 8 Clamp Frog.
Plan 334—No. 10 Clamp Frog.
Plan 335—Detail of plates for Clamp Frogs.

The Committee has not reprinted the plans (Nos. 331-335, inclusive) for clamp frogs, as they have been published in Vol. 21 of the Proceedings for 1920. Reference is therefore made to these plans, included in the folder accompanying Vol. 21. Prints of these five plans will be available at the annual meeting for those interested.

Appendix C

(2-a) GAGES AND FLANGEWAYS FOR CURVED CROSSINGS

V. Angerer, *Chairman;*
G. J. Slibeck,
J. B. Strong,
Special Committee.

The Committee submits herewith a theoretical study of the subject as information, for criticism and comparison with results obtained in practice. Appended hereto are:

(1) A tabulation of the Gages and Flangeways for curved crossings specified by a number of railroads and the practice of some of the crossing builders in the absence of such specifications, together with a comparison with the gages for curves recommended by the 1915 Manual, page 117.

This tabulation suffices to show that there is no uniformity of practice and that the Manual is not followed.

(2) A set of tables and formulae, with an explanation attached, setting forth the various factors affecting the gage and flangeway required on different degrees of curvature and how the same may be determined mathematically for a given locomotive—some of the formulae are in a simplified form.

Report of a former Committee, on the subject, as per 1908 Proceedings, may be referred to for comparison.

(3) A set of tables (4 sheets) giving the gage on various degrees of curvature worked out for a number of the principal types of locomotives (not including the Mallet or Articulated types). The tables give the "Free Gage," being the calculated neat gage for rigid wheel base with all wheels set to standard wheel gage and without allowance for lateral motion. The tables also give the "Minimum Gage," with all allowances taken up for the lateral play provided at the journal boxes and for the closer setting of the outside drivers and the wheels bearing tight against both the running and guard rails, except for such flexibility as there may be in the frame of the locomotive. The gages are given in steps of ⅛ in. as being close enough for practical purposes. The limit of widened gage is taken at 4 ft. 9½ in. and no figures are carried above it. There will further be found in the tables the swing or lateral motion necessary on the front and rear trucks for the locomotive to operate over the degree of curve and free gage given.

An analysis of these tables leads to the following conclusions:

(1) Practically all locomotives will operate on curves of 6 deg. or less laid to standard gage of 4 ft. 8½ in. and standard width of flangeway of 1¾ in.

(2) Locomotives with not more than two pairs of flanged drivers will operate over all curves within the limits of the table on standard gage of 4 ft. 8½ in. and 1¾ in. flangeway.

(3) The operation of locomotives with trucks is limited by the swing or lateral motion of the trucks and such locomotives will not take a sharper curve than the maximum swing, provided for thereon, permits.

(4) For locomotives with three or more pairs of flanged drivers "Free Gage" should preferably be used and practical width of flangeway made = F. G.—4 ft. 6¾ in. Exact figures call for slightly wider flangeway in numerous cases, but the usual side play of the axles will compensate for the difference. Minimum gage would call for a distance of less than 4 ft. 6¾ in. between gage line and opposite guard line, and should not be used through curved crossings. A practical minimum gage may be made = F. G. — ½ (FG — MG) and flangeways made this practical minimum gage G — 4 ft. 6¾ in.

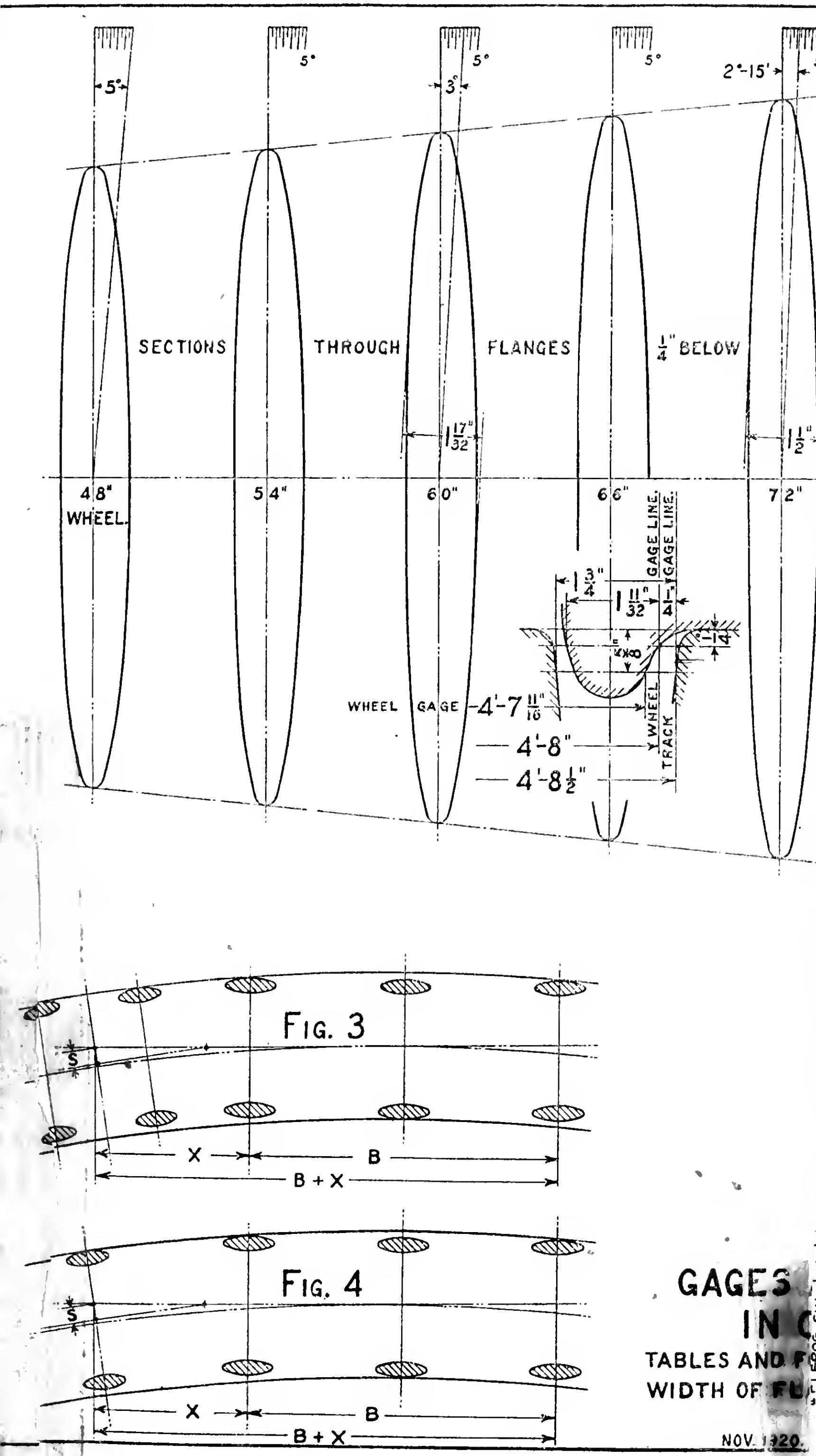
(5) Gage and flangeway thus determined for the locomotive giving the greatest values will satisfactorily admit the operation of locomotives and trucks calling for lesser values.

In specifications for locomotive the degree of the sharpest curve over which it is to operate is usually given and necessary provision is then made in side play, setting of wheels, lateral motion of trucks and sometimes special provision for floating axles are added if further required for the type under consideration.

Gages and flangeways for curved crossings should similarly be specified for the type of locomotive that is to be operated over the crossing and that requires the widest gage and flangeway, according to wheel base, number of flanged drivers and maximum degree of curve for which it is arranged. If such details are not available, but the types of locomotives operating over the crossing are known, the greatest value of gage and flangeway for such types and given curve may be used.

Where no definite information is available the rule for gage as per 1915 Manual with the flangeway made = G — 4 ft. 6¾ in. will admit most of the general types of locomotives with less than 10 drivers up to a 20-deg. curve, except where swing of trucks is insufficient. In locations where the operation is restricted to certain types of locomotives, the rule may give a wider gage than would be necessary.

The Committee recommends a reassignment of the subject for further study, practical tests and the working out of simplified concrete rules for actual practice.



GAGES ... IN C...

TABLES AND F... WIDTH OF FL...

NOV. 1920.

	FROG, SW. & MFG. CO.		A.R.E.A. P 117 1915 MANUAL
	4'-8½"	1¾"	4'-8½"
	4'-8½"	1¾"	4'-8½"
	4'-8½"	1¾"	4'-8½"
	4'-8½"	1¾"	4'-8½"
	4'-8½"	1¾"	4'-8½"
	4'-8½"	1¾"	4'-8½"
	4'-8½"	1¾"	4'-8½"
	4'-8½"	1¾"	4'-8½"
	4'-8½"	1¾"	4'-8⅝"
	4'-8½"	1¾"	4'-8⅝"
	4'-9"	2¼"	4'-8¾"
	4'-9"	2¼"	4'-8¾"
	4'-9"	2¼"	4'-8⅞"
	4'-9"	2¼"	4'-8⅞"
	4'-9"	2¼"	4'-9"
	4'-9"	2¼"	4'-9"
	4'-9"	2¼"	4'-9⅛"
	4'-9"	2¼"	4'-9⅛"
	4'-9"	2¼"	4'-9¼"
	4'-9"	2¼"	4'-9¼"
	4'-9"	2¼"	4'-9¼"

NO FLANGEWAY WIDTHS GIVEN.

(A)

O - TABLE

D & R	B = 7	8	9	11	13	15	17	19	21	23	25
5°=1146.28	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9/16	11/16	13/16
6°=955.37	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9/16	21/32	13/16	31/32
7°=819.02	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1 1/8
8°=716.78	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	15/16	1 1/8	1 5/16
9°=637.27	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1 1/32	1 1/4	1 15/32
10°=573.69	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	15/16	1 5/32	1 3/8	1 5/8
11°=521.67	[illegible]	[illegible]	[illegible]	[illegible]	15/32+	5/8+	13/16	1 1/32	1 1/4	1 1/2	1 25/32
12°=478.34	5/32	3/16+	1/4	3/8	17/32	11/16	29/32	1 1/8	1 3/8	1 21/32	2 1/16
13°=441.68	5/32+	7/32	9/32	13/32	9/16	3/4	1	1 7/32	1 1/2	1 25/32	2 1/8
14°=410.27	3/16	7/32+	9/32+	7/16	5/8	13/16	1 1/16	1 5/16	1 5/8	1 15/16	2 9/32
15°=383.06	3/16	1/4	5/16	15/32	21/32	7/8	1 1/8	1 13/32	1 23/32	2 1/16	2 7/16
16°=359.26	3/16+	1/4-	11/32	1/2	11/16	15/16	1 3/16	1 1/2	1 27/32	2 3/16	2 19/32
17°=338.27	7/32	9/32	11/32+	17/32	3/4	1	1 9/32	1 19/32	1 15/16	2 11/32	
18°=319.62	7/32+	5/16-	3/8	9/16	25/32+	1 1/16	1 11/32	1 11/16	2 1/16	2 1/2	
19°=302.94	1/4	5/16	13/32	19/32	13/16+	1 1/8	1 7/16	1 25/32	2 3/16	2 5/8	
20°=287.34	1/4+	11/32	7/16	5/8	7/8	1 3/16	1 1/2	1 7/8	2 5/16		
22°=262.04	9/32	3/8	15/32	11/16	31/32	1 9/32	1 21/32	2 1/16	2 17/32		
24°=240.49	5/16	13/32	1/2	3/4	1 1/16	1 13/32	1 13/16	2 1/4			
26°=222.27	5/16+	7/16	17/32+	13/16	1 1/8	1 1/2	1 15/16	2 7/16			
28°=206.68	11/32+	15/32	19/32	7/8	1 7/32	1 5/8	2 3/32	2 5/8			
30°=193.18	3/8	1/2	5/8	15/16	1 5/16	1 3/4	2 1/4	2 13/16			
33°=176.05	13/32+	17/32+	11/16	1 1/32	1 7/16	1 29/32	2 7/16				

F - TABLE.

A	WHEEL DIA 48"	54"	60"	66"	72"	78"	84"
0°-30'	1 11/32+	1 11/32+	1 11/32+	1 11/32+	1 11/32+	1 11/32+	1 11/32+
0°-45'	1 11/32+	1 11/32+	1 3/8-	1 3/8-	1 3/8	1 3/8	1 3/8+
1°-00'	1 11/32+	1 3/8-	1 3/8	1 3/8	1 3/8+	1 13/32	1 13/32
1°-15'	1 3/8	1 3/8+	1 3/8+	1 13/32	1 13/32	1 13/32+	1 13/32+
1°-30'	1 3/8+	1 13/32-	1 13/32	1 13/32+	1 13/32+	1 7/16	1 7/16
1°-45'	1 13/32	1 13/32	1 13/32+	1 13/32+	1 7/16	1 7/16	1 7/16+
2°-00'	1 7/16	1 7/16	1 7/16+	1 7/16+	1 15/32-	1 15/32	1 15/32+
2°-15'	1 7/16+	1 7/16+	1 15/32	1 15/32+	1 1/2	1 1/2	1 1/2+
2°-30'	1 15/32	1 15/32+	1 1/2	1 1/2+	1 17/32	1 17/32	1 17/32+
2°-45'	1 1/2	1 1/2+	1 17/32	1 17/32+	1 9/16	1 9/16+	1 19/32
3°-00'	1 17/32	1 17/32+	1 17/32+	1 9/16	1 9/16+	1 19/32	1 5/8

ABBREVIATIONS.

A	ANGLE OF FLANGE IN FLANGEWAY.
B	RIGID WHEEL-BASE (IN FEET).
C	DIST. BETW FLANGE & GAGE LINE.
D	DEGREE OF CURVE.
F	FLANGE ROOM FOR G_2.
G_2	NEAT GAGE - 2 FLANGED DRIVERS.
G_3	NEAT GAGE - 3 OR MORE FLANGED DRIVERS.
N	NEAT WIDTH OF FLANGEWAY FOR G_3.
O	MIDDLE ORDINATE OF CURVE IN B.
R	RADIUS OF CURVE (IN FEET).
S	1/2 OF TOTAL SWING OF TRUCK (IN FEET).
T	THICKNESS OF FLANGE 1/4" BELOW = 1 11/32".
W	WHEEL FLANGE DISTANCE 1/4" BELOW = 4'-8".
X	℄ OF PIN OF TRUCK TO RD. WH. BASE (IN FEET).

C - TABLE

A	WHEEL DIA. 48"	54"	60"	66"	72"	78"	84"
0°-30'						1/64	1/64
0°-45'				1/64	1/64	1/64+	1/64+
1°-00'	1/64	1/64	1/64+	1/64+	1/32-	1/32-	1/32-
1°-15'	1/64	1/64	1/32-	1/32-	1/32	1/32	1/32
1°-30'	1/64+	1/64+	1/32	1/32	1/32+	1/32+	1/32+
1°-45'	1/32-	1/32-	1/32+	1/32+	3/64-	3/64	1/16-
2°-00'	1/32	1/32	1/32+	3/64	3/64	1/16-	1/16
2°-15'	1/32+	1/32+	3/64	3/64+	3/64+	1/16-	1/16
2°-30'	3/64	3/64	3/64+	1/16-	1/16	1/16+	1/16+
2°-45'	1/16	1/16	1/16	5/64	5/64	3/32-	3/32
3°-00'	5/64	5/64	5/64+	3/32	3/32	1/8-	1/8-

FORMULAE

$A = .005 \times B \times D$ (RESULT IN DEGREES & DECIMALS OF A DEGREE)

$G_2 = (W + 2C) \times \cos A$ (SEE FIG. 1)

$N = O - C + F$ (FOR 3 FLANGED DRIVERS)

$N = \frac{8}{9} O - C + F$ (FOR 4 FLANGED DRIVERS)

$N = \frac{3}{4} O - C + F$ (FOR 5 DRIVERS, CENTRAL DRIVER BLIND)

$G_3 = W + N - T$ (SEE FIG. 2)

$S = \frac{(B + X) X}{2R}$ (SEE FIG'S 3 & 4)

G₂ - TABLE

A	WHEEL DIA. 48"	54"	60"	66"	72"	78"	84"
0°-30'				4'-8 1/64	4'-8 1/64	4'-8 1/32	4'-8 1/32
0°-45'	4'-8 1/64	4'-8 1/64	4'-8 1/64	4'-8 1/32	4'-8 1/32	4'-8 3/64	4'-8 3/64
1°-00'	4'-8 1/64	4'-8 1/64	4'-8 1/32	4'-8 1/32	4'-8 1/32	4'-8 3/64	4'-8 3/64
1°-15'	4'-8 1/64	4'-8 1/64	4'-8 1/32	4'-8 1/32	4'-8 3/64	4'-8 3/64	4'-8 3/64
1°-30'	4'-8 1/32	4'-8 1/32	4'-8 3/64	4'-8 3/64	4'-8 3/64	4'-8 1/16	4'-8 1/16
1°-45'	4'-8 1/32	4'-8 1/32	4'-8 3/64	4'-8 3/64	4'-8 1/16	4'-8 1/16	4'-8 1/16
2°-00'	4'-8 1/32	4'-8 1/32	4'-8 3/64	4'-8 1/16	4'-8 1/16	4'-8 5/64	4'-8 5/64
2°-15'	4'-8 1/32	4'-8 1/32	4'-8 3/64	4'-8 1/16	4'-8 1/16	4'-8 5/64	4'-8 5/64
2°-30'	4'-8 3/64	4'-8 3/64	4'-8 1/16	4'-8 5/64	4'-8 5/64	4'-8 3/32	4'-8 3/32
2°-45'	4'-8 3/64	4'-8 3/64	4'-8 1/16	4'-8 5/64	4'-8 3/32	4'-8 7/64	4'-8 7/64
3°-00'	4'-8 [illegible]	4'-8 [illegible]	4'-8 [illegible]	4'-8 3/32	4'-8 7/64	4'-8 7/64	4'-8 1/8

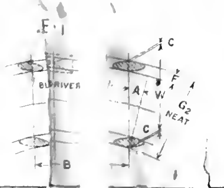


FIG. 1

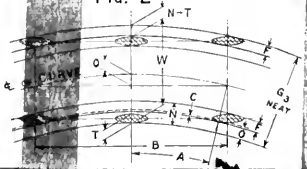
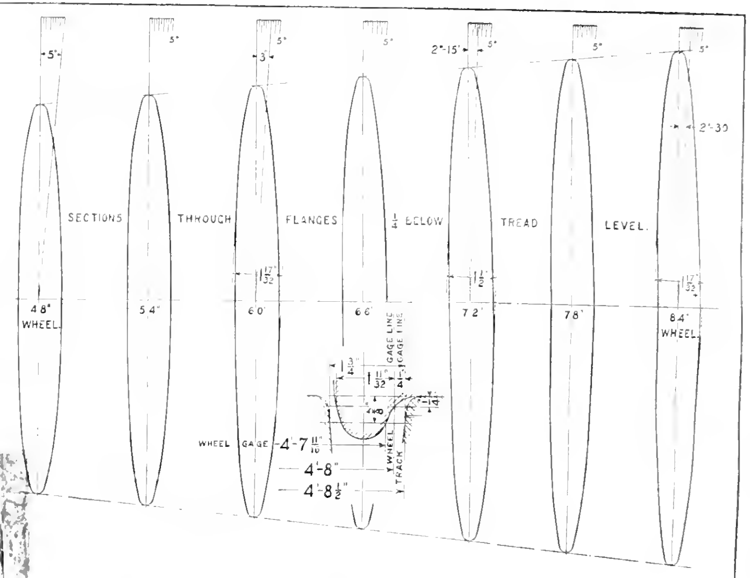


FIG. 2



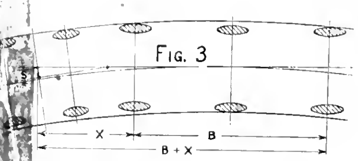


FIG. 3

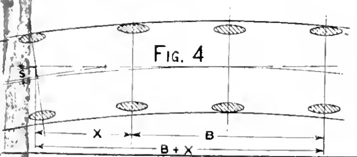


FIG. 4

GAGES AND FLANGEWAYS IN CURVED TRACK.

TABLES AND FORMULAE FOR NEAT GAGE AND WIDTH OF FLANGEWAY FOR RIGID WHEEL-BASE.

NOV

EXPLANATION

[illegible] and figures are taken at [illegible] below top of head of rail as the level where wheel flanges [illegible] contact with side of head of rail. To find the width of flangeway and gage of track for a given locomotive or truck figure angle A by formula. Example: wheel base B = 17'-0", curve 20°, A = [illegible] = 1.7 = 1° — 42'.

For locomotives with only 2 pairs of flanged drivers find F, minimum width of flangeway in F table from figured value of A. Minimum gage is found in G_2 table, figured by formula for G_2. For practical widths of flangeway, add for clearance and same amount to gage. If gage comes less than 4'-8½" increase to standard 4'-8½" and further increase flangeway by one-half of the difference, but to not less than 1¾". Sharper curves not covered by these tables require a wider flangeway.

For locomotives with 3 or more pairs of flange drivers find O, C, and F from tables and figure N = neat width of flangeway required, by formula. Figure neat gage by formula G-3. The usual lateral play allowed at journal boxes of locomotives will afford clearance for free operation on neat gage and neat flangeway. If gage figures less than 4'-8½" standard gage and standard 1¾" flangeway should be maintained.

For absolute minima without clearance from lateral play of journal boxes and close setting of front and rear drivers deduct from neat gage an amount = the full lateral play of one axle plus one-half the difference in the wheel setting of outside and middle drivers. Outside flangeway may be reduced by same amount and inside flangeway reduced by an amount = the lateral play minus one-half the difference in wheel settings. Any clearance desired in gage or flangeways must be added to these minima. The difference in level of gaging point (¼" below top of head) gives a slight initial clearance on rails with sloping sides of heads.

On locomotives with pilot trucks or rear trucks the trucks must have a swing or lateral motion equal to S as per formula; trucks without lateral motion may for practical purposes be considered the same as another pair of flanged drivers, but for strictly correct results would require a special formula.

GAGES & FLANGEWAYS FOR CROSSINGS.

SPECIFICATION OF SOME OF THE RAILROADS AND PRACTICE OF SOME OF THE CROSSING MAKERS IN THE ABSENCE OF SUCH SPECIFICATION.

NAME OF R.R. OR MANUFR.	TANG.	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°	15°	16°	17°	18°	19°	20°		25°			MAX.
B.&O. R.R.	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 3/4"	4'-8 3/4"	4'-8 3/4"	4'-8 3/4"	4'-8 3/4"	4'-9"														
	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 7/8"	1 7/8"	1 7/8"	1 7/8"	1 7/8"	2"														
ERIE R.R.	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 5/8"	4'-8 3/4"	4'-8 3/4"	4'-8 7/8"	4'-8 7/8"	4'-9"	4'-9"	4'-9"	4'-9 1/8"	4'-9 1/8"	4'-9 1/8"	4'-9 1/4"									4'-9 1/4"
	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 13/16"	1 7/8"	1 7/8"	1 15/16"	1 15/16"	2"	2"	2"	2 1/16"	2 1/16"	2 1/16"	2 1/8"									2 1/8"
GRAND TRUNK	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 5/8"	4'-8 5/8"	4'-8 3/4"	4'-8 3/4"	4'-8 7/8"	4'-8 7/8"	4'-9"	4'-9"	4'-9 1/8"	4'-9 1/8"	4'-9 1/4"	4'-9 1/4"					4'-9 1/4"
	1 7/8"	1 7/8"	1 7/8"	1 7/8"	1 7/8"	1 7/8"	1 7/8"	1 7/8"	1 7/8"	1 15/16"	1 15/16"	2"	2"	2 1/16"	2 1/16"	2 1/8"	2 1/8"	2 1/8"	2 1/8"	2 1/8"	2 1/8"					2 1/8"
I.C.R.R. CENTRAL OF GA. Y.&M.V.R.R.	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 5/8"	4'-8 5/8"	4'-8 3/4"	4'-8 3/4"	4'-8 7/8"	4'-8 7/8"	4'-9"	4'-9"	4'-9 1/8"	4'-9 1/8"	4'-9 1/4"	4'-9 1/4"					
	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 13/16"	1 13/16"	1 7/8"	1 7/8"	1 15/16"	1 15/16"	2"	2"	2 1/16"	2 1/16"	2 1/8"	2 1/8"					
D.T.&I. R.R.	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 5/8"	4'-8 3/4"	4'-8 3/4"	4'-8 7/8"	4'-8 7/8"	4'-9"	4'-9"	4'-9"	4'-9 1/8"	4'-9 1/8"	4'-9 1/8"	4'-9 1/4"									4'-9 1/4"
	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 13/16"	1 7/8"	1 7/8"	1 15/16"	1 15/16"	2"	2"	2"	2 1/16"	2 1/16"	2 1/16"	2 1/8"									2 1/8"
C.B.&Q. R.R.	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 3/4"	4'-8 3/4"	4'-8 3/4"	4'-8 3/4"	4'-8 3/4"	4'-9"	4'-9"	4'-9"	4'-9"	4'-9"	4'-9 1/4"	4'-9 1/4"	4'-9 1/4"	4'-9 1/4"	4'-9 1/4"	4'-9 1/2"					4'-9 1/2"
	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 7/8"	1 7/8"	1 7/8"	1 7/8"	1 7/8"	2"	2"	2"	2"	2"	2 1/8"	2 1/8"	2 1/8"	2 1/8"	2 1/8"	2 1/4"					2 1/4"
FRISCO ROCK ISLAND C.&E.I. R.R.	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 5/8"	4'-8 3/4"	4'-8 3/4"	4'-8 7/8"	4'-8 7/8"	4'-9"	4'-9"	4'-9"	4'-9 1/8"	4'-9 1/8"	4'-9 1/8"	4'-9 1/4"									4'-9 1/4"
	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 13/16"	1 7/8"	1 7/8"	1 15/16"	1 15/16"	2"	2"	2"	2 1/16"	2 1/16"	2 1/16"	2 1/8"									2 1/8"
MORDEN	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 3/4"	4'-8 3/4"	4'-8 3/4"	4'-8 7/8"	4'-8 7/8"	4'-8 7/8"	4'-9"	4'-9"	4'-9"	4'-9 1/8"	4'-9 1/8"	4'-9 1/8"	4'-9 1/4"				4'-9 1/2"			4'-9 1/2"
	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 7/8"	1 7/8"	1 7/8"	2"	2"	2"	2"	2"	2"	2 1/8"	2 1/8"	2 1/8"	2 1/4"	2 1/4"	2 1/4"		2 1/2"			2 1/2"
ELLIOT	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 5/8"	4'-8 5/8"	4'-8 3/4"	4'-8 3/4"	4'-8 7/8"	4'-8 7/8"	4'-9"	4'-9"	4'-9 1/8"	4'-9 1/8"	4'-9 1/4"	4'-9 1/4"					4'-9 1/4"
	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 13/16"	1 13/16"	1 7/8"	1 7/8"	1 15/16"	1 15/16"	2"	2"	2 1/16"	2 1/16"	2 1/8"	2 1/8"					
St. LOUIS FROG & SW.	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 5/8"	4'-8 3/4"	4'-8 3/4"	4'-8 7/8"	4'-8 7/8"	4'-9"	4'-9"	4'-9"	4'-9 1/8"	4'-9 1/8"	4'-9 1/8"	4'-9 1/4"									4'-9 1/4"
	1 7/8"	1 7/8"	1 7/8"	1 7/8"	1 7/8"	1 7/8"	1 15/16"	1 15/16"	2"	2"	2 1/16"	2 1/16"	2 1/16"	2 3/16"	2 3/16"	2 3/16"	2 1/4"									2 1/4"
BETHLEHEM	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 5/8"	4'-8 5/8"	4'-8 3/4"	4'-8 3/4"	4'-8 7/8"	4'-8 7/8"	4'-9"	4'-9"	4'-9 1/8"												
	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 7/8"	1 7/8"	2"	2"	2 1/8"	2 1/8"	2 1/4"	2 1/4"	2 3/8"												
C.F.&C. Co.	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 5/8"	4'-8 5/8"	4'-8 5/8"	4'-8 3/4"	4'-8 3/4"	4'-8 3/4"	4'-8 7/8"	4'-8 7/8"	4'-8 7/8"	4'-8 7/8"	4'-9"	4'-9"	4'-9"	4'-9"					
	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 7/8"	1 7/8"	1 7/8"	2"	2"	2"	2 1/8"	2 1/8"	2 1/8"	2 1/8"	2 1/4"	2 1/4"	2 1/4"	2 1/4"					
PETTIBONE MULLIKEN	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 5/8"	4'-8 5/8"	4'-8 3/4"	4'-8 3/4"	4'-8 7/8"	4'-8 7/8"	4'-9"	4'-9"	4'-9 1/8"	4'-9 1/8"	4'-9 1/4"	4'-9 1/4"	4'-9 1/4"	4'-9 1/4"	4'-9 1/4"					4'-9 1/4"
	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 7/8"	1 7/8"	2"	2"	2 1/8"	2 1/8"	2 1/4"	2 1/4"	2 3/8"	2 3/8"	2 1/2"	2 1/2"	2 1/2"	2 1/2"	2 1/2"					2 1/2"
AJAX	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 5/8"	4'-8 5/8"	4'-8 5/8"	4'-8 5/8"	4'-8 5/8"	4'-8 5/8"	4'-8 3/4"	4'-8 3/4"	4'-8 3/4"	4'-8 3/4"	4'-8 3/4"	4'-8 3/4"	4'-8 7/8"	4'-8 7/8"	4'-8 7/8"	4'-8 7/8"	4'-8 7/8"		4'-9"			4'-9 1/2"
	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 7/8"	1 7/8"	1 7/8"	1 7/8"	1 7/8"	1 7/8"	2"	2"	2"	2"	2"	2"	2 1/8"	2 1/8"	2 1/8"	2 1/8"	2 1/8"		2 1/4"			2 3/4"
RAMAPO.	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 3/4"	4'-8 3/4"	4'-8 3/4"	4'-8 3/4"	4'-9"	4'-9"	4'-9"	4'-9"	4'-9 1/4"	4'-9 1/4"	4'-9 1/4"	4'-9 1/4"	4'-9 1/4"					
	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 3/4"	2"	2"	2"	2"	2 1/4"	2 1/4"	2 1/4"	2 1/4"	2 1/2"	2 1/2"	2 1/2"	2 1/2"	2 1/2"					
FROG, SW. & MFG. Co.	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-9"	4'-9"	4'-9"	4'-9"	4'-9"	4'-9"	4'-9"	4'-9"	4'-9"	4'-9"					4'-9"
	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 3/4"	1 3/4"	2 1/4"	2 1/4"	2 1/4"	2 1/4"	2 1/4"	2 1/4"	2 1/4"	2 1/4"	2 1/4"	2 1/4"					2 1/4"
A.R.E.A. P117 1915 MANUAL	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 1/2"	4'-8 5/8"	4'-8 5/8"	4'-8 3/4"	4'-8 3/4"	4'-8 7/8"	4'-8 7/8"	4'-9"	4'-9"	4'-9 1/8"	4'-9 1/8"	4'-9 1/4"	4'-9 1/4"					4'-9 1/4"
				NO FLANGEWAY WIDTHS GIVEN.																						

THESE FAVOR WIDENING THE FLANGEWAY 1/2 AS MUCH AS THE GAGE IS WIDENED, AS ALSO DO WEIR FROG CO. AND KILBY FROG & SW. CO. (B.&O. R.R. through St. LOUIS FROG & SW.)

THESE FAVOR WIDENING THE FLANGEWAY THE SAME AMOUNT THE GAGE IS WIDENED (BETHLEHEM through FROG, SW. & MFG. Co.)

(A)

GAGES AND FLANGEWAYS IN CURVED TRACK.

TRACK GAGES FOR VARIOUS LOCOMOTIVES.

F. G. = FREE GAGE = NEAT GAGE, NOT CONSIDERING SETTING OF WHEELS NOR LATERAL PLAY OF AXLES.
M. G. = MIN. GAGE = NEAT GAGE, LESS ALLOWCE FOR SETT'G & LAT. PLAY.

1

TYPE	SWITCHERS.								FORNEY			COLUMBIA				MOGUL			PRAIRIE							
SYMBOL	0-4-0		0-6-0		0-8-0		0-10-0		0-4-2			2-4-2				2-6-0			2-6-2							
WHEEL DATA.	7' to 7'-3" ... B		11' to 11'-6" ... B		15'-0" ... B		19'-0" ... B		7'-0" ... B			7'-0" ... B				15'-2" ... B			11'-0" ... B				13'-4 1/2" ... B			
												7'-6" ... X				8'-10" ... X			8'-9" ... X				8'-4" ... X			
									9'-6" ... Xr			9'-6" ... Xr							9'-6" ... Xr				9'-0" ... Xr			
	46" to 50" ... Dr		51" to 57" ... Dr		51" ... Dr		51" ... Dr		50" ... Dr			50" ... Dr				63" ... Dr			63" ... Dr				69" ... Dr			
												DOUBLE ENDER.														
DEGREE & RAD.	M. G.	F. G.	M. G.	F. G.	M. G.	F. G.	M. G.	F. G.	M. G.	F. G.	S	M. G.	F. G.	S Fr	S Rr	M. G.	F. G.	S	M. G.	F. G.	S Fr	S Rr	M. G.	F. G.	S Fr	S Rr
33° = 176'.05		4'-8 1/2"	4'-9 1/8"	4'-9 1/4"						4'-8 1/2"	5 3/8"		4'-8 1/2"	3 5/8	5 3/8				4'-9"	4'-9 1/8"	5 7/8	6 5/8				
30° = 193'.18			4'-9"	4'-9 1/8"							4 7/8"			3 3/8"	4 7/8				4'-8 7/8	4'-9"	5 3/8	6"				
28° = 206'.68	ABBREVIA-		4'-9"	4'-9 1/8"							4 9/16			3 3/16	4 9/16				4'-8 3/4	4'-8 7/8	5"	5 11/16	4'-9 3/8	4'-9 1/2"	5 1/4	5 7/8
26° = 222'.27	TIONS.		4'-8 7/8	4'-9"	4'-9 1/4	4'-9 1/2"					4 1/4			2 15/16	4 1/4				4'-8 3/4	4'-8 7/8	4 11/16	5 1/4	4'-9 1/4	4'-9 3/8"	4 7/8	5 7/16
24° = 240'.49	B = Wh. Base		4'-8 3/4	4'-8 7/8	4'-9 1/8	4'-9 3/8					3 15/16			2 3/4	3 15/16	4'-9 3/8"	4'-9 1/2"	5 5/16	4'-8 5/8	4'-8 3/4	4 5/16	4 13/16	4'-9 1/8	4'-9 1/4"	4 9/16	5 1/16
22° = 262'.04	Dr = Driver		4'-8 3/4	4'-8 7/8	4'-9"	4'-9 1/4"					3 5/8			2 1/2	3 5/8	4'-9 1/4"	4'-9 3/8	4 7/8	4'-8 5/8"	4'-8 3/4	4"	4 1/4	4'-9"	4'-9 1/8"	4 3/16	4 5/8
20° = 287'.94	Fr = Front Tr.		4'-8 5/8	4'-8 3/4"	4'-8 7/8	4'-9 1/8"					3 5/16			2 1/4"	3 5/16	4'-9 1/8	4'-9 1/4"	4 1/2"	4'-8 1/2"	4'-8 5/8	3 5/8	4"	4'-8 7/8	4'-9"	3 13/16	4 1/4"
18° = 319'.62	Rr = Rear Tr.		4'-8 1/2"	4'-8 5/8	4'-8 3/4"	4'-9"					3"			2 1/16	3"	4'-9"	4'-9 1/8"	4"		4'-8 5/8	3 1/4	3 5/8	4'-8 3/4	4'-8 7/8"	3 7/16	3 13/16
16° = 359'.26	S = 1/2 Swing			4'-8 5/8	4'-8 5/8	4'-8 7/8	4'-9 1/4"	4'-9 1/2"			2 5/8			1 13/16	2 5/8	4'-8 7/8	4'-9"	3 9/16		4'-8 1/2"	2 15/16	3 1/4	4'-8 5/8	4'-8 3/4"	3 1/16	3 3/8
14° = 410'.27	of Truck.			4'-8 1/2"	4'-8 1/2"	4'-8 3/4"	4'-9 1/8	4'-9 3/8"			2 5/16			1 5/8	2 5/16	4'-8 3/4	4'-8 7/8	3 1/8"			2 9/16	2 3/4	4'-8 1/2"	4'-8 5/8"	2 11/16	2 15/16
12° = 478'.34	X = ℄ Fr. to B					4'-8 5/8	4'-8 7/8	4'-9 1/8"			2"			1 3/8"	2"	4'-8 5/8	4'-8 3/4"	2 5/8			2 3/16	2 3/8		4'-8 5/8"	2 1/4	2 9/16
10° = 573'.69	Xr = ℄ Rr to B					4'-8 1/2	4'-8 3/4	4'-9"			1 11/16			1 1/8"	1 11/16	4'-8 1/2"	4'-8 5/8	2 1/4			1 13/16	2"		4'-8 1/2"	1 7/8	2 1/8
8° = 716'.78							4'-8 1/2	4'-8 3/4"			1 5/16			15/16	1 5/16		4'-8 1/2	1 13/16			1 1/2"	1 5/8			1 9/16"	1 11/16"
6° = 955'.37		4'-8 1/2"						4'-8 5/8		4'-8 1/2"	1"		4'-8 1/2"	11/16"	1"			1 5/16			1 1/16"	1 1/4"			1 1/8"	1 1/4"

NOV. 1920.

TRACK GAGES FOR VARIOUS LOCOMOTIVES. 2

	CONSOLIDATION													MIKADO								DECAPOD								
SYMBOL	▲o OOOO													▲o OOOO o								▲o OOOOO								
	2-8-0													2-8-2								2-10-0								
WHEEL DATA	17'-0 1/2" B		14'-3" B		15'-6" to 16' B			16'-6" to 17' B			17'-0' B			17'-0 1/2" B				16'-6" to 16'-9" B				22'-8" B			20'-8" B			22'-0" B		
	8'-9" X		9'-1" X		8'-6" Aver. X			8'-10" Aver. X			10'-0" X			8'-10" X				9'-4" Aver. X				9'-6" X			9'-6" X			9'-1 1/2" X		
														10'-6" XR				9'-10" Aver. XR												
	62" DR		51" DR		56" to 57" DR			57" to 61" DR			55 1/2" to 57" DR			62" DR				61 1/2" to 64" DR				62" DR			57" DR			58" DR		
	2 C. Driv. Blind.													2 C. Driv. Blind								3-C. Dr. Blind			1st Driver Floating Axle.					
DEG.	F.G.	S	F.G.	S	M.G.	F.G.	S	M.G.	F.G.	S	M.G.	F.G.	S	M.G.	F.G.	S FR	S RR	M.G.	F.G.	S FR	S RR	M.G.	F.G.	S	M.G.	F.G.	S	M.G.	F.G.	S
33°																														
30°																														
28°																														
26°																														
24°					4'-9 1/4"	4'-9 1/2"	5 1/4"																							
22°	4'-8 1/2"	5 3/16"	4'-8 1/2"	4 7/8"	4'-9 1/8"	4'-9 3/8"	4 3/4"	4'-9 1/4"	4'-9 1/2"	5 1/4"	4'-9 1/4"	4'-9 1/2"	6 3/16"		4'-8 1/8"	5 1/4"	6 5/8"	4'-9 1/4"	4'-9 1/2"	5 9/16"	5 15/16"									
20°		4 3/4"		4 7/16"	4'-9"	4'-9 1/4"	4 3/8"	4'-9 1/8"	4'-9 3/8"	4 13/16"	4'-9 1/8"	4'-9 3/8"	5 11/16"			4 13/16"	6 1/16"	4'-9 1/8"	4'-9 3/8"	5 1/16"	5 7/16"									
18°		4 1/4"		4"	4'-8 7/8"	4'-9 1/8"	3 15/16"	4'-9"	4'-9 1/4"	4 5/16"	4'-9"	4'-9 1/4"	5 1/16"			4 5/16"	5 7/16"	4'-9"	4'-9 1/4"	4 9/16"	5 1/16"									
16°		3 3/4"		3 9/16"	4'-8 3/4"	4'-9"	3 1/2"	4'-8 7/8"	4'-9 1/8"	3 13/16"	4'-8 7/8"	4'-9 1/8"	4 1/2"			3 7/8"	4 11/16"	4'-8 7/8"	4'-9 1/8"	4 1/16"	4 3/8"		4'-8 1/2"	5 1/8"	4'-8 7/8"	4'-9 1/8"	7 7/16"	4'-9"	4'-9 1/4"	7 5/8"
14°		3 5/16"		3 1/8"	4'-8 5/8"	4'-8 7/8"	3 1/16"	4'-8 3/4"	4'-9"	3 3/8"	4'-8 3/4"	4'-9"	3 15/16"			3 3/8"	4 1/4"	4'-8 3/4"	4'-9"	3 9/16"	3 13/16"			4 1/2"	4'-8 3/4"	4'-9"	6 1/2"	4'-8 7/8"	4'-9 1/8"	6 3/4"
12°		2 13/16"		2 11/16"	4'-8 1/2"	4'-8 3/4"	2 5/8"	4'-8 5/8"	4'-8 7/8"	2 7/8"	4'-8 5/8"	4'-8 7/8"	3 3/8"			2 7/8"	3 5/8"	4'-8 5/8"	4'-8 7/8"	3 1/16"	3 1/4"			3 13/16"	4'-8 5/8"	4'-8 7/8"	5 1/2"	4'-8 3/4"	4'-9"	5 11/16"
10°		2 3/8"		2 1/4"		4'-8 5/8"	2 3/16"	4'-8 1/2"	4'-8 3/4"	2 7/16"	4'-8 1/2"	4'-8 3/4"	2 13/16"			2 3/8"	3 1/16"	4'-8 1/2"	4'-8 3/4"	2 9/16"	2 3/4"			3 3/16"	4'-8 1/2"	4'-8 3/4"	4 5/8"	4'-8 5/8"	4'-8 7/8"	4 3/4"
8°		1 7/8"		1 3/4"		4'-8 1/2"	1 3/4"		4'-8 5/8"	1 15/16"		4'-8 5/8"	2 1/4"			1 7/8"	2 7/16"		4'-8 5/8"	2"	2 3/16"			2 5/8"		4'-8 5/8"	3 3/4"	4'-8 1/2"	4'-8 3/4"	3 13/16"
6°	4'-8 1/2"	1 7/16"	4'-8 1/2"	1 5/16"			1 5/16"		4'-8 1/2"	1 7/16"		4'-8 1/2"	1 11/16"		4'-8 1/2"	1 7/16"	1 13/16"		4'-8 1/2"	1 1/2"	1 5/8"		4'-8 1/2"	1 15/16"		4'-8 1/2"	2 13/16"		4'-8 5/8"	2 13/16"

NOV. 1920

TRACK GAGES FOR VARIOUS LOCOMOTIVES.

3

Symbol	Santa Fe				American	Atlantic		
	▲o OOOOO o				▲ooOO	▲ooOO o		
	2-10-2				4-4-0	4-4-2		
Wheel Data	20'-9" to 21' ... B	22' to 22'-6" ... B	22'-2" ... B	22'-6" ... B	8'-6" to 9' ... B	7'-0" ... B	7'-0" ... B	7'-5" ... B
	9'-6" Aver. ... X	9'-6" Aver. ... X	10'-2 1/2" ... X	8'-11" ... X	12'-6" Aver. ... X	11'-0" ... X	7'-10" ... X	8'-5" ... X
	9'-6" Aver. ... X_R	9'-6" Aver. ... X_R	9'-7" ... X_R	10'-0" ... X_R		9'-6" ... X_R	9'-11" ... X_R	10'-6" ... X_R
	58" to 60" ... D_R	63" to 64" ... D_R	62" ... D_R	63" ... D_R	69" ... D_R	73" ... D_R	73" ... D_R	80" ... D_R
	Center Driver Blind			1st D. Float. Axle				

Deg.	M.G.	F.G.	S Fr	S Rr	M.G.	F.G.	S Fr	S Rr	M.G.	F.G.	S Fr	S Rr	M.G.	F.G.	S Fr	S Rr	M.G.	F.G.	S	M.G.	F.G.	S Fr	S Rr	M.G.	F.G.	S Fr	S Rr	M.G.	F.G.	S Fr	S Rr
33°																									4'-8 1/2"	3 15/16	5 3/4		4'-8 1/2"	4 9/16	6 7/16
30°																										3 5/8	5 1/8			4 1/8	5 7/8
28°									1&5 Drivers																	3 3/8	4 7/8			3 7/8	5 1/2
26°									Floating Axle												4'-8 1/2"	5 3/8	4 1/4			3 1/8	4 9/16			3 5/8	5 1/16
24°																						4 15/16	3 15/16			2 7/8	4 3/16			3 5/16	4 11/16
22°										4'-8 1/2"	9 3/4	9 1/16						4'-8 1/2"	6 1/8			4 1/2	3 5/8			2 11/16	3 7/8			3 1/16	4 5/16
20°											8 7/8	8 1/4							5 5/8			4 1/8	3 5/16			2 7/16	3 1/2			2 13/16	3 15/16
18°											7 15/16	7 7/16	4'-9 1/4	4'-9 1/2	5 5/16	6 1/8			5 1/16			3 3/4	2 15/16			2 3/16	3 1/8			2 1/2	3 9/16
16°	4'-9 1/4	4'-9 1/2	4 7/8	4 7/8							7 1/8	6 5/8	4'-9"	4'-9 1/4	4 11/16	5 7/16			4 3/8			3 5/16	2 5/8			1 15/16	2 13/16			2 1/4	3 3/16
14°	4'-9"	4'-9 1/4	4 1/4	4 1/4	4'-9 1/4	4'-9 1/2	4 3/8	4 3/8			6 3/16	5 13/16	4'-8 7/8	4'-9 1/8	4 1/8	4 3/4			3 13/16			2 7/8	2 5/16			1 11/16	2 1/2			1 15/16	2 3/4
12°	4'-8 7/8	4'-9 1/8	3 5/8	3 5/8	4'-9"	4'-9 1/4	3 3/4	3 3/4			5 5/16	4 15/16	4'-8 3/4	4'-9"	3 1/2	4 1/16			3 3/8			2 1/2	2"			1 7/16	2 1/8			1 11/16	2 3/8
10°	4'-8 3/4	4'-9"	3 1/16	3 1/16	4'-8 7/8	4'-9 1/8	3 1/8	3 1/8			4 7/16	4 1/8	4'-8 5/8	4'-8 7/8	2 15/16	3 3/8			2 13/16			2 1/16	1 5/8			1 3/16	1 3/8			1 3/8	2"
8°	4'-8 1/2	4'-8 3/4	2 7/16	2 7/16	4'-8 5/8	4'-8 7/8	2 1/2	2 1/2			3 9/16	3 5/16	4'-8 1/2	4'-8 3/4	2 3/8	2 3/4			2 1/4			1 11/16	1 5/16			1"	1 3/8			1 1/8	1 9/16
6°		4'-8 1/2	1 13/16	1 13/16	4'-8 1/2	4'-8 3/4	1 7/8	1 7/8		4'-8 1/2	2 11/16	2 1/2		4'-8 5/8	1 3/4	2 1/2		4'-8 1/2	1 11/16		4'-8 1/2	1 1/4	1"		4'-8 1/2	3/4	1 1/16		4'-8 1/2	7/8	1 3/16

NOV. 1920.

TRACK GAGES FOR VARIOUS LOCOMOTIVES. 4

	10 WHEEL						PACIFIC							
Symbol	◢o o OOO						◢o o OOO o							
	4-6-0						4-6-2							
Wheel Data	15'-0" ... B			15'-6" ... B			13'-8" to 14'-0" ... B				13'-10" ... B			
	11'-1" ... X			8'-7" ... X			8'-4" aver. ... X				8'-5" ... X			
							10'-0" aver. ... Xr				10'-6" ... Xr			
	68" to 69" ... Dr			69" ... Dr			73" to 80" ... Dr				80" ... Dr			
											C. Driver Blind.			
Deg.	M.G.	F.G.	S	M.G.	F.G.	S	M.G.	F.G.	S Fr	S Rr	M.G.	F.G.	S Fr	S Rr
33°														
30°														
28°														
26°							4'-9 3/8"	4'-9 1/2"	5 1/8"	6 1/2"		4'-8 1/2"	5 1/8"	6 15/16"
24°	4'-9 3/8"	4'-9 1/2"	7 3/16"				4'-9 1/4"	4'-9 3/8"	4 11/16"	6"			4"	6 3/8"
22°	4'-9 1/4"	4'-9 3/8"	6 5/8"	4'-9 3/8"	4'-9 1/2"	4 3/4"	4'-9 1/8"	4'-9 1/4"	4 5/16"	5 1/2"			4 5/16"	5 7/8"
20°	4'-9 1/8"	4'-9 1/4"	6"	4'-9 1/4"	4'-9 3/8"	4 5/16"	4'-9"	4'-9 1/8"	3 7/8"	5"			3 7/8"	5 5/8"
18°	4'-9"	4'-9 1/8"	5 7/16"	4'-9 1/8"	4'-9 1/4"	3 7/8"	4'-8 7/8"	4'-9"	3 1/2"	4 1/2"			3 1/2"	4 13/16"
16°	4'-8 7/8"	4'-9"	4 13/16"	4'-9"	4'-9 1/8"	3 1/2"	4'-8 3/4"	4'-8 7/8"	3 1/8"	4"			3 1/8"	4 5/16"
14°	4'-8 3/4"	4'-8 7/8"	4 1/4"	4'-8 7/8"	4'-9"	3 1/16"	4'-8 5/8"	4'-8 3/4"	2 11/16"	3 1/2"			2 11/16"	3 3/4"
12°	4'-8 5/8"	4'-8 3/4"	3 5/8"	4'-8 3/4"	4'-8 7/8"	2 5/8"	4'-8 1/2"	4'-8 5/8"	2 5/16"	3"			2 5/16"	3 3/16"
10°	4'-8 1/2"	4'-8 5/8"	3"	4'-8 5/8"	4'-8 3/4"	2 3/16"		4'-8 1/2"	1 15/16"	2 1/2"			1 15/16"	2 11/16"
8°		4'-8 1/2"	2 7/16"	4'-8 1/2"	4'-8 5/8"	1 3/4"			1 9/16"	2"			1 9/16"	2 1/8"
6°			1 13/16"		4'-8 1/2"	1 5/16"			1 3/16"	1 1/2"		4'-8 1/2"	1 3/16"	1 5/8"

	BALTIC				12 WHEEL			MOUNTAIN							
Symbol	◢o o OOO o o				◢o o OOOO			◢o o OOOO o							
	4-6-4				4-8-0			4-8-2							
Wheel Data	15'-8" ... B				16'-0" ... B			18'-0" ... B				18'-9" ... B			
	7'-3" ... X				7'-8 1/2" ... X			8'-0" ... X				8'-5" ... X			
	10'-2" ... Xr							9'-6" ... Xr				9'-9" ... Xr			
	63" ... Dr				56" ... Dr			69" ... Dr				70" ... Dr			
					2nd Dr. Blind.										
Deg.	M.G.	F.G.	S Fr	S Rr	M.G.	F.G.	S	M.G.	F.G.	S Fr	S Rr	M.G.	F.G.	S Fr	S Rr
33°															
30°															
28°															
26°															
24°					4'-9 1/4"	4'-9 1/2"	5 3/16"								
22°	4'-9 3/8"	4'-9 1/2"	3 13/16"	6"	4'-9 1/8"	4'-9 3/8"	4 3/4"								
20°	4'-9 1/4"	4'-9 3/8"	3 1/2"	5 7/16"	4'-9"	4'-9 1/4"	4 5/16"	4'-9 1/4"	4'-9 1/2"	4 3/8"	5 1/2"				
18°	4'-9 1/8"	4'-9 1/4"	3 1/8"	4 7/8"	4'-8 7/8"	4'-9 1/8"	3 15/16"	4'-9 1/8"	4'-9 3/8"	3 15/16"	4 15/16"	4'-9 1/4"	4'-9 1/2"	4 5/16"	5 3/16"
16°	4'-9"	4'-9 1/8"	2 11/16"	4 1/4"	4'-8 3/4"	4'-9"	3 7/16"	4'-9"	4'-9 1/4"	3 1/2"	4 3/8"	4'-9 1/8"	4'-9 3/8"	3 13/16"	4 5/8"
14°	4'-8 7/8"	4'-9"	2 7/16"	3 13/16"	4'-8 5/8"	4'-8 7/8"	3"	4'-8 7/8"	4'-9 1/8"	3 1/16"	3 13/16"	4'-9"	4'-9 1/4"	3 5/16"	4 1/16"
12°	4'-8 3/4"	4'-8 7/8"	2 1/16"	3 1/4"	4'-8 1/2"	4'-8 3/4"	2 5/8"	4'-8 3/4"	4'-9"	2 5/8"	3 5/16"	4'-8 7/8"	4'-9 1/8"	2 7/8"	3 1/2"
10°	4'-8 5/8"	4'-8 3/4"	1 3/4"	2 11/16"		4'-8 5/8"	2 3/16"	4'-8 1/2"	4'-8 3/4"	2 3/16"	2 3/4"	4'-8 3/4"	4'-9"	2 3/8"	2 15/16"
8°	4'-8 1/2"	4'-8 5/8"	1 9/16"	2 1/8"		4'-8 1/2"	1 3/4"		4'-8 5/8"	1 1/4"	2 3/16"	4'-8 1/2"	4'-8 3/4"	1 15/16"	2 5/16"
6°		4'-8 1/2"	1 3/16"	1 5/8"			1 5/16"		4'-8 1/2"	1 5/16"	1 5/8"		4'-8 5/8"	1 7/16"	1 3/4"

NOV. 1920.

Appendix D

(7) PLANS AND SPECIFICATIONS FOR SWITCH STANDS, SWITCH LAMPS AND SWITCH LOCKS

J. De N. Macomb, *Chairman;*
W. P. Wiltsee,
J. V. Neubert,
L. B. Allen,
V. Angerer,
H. T. Porter,
J. H. Reinholdt,
G. J. Slibeck,
J. B. Strong,
J. R. Watt,

Sub-Committee.

In Appendix A, Item III, are given the Committee's recommendations for Requisites for Switch Stands, including Connecting Rods.

Plans of switch targets have been prepared covering sufficient shapes and sizes to meet various operating requirements. It is found that at present there are in service a large variety of dimensions of the same shape or style, the dimensions varying in some cases by only a fraction of an inch, each set of dimensions requiring individual dies. The Committee desires to hear from the Committee on Signals and Interlocking before submitting these plans, and desires a conference.

It is found that at present there are in service lamp tips of a large variety of dimensions, varying in many cases by only a small fraction of an inch, each set of dimensions requiring individual patterns or dies. As one detail of lamp tip could not be proposed to meet all conditions, a plan has been prepared offering a sufficient variety of styles to meet various operating requirements. Before submitting this plan the Committee wishes to get an expression from the Committee on Signals and Interlocking. A conference with the Committee on Signals and Interlocking is desired.

The subjects of switch lamps and switch locks are being investigated, and the Committee's report is not ready for presentation.

Appendix E

(8) PLANS AND SPECIFICATIONS FOR TIE PLATES, DERAILERS AND ANTI-CREEPERS

H. T. PORTER, *Chairman;*
W. P. WILTSEE,
H. G. CLARK,
E. A. HADLEY,
F. L. NICHOLSON,
R. M. PEARCE,
J. H. REINHOLDT,
J. R. WATT,

Sub-Committee.

The Committee submits the following Progress Report and suggested specifications on Tie Plates to invite criticism or suggestions.

The reports made by the Special Committee on Stresses in Track by the American Society of Civil Engineers and the American Railway Engineering Association indicate that the angles of force acting outward, approximately 10 deg., cut the plane of the base at a point outside of the center line of rail for a distance as shown for the following sections:

Rail Section		*Base, In.*	*Height, In.*	*Intersection of Angle of Force Outside of Center of Base, In.*
75 lb.		5	5	3/8
80 lb.		5	5	3/8
85 lb.	ASCE	5 3/16	5 3/16	24/64
90 lb.	ARA-A	5 1/8	5 5/8	1/2
100 lb.	ARA-A	5 1/2	6	9/16
100 lb.	ARA-B	5 9/16	5 41/64	1/2
100 lb.	PS	5	5 11/16	13/32
105 lb.		5 1/2	6	9/16
125 lb.		5 1/2	6 1/2	15/16
130 lb.		5 1/2	6 5/8	43/64

These results are deductions from observations of a Mikado locomotive drifting at various speeds. It is more than probable that working under steam, these results would be increased somewhat, but in the absence of more definite information consider them useful for comparison with tie plates in use whose dimensions are based on judgment and experience.

The above results indicate and experience proves the following. First, that the canting of the rail outward results in the imbedding of the outside edge of plate in the tie producing wide gage, and, second, that the imbedding of the tie plate in the tie results in mechanical destruction of tie with the assistance of moisture causing decay.

Therefore, to properly take care of this angle of force it will be necessary to make the center of tie plate coincide with the point where the angle of force cuts the base of rail. As a matter of fact, this angle should be computed to the bottom of the tie plate in place of base of rail.

For purpose of comparison we give on an attached sheet a tabulation showing the relation between that portion of tie plate which is inside base of rail toward the center line of track and the portion outside of base toward end of tie, as now exists in the standard tie plates of the reporting railroads classified as to weight of rail used.

While the attached table representing a comparison between the standards of twenty-nine railroads indicates considerable variation, your attention is called particularly to cases of the New York Central Railroad and Illinois Central Railroad, where the actual and calculated figures correspond very closely, while the balance vary from a maximum of ⅝ in. to a minimum of 5/16 in.; the actual in all cases being less than the theoretical.

Width—The tie plate should be as wide as the face of the tie at least up to 8 in.

Thickness—Since the thickness of the plate will depend upon the length and the wheel load it must be thick enough to resist buckling. It is therefore our opinion that tie plates should be from ½ in. to ¾ in. thick.

Height of Shoulder—The height of shoulder should be not less than ¼ in. or more than ⅜ in.

Location of Spike Holes—It is thought that two spike holes on each side of rail seat spaced equidistant 1½ in. each side of center line parallel with tie will be sufficient with the idea that where ties happen to be less than 7 in. the spikes will be effective as near to center of tie as possible. A hole may be punched on center line of plate at each end when desired.

Size of Holes—¾ in. holes are recommended for ⅝ in. spikes and 13/16 in. for 11/16 in. spikes.

Top of Plate—It is thought that a slight convex upper surface in plate at right angles to tie will be beneficial in preventing ties from "rocking" and reduce noise due to suction where spikes are loose, especially with the lighter sections of rail, where rail deflection is greatest.

Bottom of Plates—(Under consideration.)

General—Plates for several sections of rail should be designed for the heaviest type of rail, especially as to length; but as a general proposition recommend that a standard plate be used with only those sections of rail having approximately the same width of base.

A copy of tentative specifications for High Carbon Steel Tie Plates has been submitted to thirty-four railroads and to various manufacturers of tie plates. From the replies received from the railroads reporting it was found that four were either using or considering the use of these plates; thirteen have not considered their use, while two do not approve of them. From replies received from five manufacturers who are in a position to roll high carbon steel plates one approved the specifications; one pointed out the difficulties of manufacture, while three offered suggestions.

From all the suggestions offered the following specifications have been drawn up and are submitted:

SPECIFICATIONS FOR HIGH CARBON OPEN-HEARTH STEEL TIE PLATES

(I) Materials

Process.

1. Steel shall be made by the Open-Hearth process.

1-b. Cold steel accumulated in the form of ingots, billets or rolled shapes which meet chemical requirements may be used.

(II) Chemical Requirements

Chemical Composition.

2. Steel shall conform to the following requirements as to chemical composition.

Carbon not less than .50 nor more than	.80
Phosphorus not more than	.05

Ladle Analysis.

3. An analysis of each melt of steel shall be made by the manufacturer to determine the percentage of carbon, manganese, phosphorus and sulphur. This analysis shall be made from drillings taken at least ⅛ in. 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.

Ladle analysis of cold steel correctly identified by melt number may be taken from the mill record.

Check Analysis.

4. Analysis may be made by the purchaser from a finished tie plate representing each melt of steel. The carbon content thus determined shall conform to the requirements specified in Section 2, and the phosphorus content shall not exceed that specified in Section 2 by more than 25 per cent.

(III) Physical Requirements

Bend Tests.

5. The finished tie plate shall bend cold through 90 deg. around a pin, the diameter of which is equal to twice the thickness of the plate, without cracking on the outside of the bent portion.

One bend test may be required from each lot of one thousand tie plates.

Tie plates that fail to meet this test may be annealed and retested.

(IV) Design

Plan.

6. The tie plates shall conform to the drawings submitted to the manufacturer, with the following permissible variations:

Tolerance.

7. (A) For plates with shoulders parallel to the direction of rolling a variation of 1/32 in. in thickness, 1/8 in. in rolled width and 3/16 in. in sheared length will be permitted.

(B) For plates with shoulders perpendicular to the direction of rolling a variation of 1/32 in. in thickness, 1/8 in. in rolled width and 1/4 in. 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 1/4 in. and from the face of shoulder to the inside end not more than 1/2 in.

(V) Manufacture

Workmanship.

8. 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.

9. The plates shall be punched, slotted and sheared hot at a temperature which will give the best results, and immediately thereafter placed in a metal box for gradual cooling from the initial heat.

Finish.

10. The finished tie plates shall be free from burrs and other surface deformations caused by the shearing and punching; they shall also be free from other injurious defects and shall have a workmanlike finish.

Marking.

11. The name or brand of the manufacture, the section and the year of manufacture shall be rolled in raised letters and figures near the inside end of the plates, and a portion of this marking shall appear on each finished tie plate, unless otherwise specified.

(VI) Inspection

Inspection.

12. 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 work 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 tie plates are being furnished in accordance with these specifications. All tests (except check analysis) 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.

Rejection.

13. (A) Unless otherwise specified, any rejection based on check analysis (Article II, Section 4) shall be reported within five working days from the receipt of samples.

(B) Tie plates which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing.

14. Samples tested in accordance with Section 4 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.

(VII) Shipment or Delivery

Packing.

15. Tie plates shall be wired together in bundles of uniform number, weighing not to exceed 100 lb., unless otherwise specified.

Name of Railroad	Miles Represented	Rail Section	Wt. per Yard, Lbs.	Width of Base Inches	Height of Rail Inches	Trade Name	Inside Projection	Outside Projection	Difference Between Inside and Outside, In.	 Distance A
hesapeake & Ohio	2,534	PS	130	5 1/2	6 5/8	....	1 3/4	2 1/4	1/2	43/64
essemer & Lake Erie	204	PS	130	5 1/2	6 5/8	....	2 1/8	3 1/8	1	43/64
. R. R. of N. J	684	....	135	6	6 1/2	....	1 11/16	2 13/16	1 1/8	41/64
enn'a Lines East	10,604	PS	125	5 1/2	6 1/2	....	2 5/8	3 1/8	1/2	41/64
ichigan Central	1,862	Dudley	105	5 1/2	6	....	1 7/8	2 1/2	5/8	9/16
. L. & W	981	....	105	5 1/2	6	....	2 1/4	3	3/4	9/16
ew York Central	5,675	....	105	5 1/2	6	....	1 1/2	2 9/16	11/16	9/16
lev., Cinn., Chi. & St. L	2,409	....	105	5 1/2	6	....	1 5/8	2 3/8	3/4	9/16
enn'a Lines East	......	PS	100	5 1/2	6	....	2 5/8	3 1/8	1/2	9/16
rand Trunk	4,785	ARA-A	100	5 1/2	6	Lundie	2 3/16	3 3/16	1	9/16
ouisville & Nashville	5,041	ARA-A	100	5 1/2	6	Herringbone	1 3/4	2 1/2	3/4	9/16
rie	2,259	ARA-A	100	5 1/2	6	Sellers	1 9/16	2 1/16	1/2	9/16
linois Central	6,136	ARA-A	100	5 1/2	6	Sellers	1 1/2	2 3/4	1 1/4	9/16
hicago, R. I. & Pacific	8,055	ARA-A	100	5 1/2	6	....	1 3/8	2 1/8	3/4	9/16
. R. R. of N. J	684	ARA-A	100	5 1/2	6	....	2 1/4	2 13/16	9/16	9/16
lissouri Pacific	7,300	ARA-A	100	5 1/2	6	RRS	1 1/2	2	1/2	9/16
anadian Pacific	13,338	RE	100	5 5/32	....	Lundie	1 5/8	2 7/8	1 1/4	1/2
orfolk & Western	2,203	ARA-B	100	5 9/64	5 41/64	....	1 13/16	2 1/2	11/16	1/2
hicago & Northwestern	8,090	ARA-B	100	5 9/64	5 41/64	Sellers	1 7/8	2 1/4	3/8	1/2
hesapeake & Ohio	......	ARA-B	100	5 9/64	5 41/64	....	1 38/64	2 17/64	43/64	1/2
essemer & Lake Erie	......	ARA-B	100	5 9/64	5 41/64	....	2 5/8	3 1/8	1/2	1/2
. & L. E.	225	ARA-B	100	5 9/64	5 41/64	....	2 55/128	2 55/128	0	1/2
outhern Pacific	7,106	ARA-A	90	5 1/8	5 5/8	....	2 47/64	2 1/2	4/16	1/2
enver & Rio Grande	2,605	ARA-A	90	5 1/8	5 5/8	....	1 1/2	1 7/8	3/8	1/2
rie	......	ARA-A	90	5 1/8	5 5/8	....	1 15/16	2 1/16	1/8	1/2
orthern Pacific	6,642	ARA-A	90	5 1/8	5 5/8	....	2 1/64	2 7/32	13/64	1/2
reat Northern	8,256	ARA-A	90	5 1/8	5 5/8	....	1 3/4	2 1/4	1/2	1/2
hicago, R. I. & Pacific	......	ARA-A	90	5 1/8	5 5/8	....	1 3/4	2 1/8	3/8	1/2
ouisville & Nashville	......	ARA-B	90	4 49/64	5 17/64	Herringbone	2 27/64	2 13/16	25/64	27/64
	......	....	......	......	......	....	......	......	......	......
. & L. E	......	ASCE	90	5 3/8	5 3/8	....	2 17/32	3 1/32	1/2	28/64
. R. R. of N. J	......	ASCE	90	5 3/8	5 3/8	....	1 11/16	2	5/16	28/64
t. Louis-San Francisco	5,257	ASCE	90	5 3/8	5 3/8	RRS	1 17/32	2 1/8	19/32	28/64
. T. & S. F	6,258	ASCE	85	5 3/16	5 3/16	....	1 11/16	2 1/8	7/16	13/32
outhern	8,520	ASCE	85	5 3/16	5 3/16	....	1 7/16	1 3/4	5/16	13/32
tlantic Coast Line	4,555	ASCE	85	5 3/16	5 3/16	....	1 1/2	1 13/16	5/16	13/32
tlantic Coast Line	......	ASCE	85	5 3/16	5 3/16	....	2	2 9/16	9/16	13/32
eaboard Air Line	3,563	....	75	5	5	....	1 1/2	2	1/2	25/64
t. Louis-San Francisco	5,257	ASCE	75	4 13/16	4 13/16	RRS	2 3/32	2 1/8	1/32	11/32
orfolk & Western	......	PS	130	5 1/2	6 5/8	....	2 3/16	3 5/16	1 1/8	43/64
ew York, N. H. & H	1,996	ARA-A	100	5 1/2	6 1/2	....	2 11/32	3 11/32	1	9/16
ere Marquette	2,247	ARA-A	90	5 1/8	5 5/8	....	1 7/8	2 1/4	3/8	1/2

Computed Difference Between Inside and Outside, In.	Length Plate Inches	Width Plate Inches	Thickness Plate Inches	No. Holes for Spikes	Size of Holes Inches	Tie Plate Bottom						Tie Plate Top			
						Flat	Ribs Parallel to Tie	Ribs Parallel to Rail	Undulated	Diagonal	Channeled	Flat	Canted	Cambered	Channeled
1 11/32	9 1/2	6	3/4	4	3/4		4 Yes					Yes			
1 11/32	10 3/4	7	3/4	6	3/4	Yes						Yes			
1 9/32	10 1/2	7 1/2	5/8	4	3/4						Yes	Yes			
1 9/32	10 3/4	7	11/16	4	3/4	Yes						Yes			
1 1/8	10	7	3/4	4	3/4					Yes			Yes	Yes	
1 1/8	10 5/8	7	3/4	5	0=31/32	Yes						Yes			
1 1/8	9 1/2	7	5/8	4	3/4		2 Yes					Yes			
1 1/8	9 1/2	6 1/2	5/8	4	3/4			2 Yes						Yes	
1 1/8	10 3/4	7	11/16	4	3/4	Yes						Yes			
1 1/8	{ 10 3/4 10 1/2 }	7	......	4	11/16				Yes				Yes	Yes	
1 1/8	10	7 1/2	9/16	4	11/16x3/4					Yes		Yes	Yes		
1 1/8	9	7	7/16	4	11/16x13/16					Yes		Yes			
1 1/8	9 3/4	7 1/2	9/16	4	11/16					Yes				Yes	
1 1/8	9	7	1/2	4	11/16			Yes						Yes	Yes
1 1/8	10 1/2	7 1/2	5/8	4	3/4						Yes	Yes			
1 1/8	9	7	3/4	No in	formation				Yes					Yes	
1	{ 10 1/2 10 1/2	6 7	} .6875	4	3/4				Yes				Yes	Yes	
1	.....	.....	.....	4	3/4		4 Yes						Yes		
1	9 1/4	7	1/2	4	11/16			8 Yes				Yes			
1	9	6	1/2	4	3/4		4 Yes					Yes			
1	10 3/4	7	3/4	6	3/4	Yes						Yes			
1	10	6 1/2	1/2	4	3/4			3 Yes				Yes	Yes		
1	10	9 1/2	.....	4	11/16	Yes						Yes			Yes
1	8 1/2	6	1/4	4	11/16		4 Yes					Yes			
1	9	7	7/16	4	11/16x13/16					Yes		Yes			
1	9	7	1/2	4	11/16x21/32			4 Yes				Yes	Yes		
1	9	7	7/16	4	11/16			4 Yes				Yes	Yes		
1	9	7 1/2	1/2	4	11/16			2 Yes				Yes			Yes
27/32	10	7 1/2	9/16	4	11/16x3/4		2 Yes			Yes		Yes	Yes		
.....	.....	.....	.....	.....	D—7/8							Yes			Yes
28/32	11	6 1/2	5/8	4	3/4										
28/32	9	6	1/2	4	3/4						Yes	Yes			
28/32	9	7	1/2	4	5/8			2 Yes	Yes			Yes			
13/16	9	7 1/2	7/16	4	11/16			2 Yes				Yes			
13/16	8 3/4	6	1/2	3	3/4	Yes						Yes			
13/16	8 1/2	6	1/2	4	5/8		4 Yes					Yes			
13/16	9 3/4	7	1/2	4	11/16		4 Yes							Yes	
25/32	8 1/2	6 1/2	5/8	4	11/16		4 Yes					Yes			
11/16	9	7	1/2	4	5/8			2 Yes	Yes			Yes			
1 11/32	11	7	3/4	4	3/4		Yes						Yes		
1 1/8	10 1/2	7 1/2	3/4	4	3/4			2 Yes					Yes		
1	9 1/4	6	9/16	3	11/16		4 Yes						Sligh	tly	

Appendix F

(9) SPECIFICATIONS AND PIECE WORK SCHEDULES FOR CONTRACTING TRACK MAINTENANCE WORK

E. T. Howson, *Chairman;*
W. P. Wiltsee,
L. B. Allen,
W. G. Arn,
H. G. Clark,
J. B. Jenkins,
H. A. Lloyd,
Sub-Committee.

Owing to the abnormal conditions under which maintenance of way work has been conducted during the past year, your Committee has been unable to find that any considerable amount of maintenance of way work has been handled under contract or piece work schedules.

The standard track work system which was in effect on the Baltimore & Ohio Railroad and the Pennsylvania Railroad prior to Federal control, and which had as one of its essentials the establishment of unit performance or piece work schedules was abandoned by the Railroad Administration and has not been re-established.

While many roads resorted to the cost-plus form of contract in handling maintenance work during the last year, this plan was in effect little more than the recognition of the contractor as a labor agent, the work being done as heretofore under the immediate direction and supervision of the regular railway officers. As such, it was not considered that this was the form of contract work which the Board of Direction had in mind when assigning this subject to the Track Committee. The Committee is, therefore, only able to report progress.

REPORT COMMITTEE I—ROADWAY

J. R. W. Ambrose, *Chairman;*
E. J. Bayer,
C. W. Brown,
H. W. Brown,
C. C. Cunningham,
W. C. Curd,
W. M. Dawley,
Paul Didier,
S. B. Fisher,
R. D. Garner,
J. A. Lahmer,
J. G. Little,
J. A. Spielmann, *Vice-Chairman;*
H. W. McLeod,
C. M. McVay,
W. H. Penfield,
P. Petri,
J. W. Pfau,
Frank Ringer,
R. B. Robinson,
R. A. Rutledge,
H. E. Tyrrell,
C. E. Weaver,
W. H. Woodbury,

Committee.

To the American Railway Engineering Association:

The following subjects were assigned the Committee on Roadway for study and report:

1. Make thorough examination of subject-matter in the Manual and submit definite recommendations for changes.

2. Make final report, if practicable, on methods of determining extent, character and effect of subsidence under embankments.

3. Make a final report, if practicable, on shrinkage of embankments, selecting a number of specific instances, reciting all the conditions, such as locality, weather, foundations, character of filling material, height of fill, method of construction, etc., to be used as a guide in estimating shrinkage.

4. Report on the use of corrugated metal culverts in railway work and prepare specifications for material and workmanship.

5. Report on sealing bad cracks in rock cuts with cement gun.

6. Report on the effect of standing water in borrow pits upon the stability of embankments.

7. Report on drainage of long cuts.

Committee Meetings

Meetings were held in Chicago, May 19th; Pittsburgh, September 24th, and Toronto, November 11th.

The names of the members who attended these meetings have been given in the Minutes, forwarded to the Secretary for printing in the Bulletin.

(1) Revision of the Manual

Sub-Committee—J. G. Little, *Chairman;* J. A. Spielmann, R. D. Garner, W. M. Dawley.

The proposed changes and additions to the Manual are given in Appendix A.

(2-3) Subsidence and Shrinkage

Sub-Committee—C. M. McVay, *Chairman;* H. W. Brown, C. C. Cunningham, Paul Didier, W. H. Woodbury.

The report and recommendations of this Committee are given in Appendix B.

(4) Metal Culverts

Sub-Committee—W. H. Penfield, *Chairman;* H. W. McLeod, J. A. Lahmer, R. D. Garner.

The findings of this Committee are given in Appendix C.

(5) Sealing of Cracks by Cement Gun

Sub-Committee—C. W. Brown, *Chairman;* S. B. Fisher, P. Petri, J. A. Spielmann, J. W. Pfau.

This Committee reports progress, as shown in Appendix D.

(6) Standing Water in Borrow Pits

Sub-Committee—W. C. Curd, *Chairman;* R. A. Rutledge, H. E. Tyrrell, C. E. Weaver, E. J. Bayer.

A progress statement is given in Appendix E.

(7) Drainage of Long Cuts

Sub-Committee—R. B. Robinson, *Chairman;* H. W. Brown, Frank Ringer, C. C. Cunningham, W. C. Curd.

The report and conclusions of this Committee will be found in Appendix F.

CONCLUSIONS

Your Committee recommends that the findings and conclusions of the Sub-Committees on Subjects 1, 2, 3 and 7 be adopted and placed in the Manual, and those on 4, 5 and 6 be accepted as information only and incorporated in the Proceedings.

Respectfully submitted,

THE COMMITTEE ON ROADWAY,

J. R. W. AMBROSE, *Chairman.*

Appendix A

(1) REVISION OF MANUAL

J. G. LITTLE, *Chairman*, Sub-Committee

Present Form	*Proposed Form*
BERME	BERM
SUBSIDENCE	SUB SI'DENCE
SHRINKAGE—The contraction of material.	SHRINKAGE (noun) — The term Shrinkage as applied to grading material is the difference in volume between the material excavated and the ultimate volume of the same material in the embankment after it has reached a state of equilibrium; negative Shrinkage is known as Swell.
	SETTLEMENT (noun) — The term Settlement as applied to grading material is the reduction in height of an embankment caused by shrinkage or subsidence.
Allowance for shrinkage in embankments (page 38).	Delete.

Appendix B

(2-3) SUBSIDENCE AND SHRINKAGE OF EMBANKMENTS

C. M. McVay, *Chairman*, Sub-Committee

Subsidence.

In June the Committee sent out a questionnaire to about seventy-five representatives of as many roads, from which much information was received; unfortunately, however, only a small portion of it could be applied to the subject in question.

1. *Subsidence.*—Subsidence occurs principally and to the greatest extent in marshes, swamps, bogs and wet lands, the reason obviously being that the natural ground will not sustain the combined embankment, track and loads.

In many cases the yardage below the original natural surface of the ground was found to be several times the quantity of that above it. In preliminary work there is no fixed rule for determining what amount of subsidence will occur. The Engineer locating a new or additional line through bogs, swamps, marshes, etc., would do well to make allowance for considerable subsidence. In some cases, before building, soundings have been taken with a view to locating the hard surface under swamps, bogs, etc., and allowance made for the fill to subside to that level. This is not always possible, however, and it sometimes happens that this hard surface will break under the weight and subsidence continue indefinitely.

It was found that subsidence to some extent will invariably occur under embankments built through ordinary grazing or agricultural land. This applies to the greater percentage of embankments as most of the land in the country comes under this class. This is due to the loose formation of the upper crust of the ground, which has not the bond, weight or density of the lower beds due to the roots of grass and other vegetation, plowing and the action of frost keeping the bond continually broken up. The percentage of subsidence will be much greater on the small fills by reason of the smaller area of the base and the tamping action of trains. On the larger and higher fills the base is spread over a much greater area and the tamping action is not so pronounced at the base, consequently the subsidence is proportionately less.

There are three methods of determining the extent of subsidence, viz.:

(1) Trenching.
(2) Bar or auger borings.
(3) Wash borings.

These methods are described in the 1920 report of the Proceedings of this Committee, Vol. 21, pages 820 to 822.

The Committee would like to call attention to the good results secured in determining the extent of subsidence on small fills by means of a slotted and pointed bar, which, when driven to the bottom of a fill and turned leaves in the slot a specimen of the material at that point. For convenience of handling an extension may be put on the bar. This method, however, would not be practical on fills of over ten (10) feet. Great care should be taken in recording the measurements of the different depths. A plan of the grooved point sounding rod referred to is attached as Exhibit A.

Exhibit A

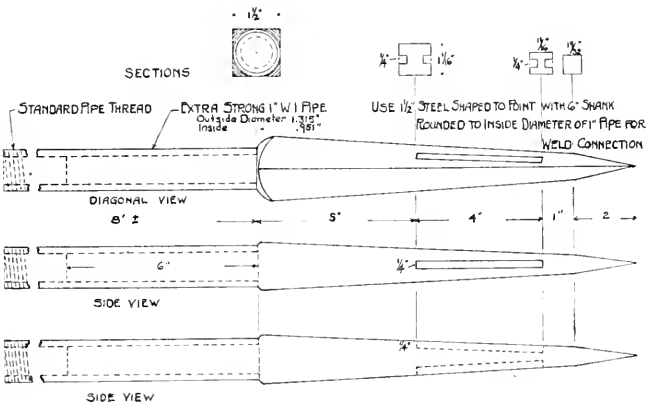


Fig. 1—Grooved Point Sounding Rod.

Trenching is the most accurate method of determining subsidence. It is not, however, always practicable or possible to trench, in which case, the boring methods must be used. Wash borings are more or less inaccurate and should be used with care. Several roads report they are unable to get any real results from their use, the holes filling with soupy, muddy water and the dividing lines of the strata impossible to determine. Dry borings protected by casing, if necessary, have given good results when proper care has been taken in making and recording same. In determining the extent of subsidence, care should also be taken in locating the line of the natural surface at the toe of the embankment. On account of the earth often sliding or washing down and spreading out at the toe, a very gentle slope is left, which can easily be mistaken for the natural surface.

Subsidence occurs in two distinct ways. By compression and by displacement. On ordinary land the upper strata of earth being weakly bonded will tamp and compress, permitting the fill to subside. This will also occur in shallow swamps, such as muskeg, or where water standing on the ground will lessen its bearing power. Subsidence from this cause, as a rule, is not serious from an operating standpoint as it will cease after the strata of soft material immediately under the fill is sufficiently compressed or tamped. Great and serious subsidence is caused by displacement. In deep, bottomless bogs and swamps, the embankment often continues to subside, displacing large quantities at the sides and requiring constant attention to prevent the interruption of traffic. In some such cases embankments have been known to reach a state of equilibrium without having reached a solid bottom, but this has taken a considerable time. Others are still subsiding after many remedies have been tried, and it seems probable will continue to do so indefinitely.

The effect of subsidence is to lower the base of the fill, causing a corresponding shrinkage of the track structure, involving heavy maintenance charges, and in some cases so large as to justify the abandonment and relocation of the line.

Conclusions

Some subsidence occurs under all embankments built on any ground except rock. It is very light in sand and gravel. The percentage of subsidence is greater under small fills than under larger ones.

Subsidence is due to compression or displacement of the strata of earth under the embankment.

Subsidence must always be anticipated in swamps, marshes and bogs, and any land on which there is standing water.

Serious subsidence is local and it is impossible to fix any rule as a guide in estimating or anticipating same.

Shrinkage.—The question has been raised as to whether shrinkage actually exists. It is felt by the Committee that the existence of shrinkage is proven by every ditch or sewer line and every post hole. Every observant person knows that material excavated for a sewer when placed back in the trench after the laying of the pipe even if it be ridged up on top, will, in a short time, pack and settle so as to leave a depression, showing the earth excavated to occupy less space than before the bond was broken. In fencing it will be noticed that the dirt excavated will not fill the hole up even after the post has been placed in it.

The Chicago, Burlington & Quincy, Duluth Missabe & Northern and Duluth & Iron Range have made shrinkage tests by the density method, which may be briefly described as follows: Samples are taken from various points in embankments with an iron or steel cylinder of known cubical capacity, care being taken to neither compress nor expand the material. The same thing was done in adjacent excavation when it was quite certain that the embankment was built from this excavation. These samples were taken to the laboratory where they were weighed and placed in a dry, warm or hot place. When samples were quite dry they were again weighed. The differences in weight is taken as measurement of change in volume. For this method in detail, see Railway Age Gazette, issue of June 4th, 1920, page 1573. Photographs showing apparatus and method of taking samples are attached as Exhibit "B" to this report.

FIG. 2.

Apparatus and tools used in obtaining samples.

FIG. 3.

Sample cutting cylinder with driving cap in initial position on top of rough unmolested projection left extending up from bottom of pit.

Fig. 4.

Cylinder completely covering sample. Driving cap removed and protruding earth being sawed off to true surface with top of cylinder. View in excavation.

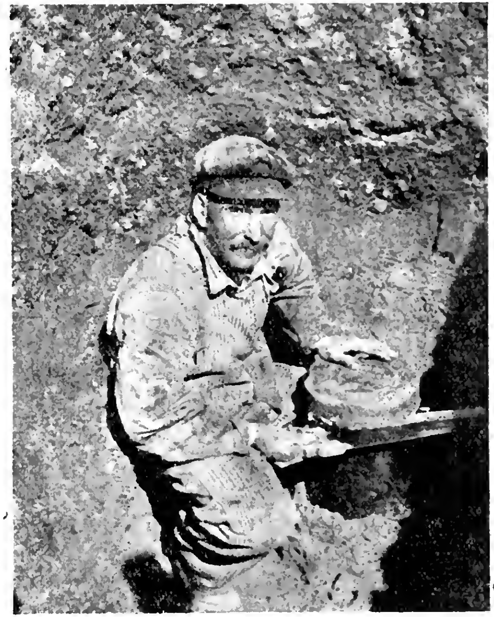


Fig. 5.

Same action as in Fig. 4. View in embankment. Note depth and irregular bottom surface of ballast.

FIG. 6.

Sample completely capped. Shovels being inserted in earth projection preparatory to breaking projection loose and inserting.

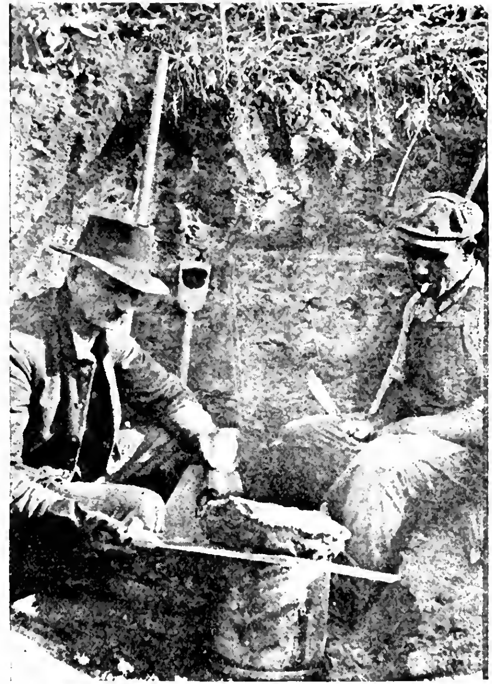


FIG. 7.

Sample and attached projection after inserting. Protruding earth being sawed off to true surface with cutting edge of cylinder. Sample complete in cylinder when this operation is finished.

The results obtained indicate that the experiments should be carried on more extensively. Some remarkable ideas are developed, such as that the shrinkage of material is proportional to its weight, and weight depends on the depth in the natural bed. These subjects are capable of great and interesting development. From the results as obtained by this method it would seem the net shrinkage (making no allowance for subsidence) of common earth, would average close to 9.5 per cent. and as 10 per cent. is the commonly used allowance this would show it to be approximately correct. It is recommended that further experiments be made and the profession be given the benefit of the results. The experiments prove that shrinkage does exist.

Shrinkage is composed of four elements:

(a) Wastage due to loss in hauling material from cut or pit to embankment. This is usually very small and may be neglected.

(b) Wastage due to wind erosion. This is an element which varies with the climate and nature of material. The exact percentages are practically impossible of determination.

(c) Wastage due to water erosion. This is a large factor and very difficult of exact determination, except where large washouts have occurred. It varies with climate, but often is quite as large in dry climates, which have sudden freshets, as in wet climates where there is an almost continuous water erosion.

(d) Compression, which is by far the most important cause of shrinkage. The condition of the material in its natural bed is usually the result of sedimentation in water and generally the particles are not compactly assembled, but are slightly cemented and thus have a temper that may be very hard to break up. Heavy plowing, picks or even blasting may be required to make it workable. After this cementaceous bond is broken up the particles will settle together much more compactly, particularly if mechanical means are used to compact them, such as the trampling and rolling caused by teams, wagons, slip or wheel scrapers and later by the pounding of locomotives and cars. Water tamping will produce a similar compacting to a large extent. This water tamping is sometimes artificially applied, but usually rains furnish the water, and the railway traffic, during both wet and dry weather, brings about a combination of water and mechanical tamping. The result is a very great shrinkage.

There is considerable confusion in the use of the terms shrink and settle. For instance, the following is a common statement. "Fills built by teams and scrapers will shrink very little while fills built by dumping from trestle settle enormously." Investigation shows that this is in error, as the fills constructed by dumping from trestle will sometimes take years to be water and train tamped to their ultimate compactness. Two fills, one built by each of these methods from identical material will finally show very little difference. The only way shrinkage can be definitely determined is by comparison with the excavation quantities.

Settlement, as used herein, may include three elements, which are shrinkage, subsidence, and a reduction in height and volume that is neither. Settlement is the decrease in height or volume or both, of an embankment or the bed of a cut from the moment of construction, until it becomes stable. Settlement may cover a change from a volume, which is larger than that found in excavation, to a volume that eventually is less. It may be a reduction from a swelled volume to the original volume as found in excavation. From this point, settlement would also be shrinkage, if the volume decreases. Subsidence is an element of settlement and may be defined as the result of a downward movement of embankment or ballast material below the natural surface line. Subsidence causes a compression downward or a displacement horizontally of the underlying material. It may be either under embankments or in cuts. Settlement may occur without there being either shrinkage or subsidence, but there can be no shrinkage or subsidence, as herein defined, without settlement.

From the information received by the Committee, it is found that an allowance of 10 per cent. for shrinkage of earth is almost universal and is generally very nearly correct. In practically all cases this is assumed to also cover the slight subsidence which will occur in arable land or glacial drift. Every problem has certain local aspects and it would always be well to determine what has happened locally in the way of shrinkage and subsidence if very accurate results are desired. In common practice, however, when grading with earth, a 10 per cent. shrinkage allowance is recommended. When the harder substances, such as rock or shale, are encountered a negative shrinkage or swell is found. Reliable data received by the Committee shows that in many cases of work of this nature the swell has been from 2 or 3 per cent. to 60 and 70 per cent.

The method of handling as well as the material will have a bearing on the swell of this material. Rock and shale will be found to vary considerably in different parts of the country. No rule is found that can be generally applied. The method of handling and shooting must be considered in anticipating swell. Local formations and conditions will govern to a great extent in this class of work.

It is estimated that approximately 90 per cent. of the grading quantities in this country would be classed as earth or common excavation. Rock and shale work, therefore, would constitute only approximately 10 per cent. of the quantities.

As stated previously by this Committee, it is not recommended that the height of fills be raised to allow for shrinkage, but that the additional width be put on the shoulder, Proceedings, Vol. 18, page 662. This is due to anticipated settlement not always occurring, especially in fills built by teams and scrapers. Quite a number of roads, however, are following the practice of building fills by dumping from trestle on fills ten (10) feet and more high, constructing the trestle one foot above the grade to allow for settlement. This, of course, cannot be done if the location of bridges interferes, but seems to work out well generally.

Conclusions

(1) Figure a shrinkage of 10 per cent. on earth removed from excavation to embankment.

(2) Ascertain local conditions and results and use them as a guide in estimating swell of rock, considering nature of formation and method of handling.

(3) The Committee recommends that the conclusions on both shrinkage and subsidence be printed in the Manual and that the subjects be closed for the present.

Appendix C

(4) CORRUGATED METAL CULVERTS

W. H. PENFIELD, *Chairman,* Sub-Committee

Corrugated metal culverts can be used to advantage on new construction work where the cost of haul for concrete, cast iron, or timber culverts would be excessive; also for waterways under highway approaches at grade crossings when the cost complete for corrugated pipe is less than for concrete or cast iron pipe.

They will give the best results when the top of the pipe is placed not less than three feet and not more than ten feet below sub-grade. They should not be used in sizes with a diameter in excess of forty-eight inches.

Care should be used in preparing foundation on which to place corrugated pipe culverts. The foundations must be of good firm material, and never of made ground or embankment if it can be avoided. A sufficient amount of camber should be provided in longitudinal bed for the pipe to insure its not settling under the center of embankment to such an extent as to permit a depression in which water and silt will collect and remain.

Before the construction of embankment over corrugated pipe culvert is begun, selected earth or filling material must be carefully placed, and thoroughly tamped and packed above and around the pipe to a height of at least three feet above the top of pipe and ten feet each way horizontally from it. This to prevent unequal pressure and distortion of the pipe when it receives the weight of the embankment; otherwise, the pipe will be flattened and its vertical diameter lessened and its horizontal diameter increased.

Corrugated pipes must be of greater diameter than required for concrete or cast iron pipes, as the corrugated surface retards the flow when pipes are discharging under head.

Concrete or cast iron pipes cannot be successfully drawn through corrugated iron pipe culverts for renewing them in the manner that timber culverts are frequently renewed, as the distortion in the corrugated pipes will make this difficult or impossible, and it is usually necessary to dig out corrugated iron pipes when making renewals.

Wichita Falls & Northwestern Railway—329 Miles
Located in Southwestern Oklahoma

GALVANIZED CORRUGATED IRON CULVERT PIPE LAID DURING CONSTRUCTION—STILL IN SERVICE—ALL NO. 18 GAGE

From Notes of I. C. C. Structural Survey, July, 1920.

	Year Installed					
Diameter	1906	1907	1909	1910	1911	*Totals*
12 in.			6	3	11	20
16 in.				2		2
18 in.			13	57	24	94
20 in.				7		7
24 in.		2	11	113	122	248
26 in.				1	2	3
30 in.	1	1	4	20	11	37
36 in.	2	4	1	56	85	148
42 in.				1	32	33
48 in.	1	4		10	29	44
Number.........	4	11	35	270	316	636
Length.........	136	444	1,178	10,055	14,846	25,659—5 1/10 Miles.

Under inspection 13 of these culvert pipes show a flattening and bending at middle of about 6 in., 17 show 2 or 3 in., due apparently to soft ground and subsidence. This flattening is about 5 per cent. of the number, 3 1/3 per cent. of the length. There were no failures of material. Apparently the life of these culverts will be 30 or 40 years. On the Trinity District, in Southeast Texas, there are 35 of these culverts; total length 882 ft., 2 in. to 36 in. in diameter, 17 of them 24 in., which have recently been put in during maintenance.

SPECIFICATIONS FOR CORRUGATED METAL CULVERTS

All corrugated metal pipe shall be of first quality, of true circular form, and shall be of such lengths as are specified in the order. The pipe shall be true and straight throughout its entire length, and free from all imperfections.

Construction.

1. Culverts may be either (1) full circle riveted, or (2) sectional nestable construction, and each section of the culvert shall be of the same kind, quality and gage of metal throughout.

All full-circle riveted culverts shall be lap-joint construction. They shall be straight and true to form, tightly riveted, and of first-class workmanship.

All sectional nestable culverts shall be constructed of upper and lower sections, admitting of each section nesting one within the other in a compact manner for knock-down shipment, and of their being joined together when set up by the use of bolts or clamps in a mechanical, practical, strong, and permanent manner.

Material.

2. The metal used in the construction of corrugated culverts shall be guaranteed by the manufacturers to conform to the following chemical requirements.

Sulphur	Not more than 0.04 per cent.
Phosphorus	Not more than 0.015 per cent.
Total of carbon, sulphur, phosphorus, manganese and silicon	Not more than 0.25 per cent.
Copper	Optional.

NOTE.—The above is subject to the customary leeway for chemical error of 0.04 per cent. plus or minus.

Galvanizing.

3. The galvanizing shall consist of not less than two (2) ounces of prime spelter per square foot of sheet uniformly distributed over the surface of the sheets of metal. It shall be applied in such a manner that the spelter will not peel off during fabrication, or in transporting or laying the pipe. Any uncoated spots, due to poor workmanship, rough handling, or any other reason, shall be sufficient cause for rejecting the pipe.

Defects in the Sheets.

4. Sheets must be thoroughly free from all scales, cracks and other defects in the underlying metal. Sheets must also be free from spots, holes, unevenness or blisters in the coating of zinc spelter. All sheets must classify as prime quality in shape, in uniformity of thickness, and in uniformity of zinc coating.

Gage of Metal.

5. The standard of gage shall be the United States Standard Gage.

(a) All culverts of a diameter from 12 in. to 20 in., inclusive, shall be made from No. 16 gage material.

(b) All culverts of a diameter from 24 in. to 36 in., inclusive, shall be made from No. 14 gage material.

(c) All culverts of a diameter of 42 in. and 48 in., inclusive, shall be made from No. 12 gage material.

(d) All culverts of a diameter of 60 in. shall be made of No. 10 gage material.

Corrugations.

6. The corrugations shall be not more than two and one-half (2½) inches, center to center, and not less than one-half (½) inch in depth.

Joints.

7. (a) Longitudinal laps shall be not less than 2 inches in 12-inch to 24-inch culverts, inclusive, and 3 inches on 30-inch to 60-inch culverts, inclusive.

(b) Circumferential laps shall be not less than one full corrugation; that is, a lap of not less than 2½ inches on all culverts.

Rivets and Riveting.

8. All rivets, bolts or clamps shall be of the same material as specified for the culverts, or of such other material as may be approved. Rivets shall be thoroughly galvanized, and shall have the following dimensions:

No. 16 gage material— $\frac{5}{16}$ in. diameter x $\frac{5}{8}$ in. long.							
No. 14	"	"	—(Two thicknesses of sheets)—				$\frac{5}{16}$ x $\frac{5}{8}$ in.
No. 14	"	"	—(Three	"	"	")	— $\frac{5}{16}$ x $\frac{5}{8}$ in.
No. 12	"	"	—(Two	"	"	")	— $\frac{3}{8}$ x $\frac{3}{4}$ in.
No. 12	"	"	—(Three	"	"	")	— $\frac{3}{8}$ x $\frac{7}{8}$ in.
No. 10	"	"	—(Two	"	"	")	— $\frac{3}{8}$ x $\frac{7}{8}$ in.
No. 10	"	"	—(Three	"	"	")	— $\frac{3}{8}$ x 1 in.

All rivets shall be driven cold in such a manner that the plates shall be drawn tightly together throughout the width of the seam. No rivet shall be closer than twice its diameter from the edge of the metal. All rivets shall have neat, workmanlike, and full hemispherical heads; shall be driven without bending; and must fully fill the hole. Circumferential shop riveted seams shall have a maximum rivet spacing of eight (8) inches, and shall lap at least one full corrugation.

Coupling Bands.

9. Coupling bands shall be made of the same material as the culvert and shall be not less than eight (8) inches wide on culverts of diameters up to and including 36 inches, and 12 inches on diameters 36 to 60 inches inclusive.

Such coupling bands shall be connected at the ends by angles or straps of malleable castings, or by corrugated flanges turned directly on and integral with the body of the joining band and having a cross-section at least equal to 1 in. x $\frac{1}{4}$ in., and fastened by galvanized bolts not less than $\frac{3}{8}$ inch in diameter, and there shall be not less than two bolts on each side of the joining band.

Inspection.

10. At any and all times, during working hours, a representative of the purchaser shall have the right to enter and inspect the work in progress; to take test samples of the material being used for the manufacture of culverts, whether from material in stock or in the process of manufacture; and the manufacturer is to afford the representative of the purchaser all reasonable facilities for making such inspections or securing samples. The culvert pipes furnished shall be subject to tests by a representative of the purchaser, and if the material and workmanship do not comply with the above specifications, they shall be rejected.

Conclusions

The Committee feel that they have not had time to exhaust the subject and recommend that it be referred back to them for next year's work, and that the present report be accepted as information.

Appendix D

(5) SEALING BAD CRACKS IN ROCK CUTS WITH CEMENT GUN

C. W. Brown, *Chairman,* Sub-Committee.

In 1914 the New York Central Railroad used a cement gun in their Spuyten Duyvil Cut on their main line, about 10 miles north of Grand Central Terminal, New York City. This is probably the most extensive work of this sort yet attempted. The cut was 500 feet long with sides 80 and 50 feet high respectively, the Third Rail System furnishing the power for operating the air compressors. The first operation was to remove the small loose stones and dirt from the crevices by air, before using the cement, and it was thought advisable in some places to use anchor bolts one inch in diameter in order to insure holding up some of the larger rock, the mixture of one to three parts cement and sand was then used. This work was done in 1914 and 1915, was inspected by a member of this Committee in June, 1920, and found to continue satisfactorily.

An article describing the work done on this Cut appeared in the Railway Age Gazette, April 21, 1916.

A cement gun was used in 1915 to further prevent the spalling of rock in the main drainage channel of the sanitary district of Chicago; the Engineering World of June, 1920, has an article describing this work, with accompanying photographs.

In 1914 the Lehigh & New England Railroad at Lansford, Pa., used the cement gun in the roof of a tunnel, part of which was lined with brick, the balance not lined. Some of the brick had fallen out; others had become loose; the rock in the unlined portion frequently fell to the track, but after treatment with cement gun the condition was corrected. There are several streams of water emptying on to the track from the roof of this tunnel, which the manufacturers of the cement gun claim can be sealed up. This work will be attempted by the Lehigh and New England Railroad this winter.

The Cement Gun is a patented machine for sale by the manufacturer, without royalty or rental. The cement gun is run by compressed air, and may be purchased with or without air compressor. It can be used with any compressor plant, including that furnished from a locomotive.

Conclusion

Your Committee feels that it can make no definite report other than to state that this class of work can be done satisfactorily and possibly more economically by this method than by any other.

Appendix E

(6) STANDING WATER IN BORROW PITS

W. C. Curd, *Chairman,* Sub-Committee.

On June 2nd, the following letter was sent out:

"To the Members:

"The Board of Direction requests a report this year on 'The effect of standing water in borrow pits upon the stability of embankments.' The Roadway Committee, which has been assigned this subject, requests your remarks on the statements and questions outlined below.

"In certain sections of the country where water stands in borrow pits unstable track and embankments are found. Your Committee is of the opinion that in such cases soil conditions are responsible for the instability and the standing water is an effect rather than a cause.

1. Will you cite specific locations where the cause of unstable track or embankment has been definitely traced to absorption or percolation of water from borrow pits?
2. Describe any experiments made by you to determine the cause of unstable embankments adjacent to borrow pits and conditions actually found.

"Drainage districts frequently place heavy assessments against railways for benefits assumed to accrue to track by direct borrow pit drainage or indirect drainage through lowering of ground water plane.

3. Please cite specific locations where such direct or indirect drainage of standing water in borrow pits has improved track or embankments and state in what way?

"Instances are known where greater benefits have been derived by reinforcing embankments with wider crowns and flatter sloped than by borrow pits drainage.

4. Please cite any such cases within your knowledge or experience.

"With your reply please forward actual cross-sections or drawings which may illustrate your remarks.

"The Committee is powerless to act on this subject without definite data and your co-operation is urged to promptly notify it of the result of any of your past investigations of the subject or of any special investigation which you will put under way to assist it.

"Please address your reply as early as consistent direct to Chairman of Sub-Committee, Mr. W. C. Curd, Consulting Engineer, 1313 Steger Building, Chicago, Illinois."

A number of replies have been received, but they are a disappointment, being usually opinions without data to support them. From the lack of interest displayed the Committee feels the importance of the subject is not fully appreciated. The railroads are annually spending large sums of money in attempts to cure unstable embankments, the results of which are largely ineffective, due to improper methods.

Each year Drainage Districts are organized in territory adjoining railroads and where borrow pits exist are assessed exhorbitant amounts for benefits assumed to accrue to embankments through drainage of the pits.

The report of the Committee should be of value to the railroad by showing the effect of standing water, how best to overcome it, and whether or not drainage ditches will benefit track. If we should go on record with a report based upon replies received to date, which are to the effect that borrow pit drainage will relieve unstable track, we feel that the Association Proceedings will be in evidence at the trial of every Drainage District case and that the railroad companies will be further burdened by higher assessments.

The Committee wishes to finally dispose of the subject, but it cannot do so without assistance. In view of its importance, we feel it would be unfortunate indeed if we had to recommend to the Association that the subject be withdrawn from further consideration.

There are very few railroads having no borrow pits, and it should be a comparatively easy matter to secure data as to their effect upon embankments under varying conditions. From many of the replies to our circular letter, it would appear that the effect of water in borrow pits is confused with that of water pockets.

The Committee does not wish to prescribe any specific form of investigation that should be carried out but rather that you follow your own ideas. What we are after is reliable data from which a conclusion may be reached.

Conclusion

From the information at hand, the Sub-Committee finds it impossible to return a report this year, and recommends that the subject be continued.

Appendix F

(7) DRAINAGE OF LARGE CUTS

R. B. Robinson, *Chairman*, Sub-Committee.

In the location of a railroad, more careful study should be given than has sometimes been given in the past to provide proper and adequate drainage where it has seemed necessary to lay a grade line in what would be a long low grade cut, and such a cut should be taken only when every means within reason has been employed to avoid it.

If such cuts be necessary, they should be taken out to such width as will permit of good, wide, deep, side ditches, and the slopes made flat enough to avoid danger of the banks sloughing in, this, of course, assuming that the material is of such nature as can be easily worked, and what would in most cases be hauled out and used instead of wasted; also if long, low grade cuts are necessary, surface ditches should be provided wherever required, and these ditches should be kept far enough back to avoid seepage or sloughing into the cuts.

Wherever it is not possible to accomplish drainage by open ditches, there are various more or less desirable schemes which have, from time to time, been used by various roads for draining cuts, such as installing vitrified tiling, sometimes with lateral weepers, and sometimes without; in other cases, trenches have been excavated and backfilled with large or small rock, and with or without lateral weepers, and still more drastic methods have had to be resorted to where water springs have been encountered and the water seeps upward and outward from subterranean veins, these sometimes occurring directly beneath the track. In this connection, some very good ideas have been brought out in previous meetings and reports of the American Railway Engineering Association, in which attention is called to the fact that where necessary to put in longitudinal tile subdrains, they should be placed below the frost line and below any saturated material, laid to a true bed, and filled over with cinders or other suitable material.

Another idea, in which we thoroughly concur, is that all water possible should be kept from reaching the roadbed; side ditches should be provided in cuts in all or any class of material, in order to hold storm water down away from the actual material and convey the water away as rapidly as possible; and, if then tile drains are still necessary, they should still be placed at satisfactory depth, and the cut ditches should still be kept open at all times; it being, of course, obvious that *all* ditches or drains must be kept open, as otherwise they defeat their own purpose.

In hauling out cleanings from ditches or opening up new ditches, the material, if wasted, should be so placed that it cannot be washed back into the drain ditches or pipes in case of heavy storm.

As illustrating some of the points mentioned, we attach hereto Exhibits Nos. 1 and 1½, being plans of two of the larger middle west railroads, showing typical methods they employ in handling this drainage question, applying especially to locations and conditions where good wide deep side ditches seem to be impossible, and where resort has to be made to trench drains and tiling.

Exhibits Nos. 2, 3, 4 and 5 show longitudinal tiling installed in various wet and springy cuts on another large western railroad, the expense of which has been heavy, but the results sought in almost every case have been fully attained.

Exhibit No. 6 shows a general study being considered by a western railroad for taking care of some very wet locations, where it has not appeared to be practicable to provide diversion channels or open drain ditches.

Exhibit No. 7 shows some tunnel drainage in very wet location on a western railroad, where, because of the topography, it was necessary to not only provide drainage in the tunnel, but to lead the drainage from the upper portal cut through the tunnel and release it through the lower portal cut by means of tile pipe at the sides and cast iron pipe directly beneath the track.

Exhibit No. 8 illustrates an interesting condition encountered on a western railroad at a tunnel about a mile and a quarter long, where the cut slopes sloughed in and blocked the portal cut with material, which was of the consistency of thick mortar; this trouble usually occurs in the spring, coincident with melting snow and thawing ground which runs off from about one thousand acres of mountain range land, draws in through a gulch above the portal cut, and despite several surface ditches, which were constructed in an effort to divert it; this water has reached this cut slope in sufficient quantities to thoroughly saturate the clay, which is of several varieties and mixed with soft soapy rock in a shaly formation; the upper formation is mostly a bright yellow clay, shading off lower down to a very tough red clay; seams run through this formation in all conceivable directions, and this gives the water an opportunity to thoroughly saturate the mass, and in this condition the clay loses all cohesive properties.

All ordinary methods to prevent this slide trouble were tried; several lines of drain tile and French drains were constructed, only to become filled and choked with silt in a short time; rows of piling were driven near the lower edge of the cut, framed together, and a system of bracing extended to other rows of piling driven about half way up the slide of the cut. This pile protection was put in where the first slide occurred, but subsequent slides went through and around it and carried some of it down to the track. Another slide occurred a short distance east of this pile bracing after the material from the first slide had been removed, and it was then necessary to devise some other methods to conquer the slide trouble. It was finally decided to construct a system of drainage tunnels, supplemented by a series of ditches filled with clay and then burned.

A 12 inch drain tile had been originally installed along the foot of the cut slope to drain the railroad tunnel, including a spring that had developed during the first slide. This drain tile now serves to carry off the additional water from the drainage tunnels and trenches mentioned. Three trenches were dug parallel with the track, and six cross trenches, approximately at right angles; the average depth of trench "A" is about 5 feet, while "B" and "D" and the cross-trenches have depths of over 20 feet, in the deeper parts of the cut. The bottoms of these trenches are cut to a grade line, which leads toward the track.

After the trenches were excavated, they were refilled with kindling, scrap ties, coal and clay, the layer of fuel being about 2½ feet thick, with next a layer of clay about two feet thick, and alternately placed to fill the trenches and tunnels; chimneys to afford proper draft were placed a short distance apart, these chimneys being of six inch tile. Care had to be used in regulating the draft, so as to keep an even fire, and thereby insure a thorough baking of the layers of clay and sides of the trenches. As the fuel burned out and the clay subsided in the trenches, more clay was put on top; and the surface thereby restored. The object sought being to get trenches and cross-trenches filled with semi-vitrified clay; also to thoroughly bake and stabilize the surrounding material. Through this mass of baked material, the water readily finds its way to the tile drains along the track.

In addition to the above-named trenches, three drainage tunnels, Nos. 1, 2 and 3, were driven back into the bank, a little below the grade of the track; tunnel No. 1 was driven 102 feet; No. 2, 120 feet; and No. 3, 142 feet. Then tunnels 2 and 3 were connected at the inner ends by a tunnel running parallel with the track, the grades being about six-tenths of one per cent. The tunnels were built rectangular in section, four ft. wide by six and one-half feet high, so as to work in them with wheelbarrows and shored and braced with timber, similar to mine work.

The inner ends of these tunnels were thirty-five feet and forty feet underground, and tapped the springs of water in the bank beneath the system of trenches described above; this method of drainage has proved to be very efficient in this location, as no further slides have occurred in about ten years' time.

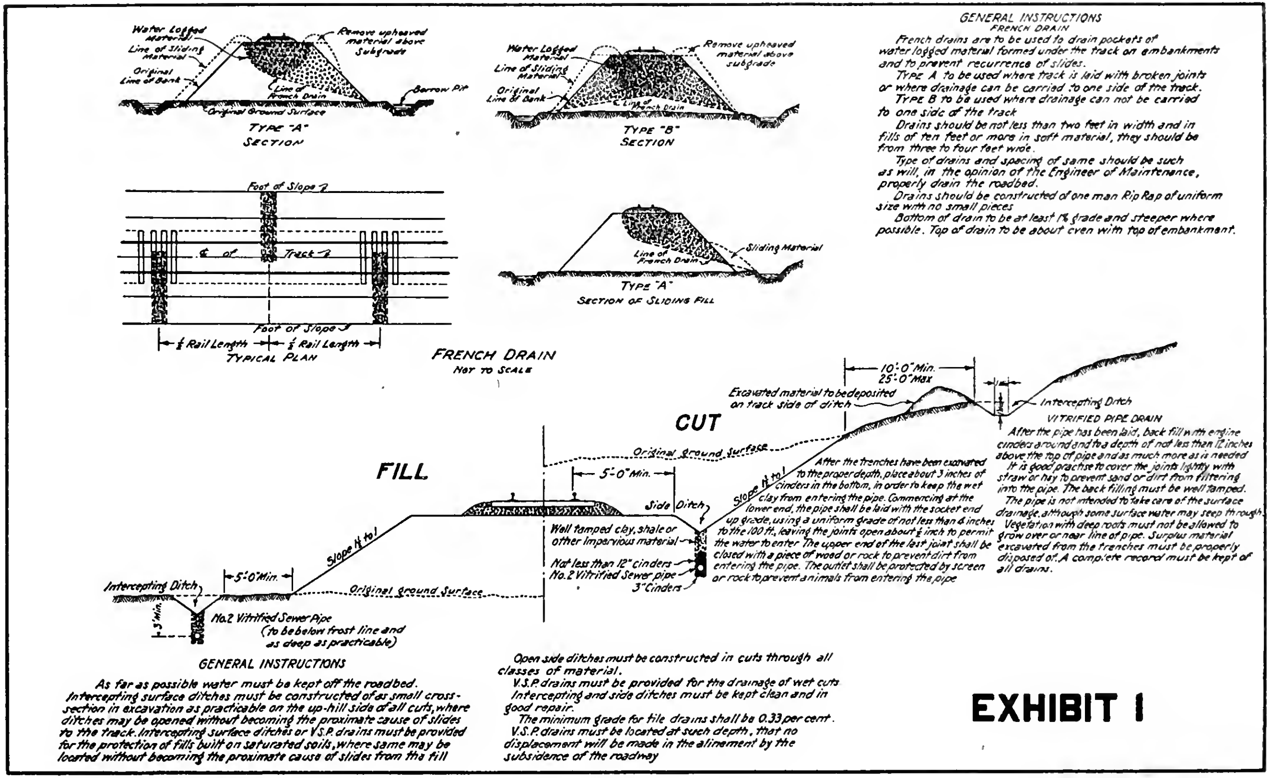
It is thought that the foregoing fairly covers the ordinary range of drainage trouble in long cuts.

Conclusions

(1) More consideration should be given by Locating Engineers to probable drainage conditions in selecting a line contemplating long, low grade cuts.

(2) If long low-grade cuts are practically unavoidable, construction and maintenance engineers should see that, where practicable, good wide deep side ditches are provided and maintained.

(3) When not possible or practicable to handle drainage with wide, deep side ditches, sub-drainage should be provided by installing blind rock drains or tiling, as it is impossible to maintain railroad track in satisfactory condition unless water is kept drained away from, over, in, around or beneath the track.


Water Logged Material
Line of Sliding Material
Original Line of Bank
Remove upheaved material above Subgrade
Line of French Drain
Borrow Pit
Original Ground Surface
TYPE "A" SECTION
Water Logged Material
Line of Sliding Material
Original Line of Bank
Remove upheaved material above subgrade
℄ Line of French Drain
TYPE "B" SECTION
Foot of Slope
℄ of Track
Foot of Slope
½ Rail Length
½ Rail Length
TYPICAL PLAN
Line of French Drain
Sliding Material
TYPE "A"
SECTION OF SLIDING FILL
FRENCH DRAIN
NOT TO SCALE
GENERAL INSTRUCTIONS
FRENCH DRAIN
French drains are to be used to drain pockets of water logged material formed under the track on embankments and to prevent recurrence of slides.
TYPE A to be used where track is laid with broken joints or where drainage can be carried to one side of the track.
TYPE B to be used where drainage can not be carried to one side of the track.
Drains should be not less than two feet in width and in fills of ten feet or more in soft material, they should be from three to four feet wide.
Type of drains and spacing of same should be such as will, in the opinion of the Engineer of Maintenance, properly drain the roadbed.
Drains should be constructed of one man Rip Rap of uniform size with no small pieces.
Bottom of drain to be at least 1% grade and steeper where possible. Top of drain to be about even with top of embankment.
FILL
CUT
Intercepting Ditch
5'-0" Min.
Slope 1½ to 1
Original Ground Surface
No.2 Vitrified Sewer Pipe (to be below frost line and as deep as practicable)
5'-0" Min.
Side Ditch
Original Ground Surface
Well tamped clay, shale or other Impervious material
Not less than 12" cinders
No.2 Vitrified Sewer pipe
3" Cinders
Slope 1½ to 1
Excavated material to be deposited on track side of ditch
10'-0" Min.
25'-0" Max
Intercepting Ditch
After the trenches have been excavated to the proper depth, place about 3 inches of cinders in the bottom, in order to keep the wet clay from entering the pipe. Commencing at the lower end, the pipe shall be laid with the socket end up grade, using a uniform grade of not less than 6 inches to the 100 ft., leaving the joints open about ⅛ inch to permit the water to enter. The upper end of the last joint shall be closed with a piece of wood or rock to prevent dirt from entering the pipe. The outlet shall be protected by screen or rock to prevent animals from entering the pipe.
VITRIFIED PIPE DRAIN
After the pipe has been laid, back fill with engine cinders around and to a depth of not less than 12 inches above the top of pipe and as much more as is needed.
It is good practise to cover the joints lightly with straw or hay to prevent sand or dirt from filtering into the pipe. The back filling must be well tamped.
The pipe is not intended to take care of the surface drainage, although some surface water may seep through.
Vegetation with deep roots must not be allowed to grow over or near line of pipe. Surplus material excavated from the trenches must be properly disposed of. A complete record must be kept of all drains.
GENERAL INSTRUCTIONS
As far as possible water must be kept off the roadbed.
Intercepting surface ditches must be constructed of as small cross-section in excavation as practicable on the up-hill side of all cuts, where ditches may be opened without becoming the proximate cause of slides to the track. Intercepting surface ditches or V.S.P. drains must be provided for the protection of fills built on saturated soils, where same may be located without becoming the proximate cause of slides from the fill.
Open side ditches must be constructed in cuts through all classes of material.
V.S.P. drains must be provided for the drainage of wet cuts.
Intercepting and side ditches must be kept clean and in good repair.
The minimum grade for tile drains shall be 0.33 per cent.
V.S.P. drains must be located at such depth, that no displacement will be made in the alinement by the subsidence of the roadway.
EXHIBIT I

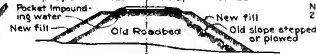
Standard Roadbed Section.

Ditches must be constructed of sufficient size and depth to take care of drainage, and must have sufficient fall to be self-cleaning, not less than 3" per 100'. All ditches must be properly maintained at all times, clean and free from obstructions.

No depressions shall be left to hold water, which would soften the roadbed. Isolated soft spots already formed must be dug out and refilled with suitable material.

When the ground slopes toward the track, surface ditches shall be constructed to intercept the water before it reaches the roadbed.

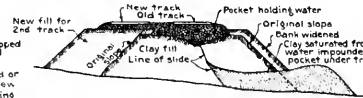
Bank Widening



New impervious material deposited above shoulder of old grade, retaining water under the track, thus creating soft spots. Slopes of old bank are not plowed, causing the new material to slide.

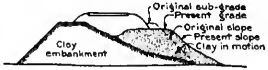
Slopes of old banks plowed or stepped to form band with new material, and to prevent sliding. Ballast removed from eroded or settled part of old roadbed, and new material brought up to sub-grade, without leaving pocket to hold water; the surplus ballast will then be available to form shoulder.

The same applies to roadbeds widened for additional tracks, and for widening roadbed through cuts.



Sliding of Clay Embankment Caused by Faulty Bank-widening and Construction of Second Track

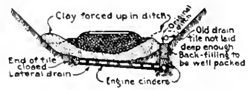
Water impounded in pocket under old track would saturate the underlying clay, causing it to slide.



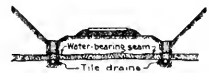
Effect of Soft Spot in an Embankment

This pocket should have been drained by transverse stone-filled trenches or by drain tiles. Stone-filled trenches are preferable for large sliding embankments, as they will not be so easily disconnected through slips or distortions.

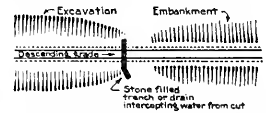
When a soft spot does not extend to a great depth, and the cut is shallow, it is economical to widen the cut and lower the ditch to a depth below the lowest pocket, and to drain the wet roadbed under the track into the ditch by means of stone-filled trenches or tile drains.



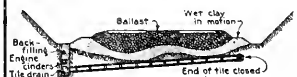
When soft spots have extended too deep to be economically drained by deepening the surface ditch, they should be drained into tiling laid parallel to the track and below the lowest part of the soft spot.



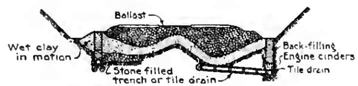
In case of seepage from both sides, intercepting drains should be constructed on both sides of the track. If only on one side, drain to be constructed only on that side.



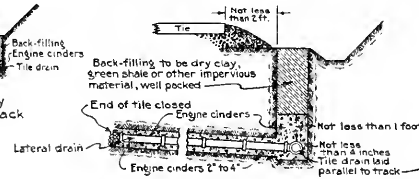
When water from the roadbed in a wet cut is liable to enter an adjoining embankment, a tile drain or stone-filled trench should be constructed across the roadbed near the end of the cut to intercept flow.

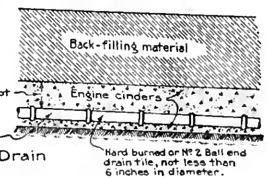


Drainage of Soft Spots by Tile on One Side of Track, Using Laterals



Drainage of Soft Spots by Tile on Both Sides of Track





Detail of Tile Drain

GENERAL INSTRUCTIONS.

Water is the worst enemy of the track and roadbed, and must be kept away therefrom as far as possible and carried away as quickly as possible. Never try to confine the water within the roadbed.

When trouble is being experienced in maintaining track and roadbed, first ascertain the cause—then apply the remedy. When water stands in pockets or troughs under the track, ascertain the exact depth by actual digging.

Sub-drains must always be laid below the wet clay or the lowest part of pockets they are to drain, and below frost line. If the drains are not laid deep enough, they will not drain the roadbed and will soon be displaced.

Trenches for the drains shall be excavated as narrow as possible to answer the requirements, and, when necessary, must be properly braced during excavation. Those parallel to the track shall be constructed as close to the track as the stability of the material will permit, and according to their depth, but not less than 2 feet from the end of ties.

The drains shall be of sufficient size, and must be laid to uniform grade with sufficient fall, not less than 4 inches per 100 feet and more if practicable, in order to keep self-cleaning.

Drains shall be vitrified hard-burned tile or No. 2 bell end tile. Porous tile must never be used.

For deep trenches or where the material is soft or slipping, bell end tile only shall be used, as it retains better alignment.

Drain tiles shall be not less than 6 inches in diameter, smaller drains are too easily clogged up. Increase the size as the drainage increases.

After the trenches have been excavated to the proper depth, place about 3 inches of engine cinders in the bottom in order to keep the wet clay from entering the tile. Tiling should be laid near the side of the trench farthest from the track, but not less than 4 inches therefrom, commencing at the lower end or outlet and laid up-grade, extreme care being taken to secure a uniform grade line.

Bell end tile shall be laid with the socket end up-grade. Joints shall be left open enough to permit the water to enter, but not so open that dirt can enter. The end of the last joint laid shall be closed with a piece of wood or rock to prevent dirt from entering the pipe. The outlet end shall be protected by screen or rock to prevent animals from entering the pipe.

After the tile has been laid, back-fill with engine cinders around and to a depth of not less than 12 inches above the top of the tile and as much more as may be needed. It is good practise to cover the joints lightly with straw or hay to prevent sand or dirt from filtering into the pipe. The material used for back-filling above the cinders shall be of selected material and must be thoroughly tamped to insure stability and to prevent settling of the roadbed. The tiling is not intended to take care of the surface drainage, although some surface water may seep through.

Lateral drains shall be constructed at such intervals as may be necessary for thorough drainage. When lateral tiling is not used, care must be taken, that all soft spots or pockets be properly tapped and drained parallel to the track.

Tiling shall not be distributed, until the work of laying is ready to begin.

A complete record must be kept of all drains.

Vegetation with deep roots must not be allowed to grow over or near line of pipe.

Surplus material excavated from the trenches must be properly disposed of.

In case of very serious drainage conditions, the matter shall be referred to the Chief Engineer.

EXHIBIT 1½

Exhibit 2

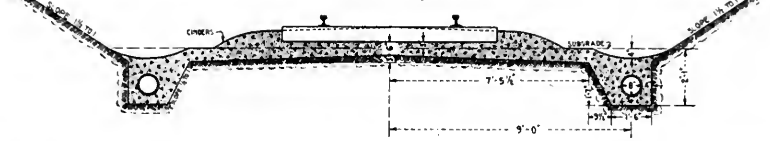


Exhibit 3

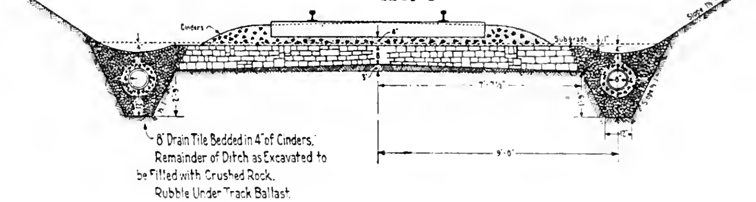


Exhibit 4

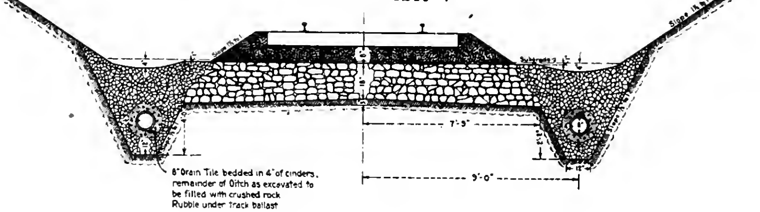


Exhibit 5

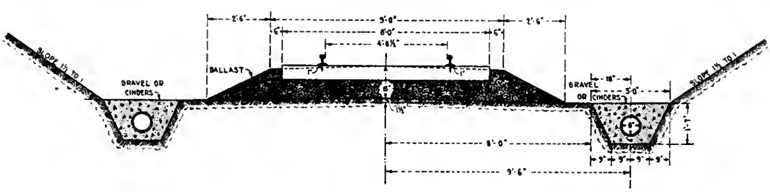


Exhibit 6

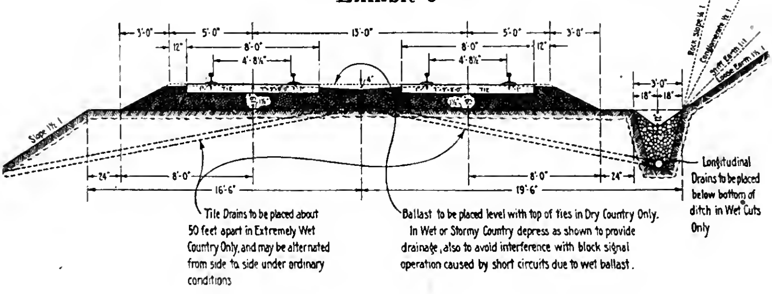


Exhibit 7

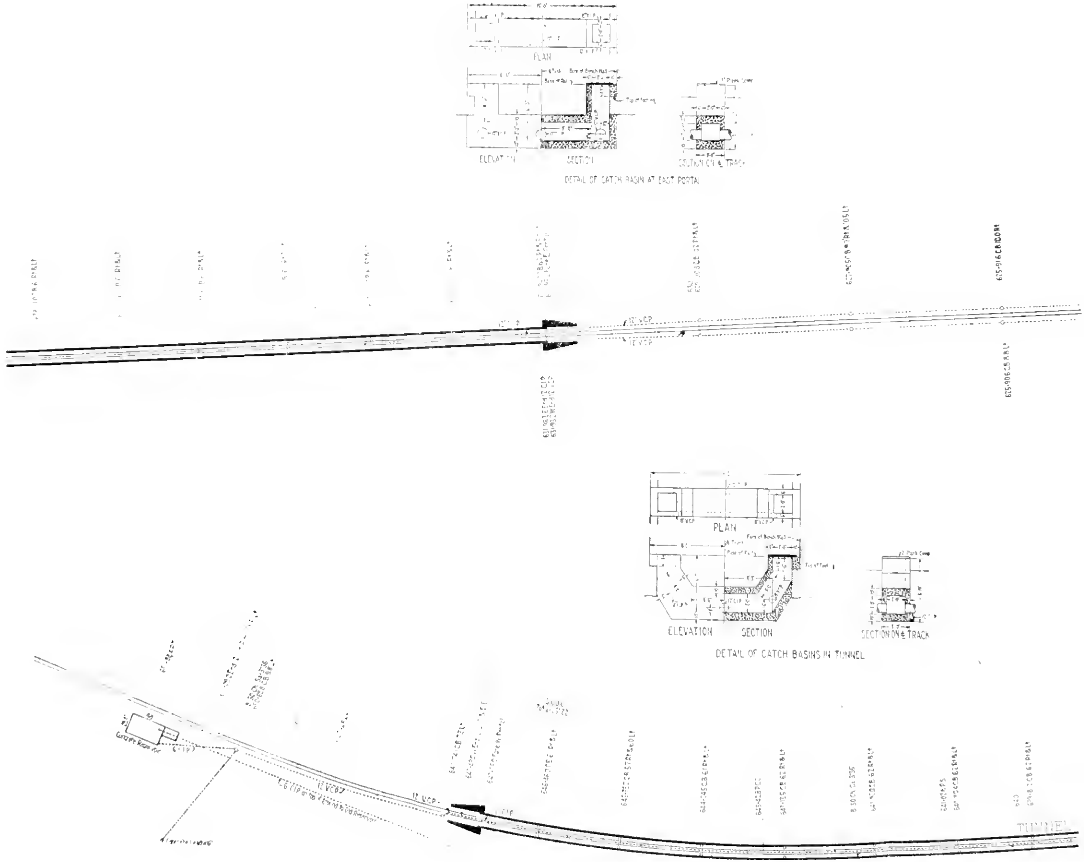
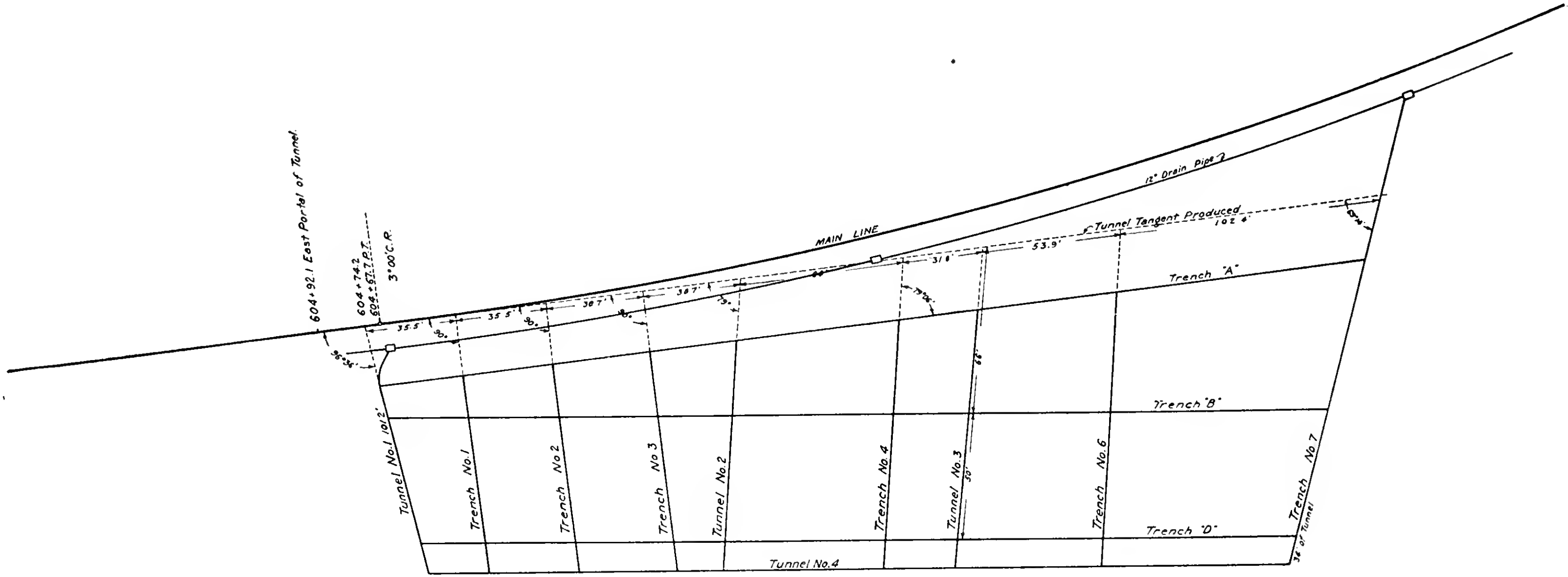

PLAN
ELEVATION
SECTION
SECTION ON ℄ TRACK
DETAIL OF CATCH BASIN AT EAST PORTAL
12" V.C.P.
12" V.C.P.
PLAN
ELEVATION
SECTION
SECTION ON ℄ TRACK
DETAIL OF CATCH BASINS IN TUNNEL
Concrete Basin
12" V.C.P.
TUNNEL

Exhibit 8



604+92.1 East Portal of Tunnel
604+74.2
604+67.7 P.T.
3°00'C.R.
96°36'
35.5'
90°
38.7'
79°
31.8'
79°06'
53.9'
102.4'
MAIN LINE
12" Drain Pipe
℄ Tunnel Tangent Produced
Trench "A"
Trench "B"
Trench "D"
Tunnel No.1 101.2'
Trench No.1
Trench No.2
Trench No.3
Tunnel No.2
Trench No.4
Tunnel No.3
66'
50'
Trench No.6
Trench No.7
34' of Tunnel
Tunnel No.4

REPORT OF COMMITTEE XXI—ON ECONOMICS OF RAILWAY OPERATION

L. S. Rose, *Chairman;*
J. B. Babcock, 3rd,
L. W. Baldwin,
J. M. Brown,
A. G. Boughner,
J. W. Burt,
Maurice Coburn,
F. W. Green,
H. B. Grimshaw,
V. K. Hendricks,
E. T. Howson,
G. D. Brooke, *Vice-Chairman;*
R. B. Jones,
E. E. Kimball,
H. A. Osgood,
R. J. Parker,
Dean Wm. G. Raymond,
Mott Sawyer,
J. E. Teal,
C. C. Williams,
Louis Yager,

Committee.

To the American Railway Engineering Association:

The following subjects were assigned to the Committee on Economics of Railway Operation for study and report:

1. Recommend methods for increasing efficiency of employees by furnishing them with reports and comparisons planned to inform and interest all concerned.
2. Report on methods for increasing the traffic capacity of a railway, conferring with the Signal Section.
3. Report on methods for analyzing costs, for the solution of special problems with which this Committee is concerned.
4. Report on the effect of speed of trains upon the cost of operation.
5. Report on the practicability and economy of through routing of solid trains and its effect on the capacity of terminals.

Committee Meetings

Meetings of the Committee were held in Chicago May 18th, attended by: L. S. Rose, Chairman; W. G. Arn (representing L. W. Baldwin), J. M. Brown, V. K. Hendricks, E. T. Howson, R. B. Jones, Dean W. G. Raymond, H. A. Osgood and Louis Yager. August 20th, attended by: L. S. Rose, Chairman; Mott Sawyer, E. T. Howson, Dean W. G. Raymond, J. E. Teal, Louis Yager, J. F. Harnit (representing R. J. Parker), J. W. Burt and J. B. Babcock. November 12th, attended by: L. S. Rose, Chairman; G. D. Brooke, E. E. Kimball, J. E. Teal, J. F. Harnit (representing R. J. Parker), A. G. Boughner, M. Coburn, Mott Sawyer, W. G. Arn (representing L. W. Baldwin), J. M. Brown and C. C. Williams. December 30th, attended by: L. S. Rose, Chairman; J. E. Teal, C. C. Williams, Dean W. G. Raymond, J. M. Burt, M. Coburn, W. G. Arn (representing L. W. Baldwin) and E. E. Kimball.

Subject No. 1 was assigned to a Sub-Committee composed of J. M. Brown, Chairman; H. B. Grimshaw and E. T. Howson.

Subject No. 2 was assigned to a Sub-Committee composed of Louis Yager, Chairman; L. W. Baldwin, V. K. Hendricks and E. E. Kimball.

On account of the illness of Mr. Yager, Mr. G. D. Brooke, Vice-Chairman, has taken up the work of the Chairman of this Sub-Committee.

Subject No. 3 was assigned to a Sub-Committee composed of H. A. Osgood, Chairman; Maurice Coburn and R. B. Jones.

Subject No. 4 was assigned to a Sub-Committee composed of Dean Wm. G. Raymond, Chairman; J. M. Burt, J. E. Teal, James B. Babcock, 3rd, A. G. Boughner, C. C. Williams and Mott Sawyer. Work of this Sub-Committee is further sub-divided into three divisions: "The effect of speed upon maintenance of track," assigned to Messrs. Williams and Burt; "Effect of speed upon transportation costs," assigned to Messrs. Teal and Sawyer; "Effect of speed on maintenance cost," assigned to Messrs. Boughner and Babcock. The plan of this subject is to combine into a single formula, if possible, the investigations of the three groups of this Sub-Committee.

Subject No. 5 assigned to Sub-Committee composed of Messrs. R. J. Parker, F. W. Green and J. C. Wroton.

Each of the Sub-Committees have done considerable work on the subjects assigned to them.

Attached to this report as appendices thereto will be found reports of the Sub-Committees.

The reports of the Sub-Committees are progress and intended to bring out discussions on the subjects presented for the benefit of the Committee and Association, in order that the Sub-Committees can complete their work next year. With the foundation contained in these reports, it is hoped that the Committee can complete the work assigned, if it is not found that this work is of a character which is never completed.

Sub-Committee No. 4 has made a study on the subject of "Allocation of Maintenance of Way Expenses to Passenger and Freight Service." On account of the lateness of this report and the necessity for further review, the Committee does not feel warranted in presenting a report at this time, and desires to advise the Association that the subject is receiving further attention.

Conclusions

There are no conclusions to recommend for insertion in the Manual.

Recommendations for Future Work

Committee recommends reassignment of Subjects 2, 3, 4 and 5.

Respectfully submitted,

The Committee on Economics of Railway Operation,

L. S. Rose, *Chairman.*

Appendix A

(1) METHODS FOR INCREASING EFFICIENCY OF EMPLOYEES BY FURNISHING THEM WITH REPORTS AND COMPARISONS TO INFORM AND INTEREST ALL CONCERNED

J. M. Brown, *Chairman;* E. T. Howson,
H. B. Grimshaw, Sub-Committee.

The Sub-Committee has determined that the term "employee" in this subject refers to those employed in minor positions on the railroad who do not see regularly the comparative reports sent out from time to time of various statistics.

The methods suggested are that comparisons of the effective work of individuals or groups of individuals or employees be tabulated and published; these comparisons to be of subjects in which an employee is engaged. The purpose of these comparisons is to stimulate friendly rivalry which may be developed in practically every line of railroad work.

These comparisons should be discussed with the employee, in groups of his fellow-workmen, for the purpose of securing their criticism and advice, recognizing their knowledge and insuring their interest. Men are interested in their own line of work; in fact, they are inclined to think all other lines are subordinate to theirs. This idea should not be discouraged.

While the final result to be secured is the cost, the units for comparison should be those in which the employee thinks; for instance, if a section foreman is asked about the number of ties he can put in, he will reply, so many per hour or per day; or a locomotive fireman will keep tally on the number of scoops of coal he uses on a run for his comparisons.

The data collected should be published at least once per month, in some instances oftener. During the season when the subject under discussion is being actively engaged in, such as insertion of ties, reports should be made every week. The reports should also be kept up to date, and if the data are not furnished by the employee promptly, inquiry should be made to ascertain the reason for the delay. If this is not done, the employee will think it has been forgotten, interest will die out, and soon there will be no records.

Methods for keeping the records should be published to prevent misunderstandings, and to insure uniformity.

Some data are published best by presenting a tabulated statement of facts, others by graphic charts.

The range of territory covering the performances should not be too great, for people are more interested in the work of their neighbors than of those a thousand miles away, and the comparison of the work will probably be on a more equitable basis. However, the comparative territory is a matter of selection. In some instances, the subjects may cover a wide range of territory.

Examples

The following subjects are submitted, and, for the purpose of comparison, the details are outlined with each subject:

Maintenance of Way

Applying Ties

This to consist of:

Unloading and distribution of new ties.
Removal of old ties.
Insertion of new ties.
Collection and disposal of old ties.

Comparison to be made upon number of ties applied in track per man per hour.

Applying Ballast

The following details to cover the work:

Stripping track.
Unloading ballast.
Raising track and tamping ballast.
Lining and surfacing track.
Trimming ballast to standard cross-section.
Cleaning up surplus ballast.

Comparisons to be made on a basis of hours of labor per linear foot, properly equated if there is a material variation in the average raise.

Laying Rail

The following details to cover the work:

Unloading and distributing rail and other track material.
Adzing ties.
Laying new rail, including full spiking and bolting.
Tightening bolts twice.
Picking up and loading rail and other track material released.

Comparison to be on a basis of hours of labor per mile of track laid.

Construction of Pile Trestle Bridges

The following details will cover the work:

Unloading all new material.
Driving piles.
Framing and applying all new material including ties.
Removal and disposition of all old material.

Comparisons will be made on a basis of hours of labor per linear foot of bridge. Bridges of approximately the same height should be compared. In time an equation factor can be developed for varying heights. Time consumed in traveling is to be eliminated in the comparisons.

Painting

BUILDINGS—Details covering same to be:

Transporting tools and material to and from paint car
Erecting ladders, scaffolding, etc.
Scraping all loose paint.
Applying putty to weather cracks and defects of like nature.
Mixing and applying new paint.

Comparisons to be based on hours of labor per square of 100 feet.

Painting

STEEL BRIDGES—Details covering same to be:

Transporting tools and material from paint car.
Erecting ladders, scaffolding, etc.
Cleaning and scraping metal.
Mixing and applying new paint.
Cleaning up after work is done.

Basis of comparison to be hours of labor on bridges of equal length.

COALING STATIONS

Operation of Chute

Details covering same:

Unloading cars.
Breaking coal.
Hoisting.
Cleaning up all spilled coal.

Basis of comparison to be tons housed per hour of labor.

Weight of coal to be determined from shipping bills.

PUMPING WATER

Operation of Water Station

The man-hour comparison cannot be introduced, but a comparison of the amounts of oil and fuel consumed can be made, and the whole expense reduced to a horsepower basis.

Details for comparison:

Cost of unloading fuel and supplies.
Cost of operating pumps and engines.
Amount of fuel consumed.
Amount of lubrication used.
Gallons of water (in thousands) pumped.

Basis of comparison will be cost of 1,000 gallons of water pumped per horsepower per hour.

TRANSPORTATION

Comparison of Initial Terminal Time Efficiency for Period May 1st to May 10th

Standing		Yard	General Yard Master	Day Yard Master	Night Yard Master	Number Trains	Average Time	Allowed Time	Efficiency	Last Period Efficiency
Last Period	This Period									
				Names						
1	1	A				49	35	43	122.8	
12	2	B				16	25	30	120.0	
2	3	C				118	32	37	115.6	
6	4	D				16	15	17	113.9	
5	5	E				8	37	40	108.2	
16	6	F				49	35	35	100.0	
....	7	G				54	50	47	94.1	
8	8	H				98	29	27	93.1	
3	9	I				61	28	25	89.4	
7	10	J				38	54	47	87.1	
15	11	K				47	46	40	87.0	
9	12	L				49	32	27	84.4	
11	13	M				54	40	33	82.5	
17	14	N				65	48	39	81.5	
10	15	O				79	32	25	78.2	
4	16	P				18	41	32	78.1	
19	17	Q				16	46	35	76.1	
14	18	R				83	58	44	75.9	
18	19	S				21	23	17	73.9	
21	20	T				65	64	47	73.4	
12	21	U				72	46	33	71.8	
23	22	V				24	47	33	70.3	
20	23	W				63	37	25	67.7	
24	24	X				57	44	29	65.9	
22	25	Y				75	62	40	64.5	
26	26	Z				19	77	49	63.7	
25	27	AA				80	68	35	51.5	
27	28	AB				6	47	23	48.9	
						1,400	1,198	954	79.6	
				Last Week	....	1,423	1,242	907	73.0	

NOTE.—The rating given in Column, "Allowed Time," is determined by a comparison of the facilities for departure of trains from all terminals.

RECORD OF DRAWBAR FAILURES BETWEEN TERMINALS
and Comparison of Ranking of Engineers per Failure per Car Mile

Period—One Month

Territory—One Operating Division

Comparison to be made upon Drawbar Failure per car miles accumulated on the Division for one month.

Rank	Engineer's Name	Draw Bar Failures	Number of Cars Hauled	Total Car Miles Per Engineer	Car Miles Per Draw Bar Failure
....	....	....	....	....	....
....	....	....	....	....	....
....	....	....	....	....	....
....	....	....	....	....	....
Totals....	....	....	....	....	....

RECORD OF CARS SET OUT ON ACCOUNT OF HOT BOXES BETWEEN TERMINALS

and

Comparison of Ranking of Conductors per Car Set Out

Period—One Month

Territory—One Operating Division

Rank	Conductor's Name	Car Set Out Account of Hot Box	Number of Cars Hauled	Car Miles Per Conductor	Car Miles Per Hot Box Set Out
....	....	....	....	....	....
....	....	....	....	....	....
....	....	....	....	....	....
....	....	....	....	....	....
Totals....	....	....	....	....	....

Comparisons of Cost of Handling L.C.L. Freight and Number Pounds Handled per Man per Hour

Illustration for April, 1920—1919, and March, 1920

Station	Month and Year	Total Tons Handled	Total Cost	Cost Per Tons Cents	Total Hours Worked	Average No. Lbs. Handled Per Man Per Hour
"A"	April, 1920	18,748	16,850.88	94.95	32,020	1,109
	April, 1919	18,163	13,056.07	71.88	27,020	1,426
	March, 1920	22,296	20,126.28	90.27	38,125	1,170
"B"	April, 1920	5,772	3,944.25	68.33	6,099	1,893
	April, 1919	9,380	5,745.19	61.24	9,684	1,937
	March, 1920	10,487	7,297.13	69.58	10,830	1,936
"C"	April, 1920	2,062	828.98	40.20	1,866	2,210
	April, 1919	2,100	641.32	30.53	1,458	2,882
	March, 1920	2,911	974.34	33.47	2,252	2,661
"D"	April, 1920	7,061	4,551.19	64.45	9,713	1,454
	April, 1919	6,192	3,959.40	63.94	8,921	1,388
	March, 1920	7,151	4,336.26	60.63	9,630	1,455
"E"	April, 1920	5,262	3,204.09	60.89	6,766	1,555
	April, 1919	4,650	2,562.96	55.11	5,655	1,645
	March, 1920	5,273	3,079.76	58.40	6,511	1,620
"F"	April, 1920	14,471	9,563.51	66.08	19,653	1,472
	April, 1919	11,987	7,738.30	64.50	17,317	1,383
	March, 1920	16,308	10,863.13	66.61	23,059	1,416
"G"	April, 1920	19,721	17,120.05	86.86	34,713	1,136
	April, 1919	16,948	10,661.27	62.91	24,119	1,405
	March, 1920	23,201	19,384.19	83.54	38,456	1,207

Comparison of Errors in Checking and Loading per Ton of L.C.L. Freight Handled at Various Stations

Month of October, 1920

Stations	*Tons Handled*	*Errors Made*	*Tons Handled per Error Made*
A	5,514	49	113
B	3,333	46	73
C	1,491	18	83
D	3,861	20	193
E	2,984	25	119
F	2,478	3	826
G	1,649	7	235
H	949	9	105
I	7,419	22	383
J	651	7	93

Note.—Tonnage shown indicates total L.C.L. tonnage handled, both inbound and outbound and transferred. Errors compared are simply those made in loading and checking. Errors for other causes are not included.

COMPARISON OF CAR LOADINGS AT VARIOUS STATIONS
OCTOBER, 1920

Stations	*No. Cars*	*Total Weight of Load*	*Normal Capacity of Cars*	*Per Cent. of Normal Cap.*
		WHEAT		
A	7	592,380	540	109.7%
B	5	352,080	320	110.0
C	7	572,000	520	110.0
D	5	414,000	380	109.0
E	61	4,844,070	4,873	99.0
F	17	1,398,741	1,290	108.4
G	13	1,128,760	1,060	106.5
H	17	1,317,825	1,260	104.6
I	6	527,040	480	109.8
J	66	5,366,144	5,869	91.0
		FLOUR		
A	13	822,938	840	98.0
B	30	2,026,450	2,130	95.1
C	47	3,527,969	3,770	93.7
D	7	441,604	480	92.0
E	13	948,404	1,080	87.8
F	52	3,195,560	3,680	86.8
October, 1920	188	12,543,972	13,620	92.1
September, 1920	209	14,518,621	14,970	97.0
October, 1919	412	26,803,775	30,980	86.5
		HAY		
A	49	1,942,540	3,620	53.6
B	6	216,700	420	51.6
C	20	542,185	1,360	39.9
D	19	545,450	1,390	39.3
E	72	1,790,900	5,220	34.3
F	55	1,111,315	3,330	33.3
G	5	115,130	360	32.0
H	34	765,723	2,440	31.3
October, 1920	304	8,047,458	21,240	37.8
September, 1920	542	13,530,346	39,590	34.2
October, 1919	106	2,543,720	7,850	32.4
		COTTON		
A	7	206,055	440	46.8
B	11	261,225	740	35.3
C	6	128,975	380	33.3
D	21	457,685	1,320	34.7
E	6	76,325	440	17.3
October, 1920	78	1,450,039	4,580	31.7
September, 1920	40	613,735	2,640	23.2
October, 1919	77	1,534,061	5,720	26.9

NOTE.—Allowable capacity is 10 per cent. above normal capacity.

Examples of Published Information

ROLL OF AGENTS WHOSE ACCOUNTS CURRENT WERE CORRECT FOR MONTH OF................., ...DIVISION

Station of Agency	*Name of Agent*
....	....
....	....
....	....
....	....

Divisions	Number of Agencies	Correct	Incorrect	Percentages			
				Correct		Incorrect	
				1920	1919	1920	1919
A............	83	58	25	69.9	70.6	30.1	29.4
B............	37	25	12	67.6	63.2	32.4	36.8
C............	78	50	28	64.1	71.5	35.9	28.5
D............	82	49	33	58.6	54.9	41.4	45.1
E............	46	25	21	54.4	52.1	45.6	47.9
Entire Line....	326	207	119	63.2	63.4	36.8	36.6

OFFICE OF GENERAL MANAGER

Comparison of Average Miles per Car per Day

	1917	*1918*	*1919*
January	28.57	20.1	27.2
February	27.59	25.9	25.6
March	29.30	27.1	26.4
April	27.37	27.6	25.1
May	27.92	31.2	26.2
June	29.27	31.5	24.5
July	30.02	32.5	25.9
August	29.43	31.0	30.3
September	27.66	29.3	31.5
October	26.38	30.9	32.2
November	28.27	30.2	27.4
December	23.28	28.3	27.8

Average Freight Cars on Line Daily

1917	37,871
1918	35,927
1919	33,447

Make more miles by—

Prompt loading and release.
Prompt movement to loads and empties.
Prompt repairs to bad order cars.
Prompt furnishing of material for bad order repairs.
Prompt transfer of bad order loads.
Prompt action to forestall accumulation and congestion.
Prompt and regular attention to all angles of car efficiency.

Appendix B

METHODS FOR INCREASING THE TRAFFIC CAPACITY OF A RAILWAY

G. D. BROOKE and LOUIS YAGER, *Chairmen;* E. E. KIMBALL, L. W. BALDWIN, V. K. HENDRICKS,

Sub-Committee.

Two studies have been presented, the object of the first being to outline steps which will establish whatever weak points there may be in the organization of a railroad and the ways for improving operation so as to obtain increased capacity with the existing facilities or with slight modifications of them.

The second is a discussion of the physical elements which affect the traffic capacity. That is, it begins with the assumption that new facilities are required and a study is to be made to determine what these facilities shall consist of. This study was undertaken late in the year and is incomplete due to lack of time to secure the data necessary to develop it to the point of determining where new facilities are required or to forcast what the benefits of the new improvements will be. It is proposed as a part of next year's work to collect such data from actual operations on existing railroads and to use it in the continuation of this division of the subject.

Study of Railroad Operation with the View of Increasing Its Capacity with Its Existing Facilities

In considering the means of increasing the traffic capacity of a railroad, the logical first step is an examination to ascertain

(A) If the facilities as they exist are being utilized to the maximum capacity;

(B) What changes, if any, in methods of operation will produce increases of capacity;

(C) What minor additions or alterations to facilities can be quickly made which will produce increases of capacity.

For this examination the engine district—embracing two terminals and the one hundred miles more or less of line between them—is the most suitable unit. If the problem should have to deal with more than one such district each will have to be examined of itself and then with the results so obtained they must be studied together, each in its relation to the adjoining districts and to the line as a whole, and thus by progressive study the examination completed for the entire railroad.

The facilities of an engine district consist roughly of the main tracks, passing tracks and other sidings, yards, telegraph offices, signals, water stations, engine houses, ash pits, coal chutes, etc., the locomotives assigned to the district, the locomotive repair shops, and the special equipment, most important of which is the steam derrick outfit.

It will be seen that the examination must deal largely with the operating organization of the railroad. It must determine if there is intelligent supervision, if there is proper effort on the part of the men in the ranks, if there is co-ordination of the several departments, if a proper *esprit de corps* pervades the organization; in short, if the performance of the machine in the hands of the organization is of a high standard of efficiency.

The examination should be started by a preliminary study of the operating conditions on the district. This will to a large degree determine the scope of the more thorough and detailed study which should follow. These studies can best be made by examinations of the movement, locomotive performance and other operating records, the comparison of the current performances with those of former periods, and by consultation with the operating officers having the district in charge.

The preliminary study will probably disclose one of two operating situations:

(1) A heavy traffic being moved with comparatively free road and terminal movements, the volume of business handled approximately equaling or exceeding that of prior periods of good performance.

(2) The road movement free and the terminals—one or both—congested, or both road and terminals congested, the volume of business moved being less than during former periods of good performance.

The first case is one requiring very careful study and mature consideration before steps are taken looking to increasing the capacity by changes in the methods of operating the district. When a heavy traffic is being moved it is logical that the numbers of cars in yards will be high, that there will be many trains on the road and therefore some interference to train movement, that the locomotive terminals will have large number of locomotives to handle, that all the facilities will have heavy loads imposed upon them. Nevertheless, to obtain the maximum capacity the road and terminal movements should as a rule be free and unrestricted, and the crowding, the over-feeding of any part of the machine should be reduced to a minimum. It is true that crowding of facilities will follow speedily if there are interruptions to traffic and they will doubtless be frequent. If of short duration the resulting accumulations will be overcome by the reserve power of the organization; if of long duration other means of relief should be resorted to, such as the diversion of traffic to other routes and the restriction of loading by embargoes, but the remedy, whatever it may be, must be applied promptly and vigorously so as to avoid congestion and its attendant losses of efficiency and capacity. The length of time necessary and the difficulties experienced in overcoming these accumulations of freight will give some indications of the possibilities of increasing the movement of traffic over the district.

It will undoubtedly be found that the officers are well informed as to the limitations of the district and can point out those facilities which are being utilized most nearly to their capacity and which first show signs of overloading, and perchance they will have available the results of experiments which have been made with the view of increasing the traffic capacity so that the expediency of possible changes of operating methods can be definitely determined without the necessity of experimentation, which is in itself very objectionable on a railroad working approximately to its capacity.

It will be found that the performance of the men is generally good; that trains start promptly and move into and out of sidings with precision; that there are very few accidents caused by non-observance of rules or by carelessness of trainmen; that the condition of tracks, locomotives and cars are good; that the locomotives attain a high average mileage, and the detentions for cleaning fires, washing boilers, making running repairs, etc., are reasonably low. All trains will be found to be handling the prescribed tonnage rating and the local work being done by the local freights and pick-ups, thus reserving the through trains for long haul freight. The schedules for calling extra freight trains have been so arranged that the movements of these trains will best fit in with the schedules of the passenger trains and scheduled freight trains. In short, the examination will disclose an efficiently operated district in charge of officers who know the limitations of the facilities and who are in a position to and do take steps to restrict the business should occasion demand it so that the facilities will not be overloaded.

The subsequent study should be confined to those facilities and features of operation which, as has been developed in conference with the officers, are the first to give trouble under increases of traffic. A brief discussion of two or three assumed cases will indicate the methods to be followed.

Assume, first, that the ashpit at one terminal becomes overloaded and power is delayed there:

Careful observations of the operations of the pit and tracks leading to and from it should be made covering periods of sufficient length to thoroughly familiarize the observer with them. This may develop that some slight rearrangement of tracks or other facilities will be beneficial; as, for example, the building of an additional cross-over or the re-location of a water column. It may bring out that some part of the organization needs strengthening. If the capacity of the pit itself is the limiting feature, consideration should be given to affording relief by installing steel ties in an adjoining track for a length of eighty to one hundred feet and the cleaning there of the fires of yard engines and other small power during the heavy periods of the day. Means may be found also of changing the runs of certain locomotives so that they can be taken care of at some other terminal where the facilities are less crowded, thus reducing the load on the terminal under examination.

Assume, second, that one of the yards is unable to keep up with the switching under increased business:

Observations of the work of all parts of the yard should be made by capable men. If these should develop any lost motion, interference of the work of the yard crews by other yard crews or by road crews, inefficient use of yard power, etc., by careful planning, and possibly by some minor improvements which can be quickly made, some of these difficulties can be overcome. Consideration should be given to the question of systematized classification of the freight at other yards through which it moves so as to reduce the work of this yard. If practicable a part of the trains should be so made up as to pass this yard without switching. Some feasible change in the yard power may be found advisable.

Assume, third, that the road movement gives trouble:

A study of the train sheets will indicate where to look for the cause. It may be found that a small number of additional block offices will be beneficial; that the scheduling of drag freight trains out of the terminals so as to reduce interference with schedule trains is practicable; that a very slight reduction in the tonnage rating of drag freight trains will eliminate stalling of the trains when the rail is bad, will speed up the movement and enable better use of the power to be made, and in this way the capacity of the railroad increased.

The second situation, that of congested engine district, presents an entirely different problem. It can be stated without fear of contradiction that an engine district that is continually congested for long periods can not be handling traffic to its maximum capacity. Congestion carries with it heavy delays to trains getting out of and into yards, slow movement on the road, holding trains out of yards, too many relief crews to prevent hours of service law violations, excessive interference to switching in yards and an increased quantity of switching, crowded ashpits and engine houses, tired, indifferent men, carelessness, accidents, petty and serious, with damage to engines, cars and tracks, all resulting in inefficient use of power, of facilities, of men, in a general slowing up of the movement and in a reduced capacity of the railroad.

When such conditions exist it is necessary, in order to bring about any lasting improvements, to determine the seat and the cause of the congestion before remedial action can be taken. Congestion in one or both of the terminals at the extremeties of an engine district does not necessarily affect the road conditions to any serious extent. For while it may be found necessary to set trains off at sidings on line of road and to hold other trains out of the yards for varying periods, thus causing inefficient use of power and crews, the result will be a tendency to increase the terminal difficulties, and if proper precautions are taken to safeguard the road movement it will continue to be free and unrestricted. Congested road movement on the other hand means a general slowing up of trains and a continued inefficient use of the available power and crews, so that even if the terminals are adequate to handle the traffic with free road movement they will become crowded with movable cars, switching will be made difficult, and unless handled very skilfully congestion of the terminals themselves will follow as a result of the road congestion.

If it is found that the road movement is as a rule free while one or both terminals are congested, then it is necessary to look only to the terminals for the cause of the trouble. If both road and terminals are congested the difficulty may lie entirely with the road conditions, but the chances are that the congestion in the terminals, brought on perhaps by the inadequate road movement, has been aggravated by unfavorable conditions within the terminals themselves.

The detailed studies then should embrace both road and terminal facilities, organizations and operating methods or such portions of them as the preliminary investigation may determine is necessary. They should be made by consulting the train sheets and the various daily and periodic reports of operating performance and by making comparisons with the performance during previous periods, by suitable observations of actual work and by free discussion of the problems and conditions with the officers in charge of the operations.

There is given below a synoptical outline of some of the elements which affect the capacity of a railroad, and following it a brief discussion of a number of them. The subject is covered only in a very elemental way, but its purpose is simply to indicate the method of procedure, for it is evident that each case will present a problem in itself and that each will require modifications of the general treatment.

Road Capacity Affected by

Method of train operation...	Spacing system. Dispatching trains. Scheduling extra trains out of terminals. Running speed. Tonnage rating. Handling local work by locals or pick-ups. Helper stations.
Derailments and accidents...	Defective track. Defective equipment. Carelessness. High speed.
Performance of power	General condition. Running repairs. Preparation. Fuel, water.

Yard Capacity Affected by

Work to be performed	Quantity of switching. Overcrowding. Yard design.
Performance of power	General condition. Running repairs. Preparation. Fuel, water.
Derailments and accidents...	Defective track. Defective equipment. Carelessness.

Engine Terminal Capacity Affected by

	Ashpit, turntable, coal tipple and ready track operation. Running repairs.

Spacing System.—The spacing of trains may be by train order and rules, manual block signals, automatic block signals or otherwise. If the spacing is by train order and rules, give consideration to establishing the manual block system. The cost will probably be light and the advantages in reduced liabity to accident great. Determine if the system in use is functioning properly and if additional telegraph offices or block offices or signals are required to shorten particularly long blocks. Consider the possibility of modifications of rules looking to expediting train movements without sacrifice of safety, as for example the fullest practicable use of the "19" train order.

Dispatching Trains.—A first-class train dispatcher will work wonders with a busy railroad, while one who is not capable, whether from inexperience or other cause, is entirely out of place where there is congestion. Determine if the dispatching force is competent and adequate; if the dispatchers are found up to the mark and still trains are being delayed for orders, give consideration to subdividing the district, adding an additional set of dispatchers. The dispatchers must keep a constant pressure on the train movement. They must not be on the defensive.

Scheduling Extra Freights Out of Terminals.—It will be found that the chief dispatcher calls the extra freights so as to avoid passenger trains and scheduled freight trains in getting out of the terminals. Take advantage to the fullest extent of the idea he is using. Call into conferences the Superintendent, trainmaster, chief dispatcher and traveling engineer and prepare a schedule for each terminal of the leaving times of all extra trains for the twenty-four-hour period. Provide for the heaviest practicable movement with the understanding that trains scheduled for departure at certain hours can be annulled if not required. Place this schedule in the hands of the roundhouse foreman, yard foreman, and chief caller, as well as in the hands of division officers; there will soon be evidence of preparation to meet the schedule, power will be selected in advance, the yard crews will speed up to get the train ready, the trainmen will watch their standing on the crew board and be prepared to promptly respond when called. Regularity and certainty will prevail and the train will leave terminal on schedule—a good start for a good run.

Running Speed.—Do the slow freights drag uphill at snail's pace, with slipping drivers, stalling if the steam pressure drops a few pounds below the maximum? When over the hill do they roll away, passing the bottom of the sag at passenger train speed—"as fast as a wheel will turn over?" Both are objectionable. The first tends to uncertainty of movement, delays, inefficiency; the second increases wear and tear on track and equipment and tends to accidents—and freight train accidents at high speed are usually serious. Moderate freight train speeds tend to reliability and safety. They sacrifice little in time saving and quicker movement as compared with excessive speeds on descending grades.

Tonnage Rating.—Increased traffic means more ton miles produced. Look well then to the tonnage rating of the locomotives. Proper tonnage rating does not mean overloading the locomotive. It does mean maximum loading for the efficient speed on the ruling grade. It means all trains of the same class uniformly loaded in the direction of heavy traffic. It means full trains from terminal to terminal. It means uniform performance. If the tonnage ratings are found to be low, do not hesitate to increase them, but do this gradually. Add one car per train and run this way for a week, then add a second car. Keep this up until the proper rating is reached and the psychological tendency to oppose increased train loads will probably be avoided. If on the other hand it is established that the rating is too high, it should be reduced. Difficulty in starting trains, slow movements into and out of side tracks, very low speed on the ruling grades, with trains stalling when the rail is bad and other unfavorable conditions exist, spell uncertainty, delays and inefficiency. Rate the locomotives to their capacity, but so as to provide a reliable, dependable movement of trains.

Handling Local Work by Locals and Pick-Ups.—To make the maximum ton mileage a train must move through from one terminal to the other with full tonnage. When this is done with a minimum of delay efficient operation is obtained. If the through tonnage freights are to make good runs they must be relieved of local work, setting off and picking up at stations, so that they will have nothing before them but to make the other end of the road. This is one of the surest ways of increasing the ton miles per hour of crew time and the ability to handle traffic. If the local work is light it can all be handled by the local freight, but this local must not be overloaded. It will necessarily meet with delays at stations unloading freight and switching, and in order to get over the road in a reasonable working day its tonnage will have to be light so that it can make quick moves from station to station and in avoiding other trains. Excessive hours on the road day after day will wear out any crew and the service will suffer as a consequence. Therefore, when the carload business is heavy pick-ups must be run as necessary to keep the freight well moved up and the road free of cars.

Helper Stations.—If there are grades requiring helper engines ascertain if the through trains are meeting with delays waiting for helpers. In scheduling the slow freights out of the terminals favor the helper stations as far as practicable. Consider possible changes in the helper runs and the loading of through trains to the end of increasing the efficiency of the helper and road power.

Defective Track.—Poor track is responsible for a large percentage of derailments. There are two remedies: The first, repair and build up the track. This can be done in a short time if the defective conditions are confined to a few short stretches of line, but if they are general much more time will be required. The second, reduce the speed of trains to the safe limit. This remedy fortunately can be applied immediately with certain results. Better reduced speed of trains than frequent interruptions to traffic and expensive derailmnts.

Defective Equipment.—If the accident reports show an excessive number of derailments caused by defective equipment, an analysis may indicate that the inspection at a certain terminal is poor or that a particular type of car is causing the trouble. More careful inspection of all cars at terminals and quick inspections by the trainmen when standing at water stations, in sidings and in pulling into and out of side tracks will do much towards preventing these derailments.

Carelessness.—Accidents resulting from non-observance of rules and carelessness are an indication of demoralization. Switches run through, switches thrown under moving locomotives or cars, short flagging, improper train handling, result in derailments, collisions, destruction of cars, damage to locomotives, delays and serious interruptions to traffic. Such a situation requires strict but careful discipline, thorough and relentless investigation of all accidents and detected breaches of rules and the free use of efficiency tests. Proper methods will slowly but surely overcome the spirit of carelessness and as conditions improve there will appear among the men a spirit of pride in being a part of an alert, effective organization.

High Speed.—Excessive speed will cause derailments even if the track and equipment are in good condition; in combination with defective track and equipment it is a fruitful source of accidents. Derailments of trains running at high speed usually result in serious wrecks, with heavy damage to property and serious delays to traffic. The remedy is to reduce the speed of the trains; to place restrictions where required, holding the speed to well within the limits of safety.

General Condition.—On a congested railroad there is almost sure to be found a shortage of good serviceable power. There may be an abundance of locomotives; in fact, there are frequently too many, but so often the average condition is low and the number of locomotives actually available for service falls short of the requirements. A freight locomotive after receiving general repairs should be good for approximately twelve months' service. For the power condition to be good then 50 per cent. or more of the locomotives should be good for more than six months' service and a very small number should be awaiting shop. If too many of the locomotives are good for only one, two or three months' service the number of failures will be large, the running repair force will fall behind in their work and the power conditions will drop further and further behind instead of improving. The remedy for such a condition is to assign to the district more shop space or to increase the output of that assigned by double shifting in the machine shop. the boiler shop or that part or parts of the shops which is limiting the output. To afford prompt relief consider having a number of locomotives repaired by other railroads or by contract shops.

Running Repairs.—If there is any one thing that is disheartening to a train dispatcher it is to have on a busy railroad two or three locomotives that are performing poorly—failing. If the failures are not complete and the locomotives are able to limp into the terminals with their trains, their movements will be slow and unreliable and the delays to these and other trains will be serious; if the engines give up their trains after exasperating delays other locomotives will have to be dispatched light to move in the trains. All of this makes for inefficiency and reduced capacity of the railroad. Running repairs are those required to place the locomotive in condition for a successful trip over the district. If properly made there will be few failures. Insist on the running repairs being well done. Do not dispatch a locomotive until all required repairs are completed. If neglected, the failures will be many. Watch closely the number of engines held for running repairs; if too high, ascertain the trouble and apply the remedy. If necessary increase the force assigned to running repairs, as a last resort reducing the force on general repairs in order to do this. By all means see that this work is kept close up, for it means the maximum number of serviceable locomotives and good performance on the road.

Preparation.—Locomotive failures may occur from broken or worn-out parts—defects in the locomotive itself—or from conditions resulting from improper preparation, such as obstructed flues, foul boiler, dirty fire, etc., those conditions other than repairs which are remedied in preparing the locomotive for the next trip. If it is developed that the failures are being caused by improper preparation, look to the ashpit and roundhouse forces to remedy this. It may be well to temporarily place a special inspector to thoroughly inspect and approve the condition of all engines before they are turned over to the road crew.

Fuel and Water.—Determine if the fuel is of good quality and adapted to the locomotives. Also that the locomotives are suitably drafted to burn the fuel. If the fuel is poor a great opportunity for increasing the capacity will be presented provided a suitable quality of fuel is available. If the water is generally bad the problem is serious, but some relief may be had by the use of boiler compounds and other such expedients. If only one or two water stations cause the trouble avoid the use of water from them as far as practicable. Consider relief through hauling water of good quality.

Quantity of Switching.—Freight trains can be put through a terminal with regularity in from ten to thirty minutes if there is no switching to be done. If they have to be broken up and classified, consolidating with other trains, several hours will be required. If the ability to move freight through a given yard is the limit of the capacity of the district and the switching is heavy, every effort should be made to reduce the switching in this yard. Consideration should be given to doing certain of the switching at other yards in order to reduce the work at this one. This may consist of building at other yards of solid trains to pass through this yard without classification, of routing some of the freight around the yard if practicable and of reducing the work in this yard by well-planned use of the tracks and by systematizing the switching.

Overcrowding.—The work of any yard will be badly hampered if it is continually overcrowded. Effective switching requires open tracks into which to throw the cars. With crowding comes the frequent blocking of running tracks, the interference with switch engines by other switch engines and by road engines, increased liability to collisions and accidents, forced departures from the usual plan of switching and operation, all tending to inefficiency and reduced capacity. The remedy is to divert some of the freight so that it will not be handled in this yard or to reduce the traffic temporarily by embargoes until normal operating conditions are restored.

Yard Design.—While any extensive changes in a yard under heavy traffic would not come within the scope of this particular study, careful consideration should be given to the possibilities of increasing the capacity by minor changes in design. For example: It may be found advisable to raise the summit of a hump a foot or two so as to give the cars a quicker run-off; to lengthen a few tracks so as to avoid road trains doubling over; to make changes in the arrangement of switches at some point so as to avoid interference and reduce switch engine movements, or to put in a stand pipe and prevent loss of time on account of switch engines running for water. In general, the effect of the performance of power, derailments and accidents on yard operation is similar to that on road operation and the discussions of the causes and conditions affecting them given above can be applied with suitable modifications to adapt them to yard work.

Ashpit, Turntable, Coal Tipple, and Ready Track Operation.—Determine if the facilities and appliances are maintained in such condition as to give efficient operation; if coal and cinder cars are promptly switched to and from the coal tipple and cinder tracks as required; if the necessary tools, torches, etc., are provided. Careful observation should be made to determine if any change in routing of locomotives to and from the ashpit and engine house will reduce the interference and promote freedom of movement. The ashpit forces and other forces handling the locomotive should be studied carefully to ascertain if there is any lost motion on account of lack of force, improper arrangement of force or weaknesses in the organization. Men of strong character are required to supervise the work around an overloaded engine terminal and any expenditure made in improving the organization will pay large returns in increasing the capacity of the railroad.

Running Repairs.—It may develop that the locomotives are passing promptly over the ashpit but are being delayed getting into the engine house on account of the inability of the engine house organization to promptly handle the running repairs. Such a condition may be found to be caused by inadequate engine house force and equipment, by failure of other terminals to properly make running repairs to the locomotives, by neglect of the locomotives on the road by engine crews to such an extent that defects arising on line of road result in much heavier damage to the locomotives than should occur, or to a shortage of power, causing the locomotives to be run out without proper running repairs and this leading to failures on line of road, causing much damage to the equipment and consequently requiring a great deal more time and expense for repairs than would have been the case if the locomotives had been in proper condition when dispatched. When such conditions are found they should be remedied promptly by methods which will doubtless suggest themselves as the most practical. If the force can be added to so as to increase the capacity of the roundhouse for making running repairs this should be done. Steps should be taken to insure proper handling of the locomotives when on line of road and by all means proper running repairs should be made before the locomotives are dispatched. By selecting those locomotives requiring the lightest repairs and concentrating on them, they can be dispatched promptly, while those requiring heavy repairs can be held so that the work can be properly done. If all locomotives are placed in first-class condition as to running repair work before dispatched the trains will move with precision and reliability, the locomotives will make quicker trips between terminals and produce more train miles. The same number of trains can be handled with a less number of locomotives. By following this method those locomotives requiring heavier running repairs can gradually be put in good condition one by one until all of the power of the district is brought up to a high standard, the running repair work per locomotive will be reduced and the efficiency of the power and with it the traffic capacity of the district increased.

NOTES ON THE DETERMINATION OF THE TRAFFIC CAPACITY OF SINGLE AND MULTIPLE TRACK RAILWAYS

Introduction

The traffic capacity of any railroad depends upon three factors, organization, equipment and track facilities. In setting about to improve the traffic capacity of any road it will generally be necessary to set apart sections of the line to be studied and ascertain whether it is a question of organization or facilities which requires investigation. The two are very closely interlinked, for it is part of the organization to see that the most which can be obtained from the facilities is obtained. The organization, however, can only be looked to to devise methods of operation which will secure the best results with the facilities at hand and beyond this point new facilities will be required. The difficult part about this problem is to determine when such a point has been reached and then how to go about to secure those facilities which will give the greatest improvement for the least investment.

The problem is also peculiar for the reason that the results which might be expected from theoretical considerations of the factors involved are greatly in excess of the results which have been obtained in actual operation. On this account it has been difficult to obtain the best facilities when needed, largely because of the fact that the true conditions could not be set forth. The purpose of this discussion is to obtain a conception of the physical elements which determine the traffic capacity of a line and to show how operating results may be analyzed so as to form the basis for comparing the costs of providing new facilities with the financial benefits to be gained therefrom. Such analyses will be of value in demonstrating the feasibility of proposed undertakings for increasing the traffic capacity of a given line.

Traffic Capacity

In the first place "traffic capacity" is a term which conveys the idea of tonnage capacity, that is, the maximum tonnage which can be moved regularly over a given arrangement of tracks in a given time. In these notes the discussion is confined to that portion of a road between terminals and no account is taken of the limitations imposed by insufficient yard capacity. On this basis the traffic capacity will depend upon the train weight and the number of trains which can be operated over the line in the given time. The train weight will depend upon the size of locomotives employed. The number of trains will depend upon how fast the locomotives will haul them and upon the track arrangement. It will be shown that the track capacity of any section of road between terminals depends wholly upon the number and arrangement of sidings or passing tracks in the case of single track lines and upon the minimum allowable headway between trains in the case of multiple track roads. Also, track capacity can be measured in terms of train hours.

Track Capacity of a Single Track Line

For the purpose of illustration, assume a single track section 100 miles long with sidings or passing tracks 10 miles apart. This line will be made up of ten single track sections between sidings (see Fig. 1). When these sections are all occupied at the same time it can be assumed for the moment that the road is being operated at full capacity. On this basis there will be ten trains on the line at the same time and if this condition lasts for twenty-four hours then the daily capacity of the line can be expressed by the product of the number of trains constantly on the line and the number of hours, that is, in this case $10 \times 24 = 240$ train hours.

One way to have every single track section occupied at the same time is to dispatch trains so that each train meets another going in the opposite direction at every siding. This means that trains have to be started simultaneously from opposite terminals at intervals equal to twice the distance between sidings, in this case 20 miles apart. That is, if each train makes 10 m.p.h., they will have to be started from the terminals at intervals of every two hours. At 10 m.p.h. each train will be on the road 10 hours and since the trains are two hours apart it will be possible to dispatch 12 trains from each terminal in 24 hours, that is, 24 trains; each train taking 10 hours makes 240 train hours.

If the trains make 12½ m.p.h. and are spaced 20 miles apart they would be started from the terminals at intervals of 1.6 hours (see Fig. 2). That is, each train will be on the road 8 hours and 15 trains can be dispatched from each terminal in 24 hours, or a total of 30 trains each taking 8 hours makes 240 train hours, as previously found.

Track Capacity of a Double Track Line

If the illustration is carried a step or two farther the track capacity of a double track line can be shown. Suppose there are two lines each 100 miles long, one line having ten single track sections between terminals and the other fifty single track sections between terminals. The capacity of the latter line will be, according to the above rules, five times the capacity of the former. In the case of the line with 10 sections there will be the equivalent of 10 sidings against 50 sidings for the 50-section line. If the sidings are all a mile long in both cases, then the amount of side track in the two cases is proportional to the relative capacities. When a point has been reached where the section between sidings is the same length as the sidings then the next step is double track. Assume this is the condition for the 50-section line assumed above, and to make it double track will require 50 miles of additional side track. By the same reasoning the capacity of the double track would be twice the capacity of the 50-section line and 10 times the capacity of the 10-section line. That is, the relative capacities of the two lines is proportional to the relative amounts of passing tracks. Or the capacity of a line, which has a track mileage in sidings equivalent to one-fourth of the main line, could be increased four times if the line were double-tracked. Likewise, the capacity of a line which has one-fifth of the main line mileage in sidings could be increased five times if it were double-tracked, etc.

This is not strictly true unless a limit is placed on the headway between trains on double track lines. In the case of a single track line the minimum headway between trains in the same direction is twice the distance between sidings, which in the limiting case is two train lengths. On a double track line, trains in the same direction may be operated theoretically on any headway, but in order for the above rule to be true, trains in the same direction must be operated one train length apart. If a value of one mile is assumed for this distance then the daily capacity of a multiple track line expressed in train hours is equal to 12 times the number of tracks times the miles between terminals.

Actual Versus Theoretical Track Capacity

The above illustrations give a conception of track capacity which is perhaps new and show how the theoretical track capacity of a perfectly laid out line can be determined. It is important to emphasize the point that the theoretical track capacity of a line is fixed by the arrangement of tracks and can be given a value in train hours. The actual track capacity may not be as definitely fixed, but it is manifestly less than the theoretical and possibly can be assigned some value expressed in train hours which will represent the actual use that can be economically obtained from the tracks.

Because of the many elements which enter into actual railway operations the only safe way of determining the actual track capacity is by a study of actual operations. It is unsafe to arrive at a figure for actual track capacity working it out from theoretical cases, but for the purpose of illustration a few theoretical examples have been selected to show how the introduction of simple operating conditions will modify the results.

In the first place, on a single track road where the sidings are designed for passing only a single train at a time, meets cannot be arranged so that neither train is delayed. One or the other or both trains will be delayed at each meeting point. Fig. 3 shows the condition where only one train is delayed at each meeting point and Fig. 4 where both trains are delayed at each meeting point. The trains are assumed to average 12½ m.p.h. while running or the same as shown in Fig. 2, but the effect of delays in both cases is to reduce the number of trains which might have been run from 30 to 24 per day and the total train hours on the road from 240 to 235.2, the difference in train hours being accounted for by the lost time at terminals (0.2 hour per train).

If the sidings are designed for passing two or more trains at a time it will be possible to operate trains in fleets, that is, two or more trains in a section at the same time, as shown in Fig. 5. In this case, the delays to trains at meeting points will be at least equivalent to the headway between trains in a fleet, that is, part of the advantage obtained by operating in this manner is lost by reason of the fact that the delays are more than they would be if single train operation were employed. As shown in Fig. 5 the number of trains has been increased from a theoretical of 30 to a theoretical of 40 and the train hours from 240 to 464. However, the sidings are twice as long as they would have to be if they were arranged to pass only single trains, and if the same amount of side track were rearranged and single sidings installed at midway points then it would be possible to operate theoretically 60 trains, but these trains would be delayed twice as often, so that with the same delay at each point as shown in Fig. 4 the time on the road would be increased to 11.8 hours against 11.6 hours for fleet operation and the actual number of trains which could be operated reduced from 60 to 40. On this basis the theoretical track capacity can be shown to be unchanged by fleet operation, although advantages may be claimed for it in practice. It is not important at this time to touch upon these points, but reference should be made to the following table which shows the effect of frequent stops upon the average running speed of freight trains. Where there are a large number of trains operated as single trains the meets become very frequent and the reduction in average running speed becomes serious. In such cases fleet operation secures practical advantages, although in case of bad meets delays are less where intermediate sidings are installed.

Table 1—Showing Reduction in Average Speed of Freight Trains Caused by Frequent Starts and Stops

Max. Speed M.P.H.	*Miles Between Stops*						
	1	2	3	4	5	10	20
10	8.5	9.2	9.4	9.6	9.7	9.8	9.9
15	10.7	12.5	13.2	13.6	13.9	14.4	14.7
20	11.6	14.7	16.1	16.9	17.5	18.7	19.3
25	11.8	16.0	18.2	19.5	20.4	22.5	23.7
30	11.8	16.6	19.5	21.3	22.7	25.8	27.7
35	11.8	16.7	20.2	22.5	24.3	28.7	31.5
40	11.8	16.7	20.4	23.2	25.4	31.1	35.0

It has been assumed for the purpose of the previous discussion that the sidings are all equally spaced and the speed of trains is constant. If the sidings are not equally spaced but the speed of trains can be taken as constant then the number of trains which can be operated over the line will be governed by the time it will take for a train to make the run over the longest section in both directions. That is, if the middle siding in Fig. 1 were omitted, the middle section would be 20 miles instead of 10 miles long, and it would take two hours for a train to run over this section in one direction and two hours for an opposing train to run back, so that the minimum interval between trains in the same direction would be four hours instead of two. In other words, the capacity of the whole line would be reduced to half.

In actual practice steps would be taken to correct such a condition if it were found that greater track capacity was needed. If the siding could not be installed in its proper place on account of rough country or on account of long tunnels, then by lengthening the sidings adjacent to the long section so that fleet operation can be used over this particular section a very considerable improvement in operation over the entire line could be obtained.

If the speed of trains cannot be taken as constant then the sidings should be spaced so that they are equidistant as regards time rather than distance. These are some of the elements that should be investigated in setting about to improve the traffic capacity of a particular section. This phase of the subject has been so well treated in the Proceedings of the American Railway Engineering Association that it is not necessary to dwell longer upon these points here.

Effect of Operating Two Classes of Trains

There is another important element which enters into nearly every railroad operation—namely, the condition of operating more than one class of trains over the same tracks, that is, the condition where superior trains overtake as well as meet inferior trains. The problem is difficult to handle in the way that the previous examples have been discussed, but an attempt has been made to construct a number of typical train diagrams to show how the performance of the inferior trains is affected by the number, speed and passing points of superior trains on a single track line.

TABLE 2—DATA DERIVED FROM FIGS. 1-11

Figure Numbers	1	2	3	4	5	6	7	8	9	10	11
No. of Trains											
Freight	24	30	24	24	40	22	22	20	20	20	20
Passenger	..	..	..	..	..	2	2	2	2	2	2
TOTAL	24	30	24	24	40	24	24	22	22	22	22
Speed of Trains											
Freight	10	12½	12½	12½	12½	10	10	10	10	10	10
Passenger	..	..	..	..	..	15	20	25	15	20	25
Time Running											
Freight	240	240	192	192	320	220	220	200	200	200	200
Passenger		...	...	...	...	13⅓	10	8	13⅓	10	8
TOTAL	240	240	192	192	320	233⅓	230	208	213⅓	210	208
Road Delays											
Freight		...	43.2	43.2	144	28	24	20	24	24	20
Passenger		...	....	....	...	..	..	..	..	..	..
TOTAL		...	43.2	43.2	144	28	24	20	24	24	20
Terminal Delays											
Freight		...	4.8	4.8	...	..	..	..	..	..	..
Passenger		...	...	...	...	..	..	..	..	..	..
TOTAL		...	4.8	4.8	...	..	..	..	..	..	..
Total Train Hours											
Freight	240	240	240	240	464	248	244	220	224	224	220
Passenger		...	...	...	...	13⅓	10	8	13⅓	10	8
TOTAL	240	240	240	240	464	261⅓	254	228	237⅓	234	228

A study of these diagrams emphasizes one or more reasons why the railroads must have many more facilities than they can ordinarily make use of. These diagrams by no means tell the complete story, for in actual operation the speed of trains is irregular, stops have to be made for coal and water and time is required to issue and transmit train orders, etc. On a double or multiple track system these conditions are more or less minimized, but it is felt that the problem is the same whether the road is single or multiple track and some other method must be devised to get closer to the facts.

On this account it is proposed to take actual train-dispatcher sheets for a considerable period and construct from the data shown thereon train-hour diagrams which will show the characteristics of actual operation over this period. If the same data for another period is taken when the conditions are different the effect of the changes in conditions will be reflected in the shapes of the train-hour diagrams.

Train-Hour Diagrams

The construction of these train-hour diagrams is best described by referring to the model Fig. 12. Suppose the train hours, that is, the total time from the time crews were called to the time they were relieved, were taken from ten or a dozen actual train sheets and tabulated. If each train is represented by a cardboard strip and the cardboard strips are cut in lengths to represent the elapsed time and stacked in a box according to length, the stack would resemble Fig. 12. The horizontal edge of the box could be scaled to read in hours and the height in number of trains, or the data could be plotted as shown in Fig. 13. Such diagrams can be made to show graphically many features about actual train operations which are not evident from a study of the data itself. In the first place the area of the diagram represents train hours and in the particular case represented in Fig. 13, 35 per cent. of trains (39 trains) had crews assigned for more than 10 hours and 70 per cent. (79 trains) had crews assigned more than 8 hours. Only a few trains were on the train sheet less than 6 hours and likewise only a few trains were on the train sheet more than 14 hours.

The train-hour diagrams representing the theoretical performance shown in Figs. 1 and 2 will be rectangles for the reason that it is assumed that all trains cover the distance in the same time. In an actual case if every train were operated as well as the best then the train-hour diagram would be rectangular also, but on account of delays which happen to some trains and not to others the operation is not perfect but largely a matter of chance. In fact, the dotted line shown in Fig. 13 is the "probability curve" calculated to pass through the points a and b. It is not intended to deal with the advanced mathematics of the problem now, but this feature may be used to some extent later in forecasting what results can be looked for.

It has been possible to develop the theory thus far from general data furnished the Eight-Hour Commission and limited applications have been made of it with more or less encouraging results. There has been no data available, however, where the method could be used to determine the actual track capacity of a given line. If data could be obtained from a section of line that has been operating single track and recently changed over to double track, such operating data would be a criterion for establishing the single track capacity of the line as well as serving as a basis for analyzing the benefits to be obtained by double tracking. Likewise if data can be obtained for comparing the results obtained with heavy locomotives against light locomotives it could be analyzed by means of these diagrams and a theory built up which would have many applications to operating problems.

For instance, assume that a road had been operating for a considerable period around a certain point, which indicated that it was up to or nearly up to capacity. A train-hour diagram of this period would show certain characteristics of operation, let it be represented by Fig. 13. The train hours obtained would be the measure of the track capacity. If it were required to increase the traffic capacity of the line, that is, haul more tonnage over it in a given time, there would be five ways to proceed:

(a) Increase the tonnage per train by the purchase of larger locomotives, allowing the speed to remain the same.
(b) Increase the speed of the trains by the purchase of larger locomotives, allowing the tonnage per train to remain the same.
(c) Reduce the delays by such means as are available.
(d) Some combination of the above.
(e) Add more track.

It would be expected that each one of these methods if adopted would show train-hour diagrams of different shapes, that is, if it were decided to purchase larger locomotives and haul heavier trains the same tonnage would be hauled over the road in fewer trains and the height of the diagram would be correspondingly less, but the base would be essentially the same. The reduction in the total number of train hours thus obtained would be a measure of the increased tonnage which could be hauled over the line by the use of heavier locomotives. In other words, for the train hours saved other trains could be operated, but eventually it would be found that the same number of trains would give the same congestion and, if necessary to haul a still greater number of trains, train movements would have to be speeded up. By this means the base of the diagram can be shortened and the height correspondingly increased.

Likewise by the introduction of signals or other devices which may be available delays may be minimized and the train hours thus saved represent a margin which can be employed for the operation of additional trains.

By a combination of some or all of the above methods the improvement in traffic capacity ought to be equivalent to the sum of the individual gains, but in all cases we would expect that the same total train hours would represent about the actual limit of trains which can be hauled over the line without adding more track.

If more track is added or the line double-tracked, trains will move freer and at the same time the train hours which can be operated will be increased, making it possible to move many more trains on the line before a limit to its capacity is reached.

At some time or other most roads will have to consider some one or all of these methods for increasing the traffic capacity of their lines. Funds may not be spent for large power if it can be shown that greater benefit can be obtained in some other way, but before a quantitative analysis of these different schemes can be undertaken it will be necessary to have actual examples to serve as guides.

Crew Expense Diagrams

A simple application which has been made of this method of assembling operating data is in connection with a study of The Effect of Punitive Overtime for Engine and Train Employees Upon Crew Expense. This leads up to a discussion of Crew Expense Diagrams, which are described below:

Prior to January 1, 1917, "100 miles or less 10 hours or less constituted a day's pay" for freight train employees. In March, 1917, and dating back to January 1, 1917, the wage agreements were changed to read 100 miles or less, 8 hours or less constituted a day's pay, with pro-rata overtime. In 1920 and dating back to December 1, 1919, the trainmen and enginemen were awarded in addition to a basic eight-hour day "time and a half for overtime."

If it is assumed that Fig. 15 represents the train-hour diagram for a 100-mile section it can also represent the hours the crews are on duty. On the old 10-hour basis, the pay for a 100-mile run represented 10 hours' pay. That is, the crews were paid for 10 hours' work regardless of the actual time it took to make the run unless the time exceeded 10 hours. If the time exceeded 10 hours the pay for the run was by the hour at one-tenth the daily rate.

In Fig. 16 the area FCG represents the hours overtime, which would be paid for at one-tenth the daily rate, that is, hour for hour. The "hours on duty" is therefore represented by the area ABCE and the "hours paid for" on the old 10-hour basis is represented by the area AHFCE.

On the eight-hour basis of pay the area ICK would represent the hours overtime, which would be paid for at one-eighth the daily rate, which is 25 per cent higher than the rate paid for overtime on the old 10-hour basis, hence if this area is increased 25 per cent it will represent the equivalent hours' overtime paid for on the old 10-hour basis.

The area LMG, representing the overtime hours paid for, is 25 per cent larger than the area ICK and the total hours paid for on the eight-hour basis straight time for overtime is represented by the area AHLME.

On the eight-hour basis with time and a half for overtime it will be necessary to increase the area LMG 50 per cent to represent the hours paid for in overtime. This is shown as area LNG. The total hours paid for on the present basis of time and a half for overtime is represented by the area AHLNE.

These illustrations serve to show to the eye certain relationships which are more or less difficult to explain in words and figures. It is quite possible by an extension of the method to show graphically other relationships which have to do with the economic operation of railways so that the eye will grasp them.

Typical Train Charts
Showing Simple Cases of Perfect Operation
Trains of One Class

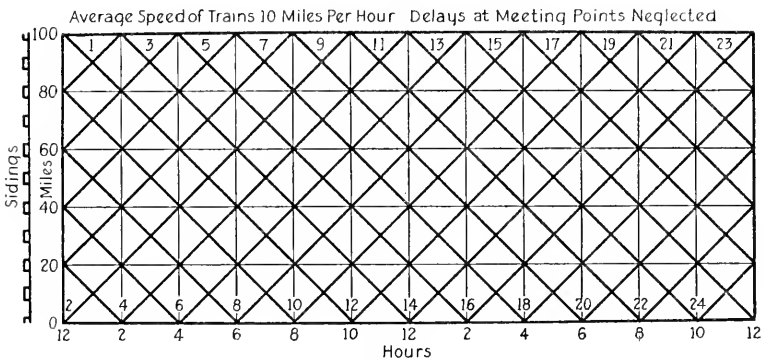


FIG. 1.

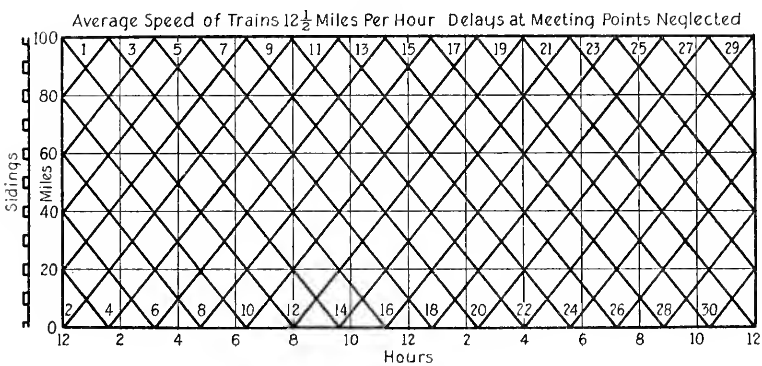


FIG. 2.

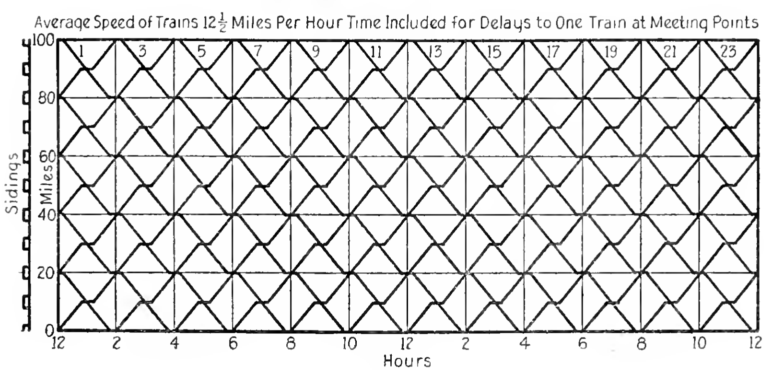


FIG. 3.

Typical Train Charts
Showing Simple Cases of Perfect Operation
Trains of One Class

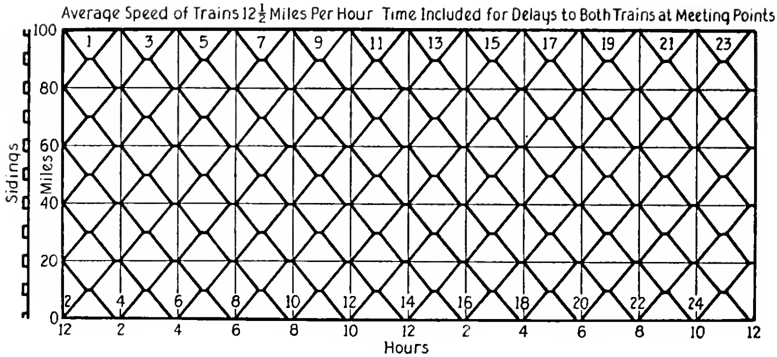


Fig. 4.

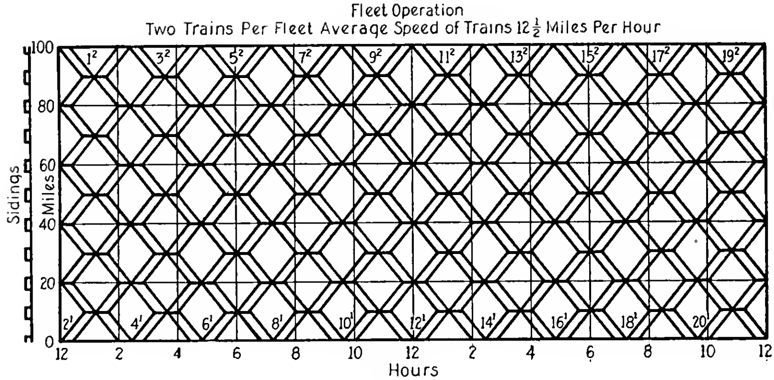


Fig. 5.

Typical Train Charts
Showing Simple Cases of Perfect Operation
Trains of Two Classes

Only One Passenger Train on Road at a Time. Delays to Freight Trains for Meets with Passenger Trains Shown. Other Delays Neglected. Based on Single Sidings.

Average Speed Passenger Trains $1\frac{1}{2}$ Times Speed of Freight Trains
Average Speed Freight Trains Neglecting Delays 10 Miles Per Hour

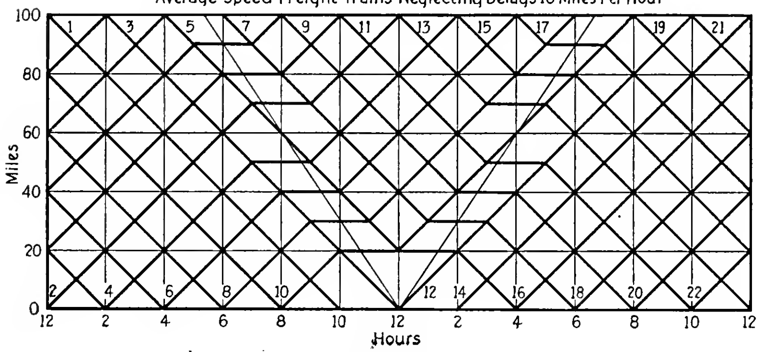


Fig. 6.

Average Speed Passenger Trains 2 Times Speed of Freight Trains
Average Speed Freight Trains Neglecting Delays 10 Miles Per Hour

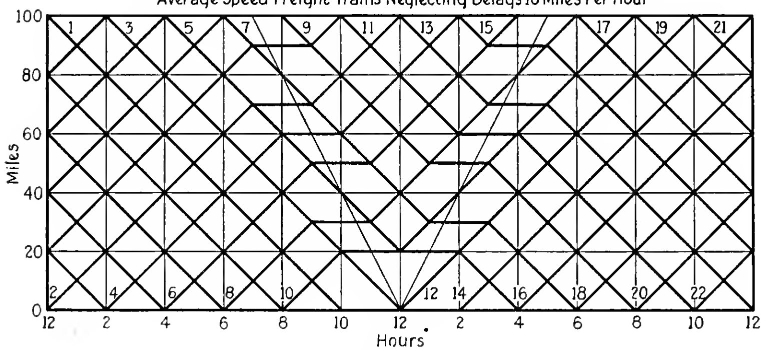


Fig. 7.

Average Speed Passenger Trains $2\frac{1}{2}$ Times Speed of Freight Trains
Average Speed Freight Trains Neglecting Delays 10 Miles Per Hour

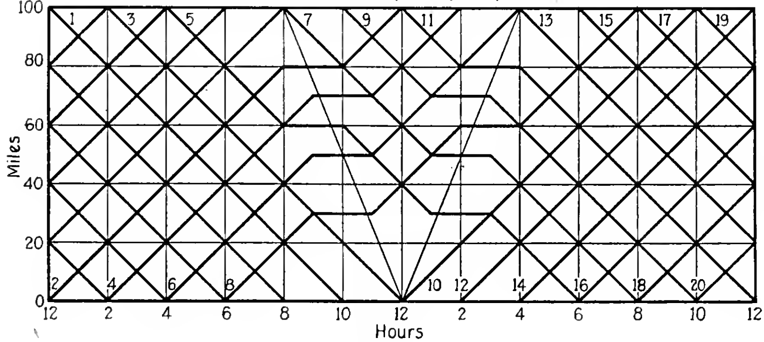


Fig. 8.

Typical Train Charts
Showing Simple Cases of Perfect Operation
Trains of Two Classes

Two Passenger Trains on Road at a Time. Delays to Freight Trains for Meets with Passenger Trains Shown. Other Delays Neglected. Based on Single Sidings.

Average Speed Passenger Trains $1\frac{1}{2}$ Times Speed of Freight Trains
Average Speed Freight Trains Neglecting Delays 10 Miles Per Hour

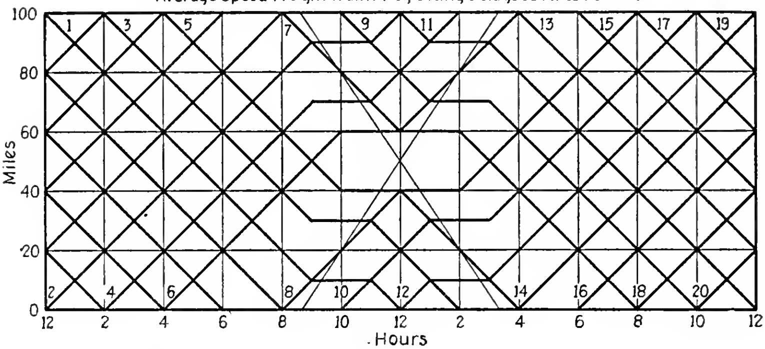


Fig. 9.

Average Speed Passenger Trains 2 Times Speed of Freight Trains
Average Speed Freight Trains Neglecting Delays 10 Miles Per Hour

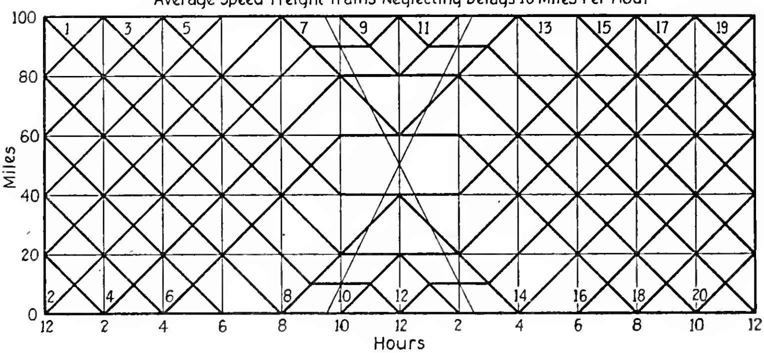


Fig. 10.

Average Speed Passenger Trains $2\frac{1}{2}$ Times Speed of Freight Trains
Average Speed Freight Trains Neglecting Delays 10 Miles Per Hour

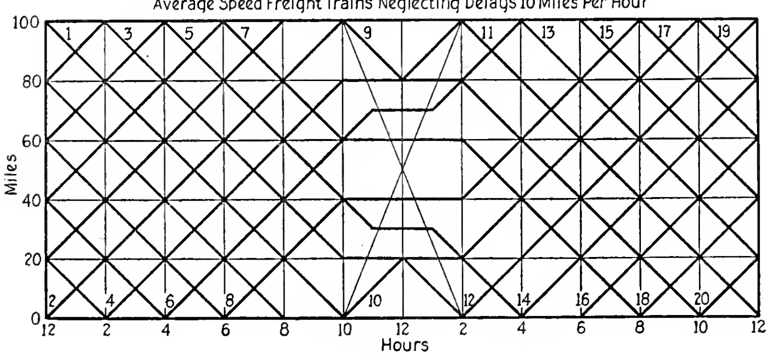


Fig. 11.

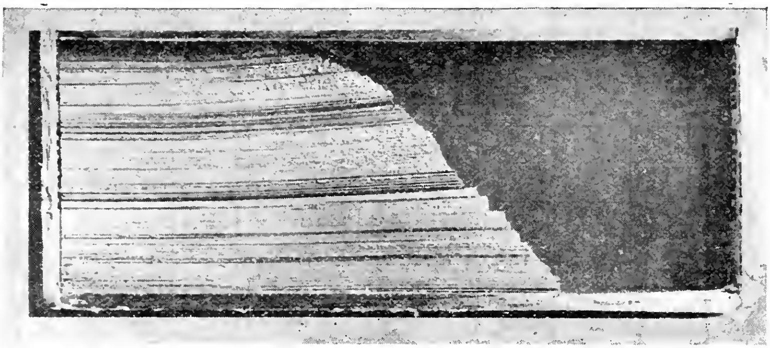
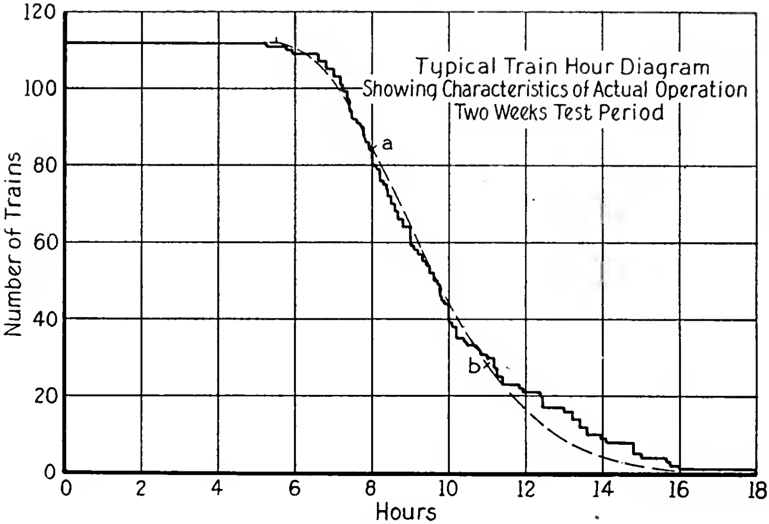
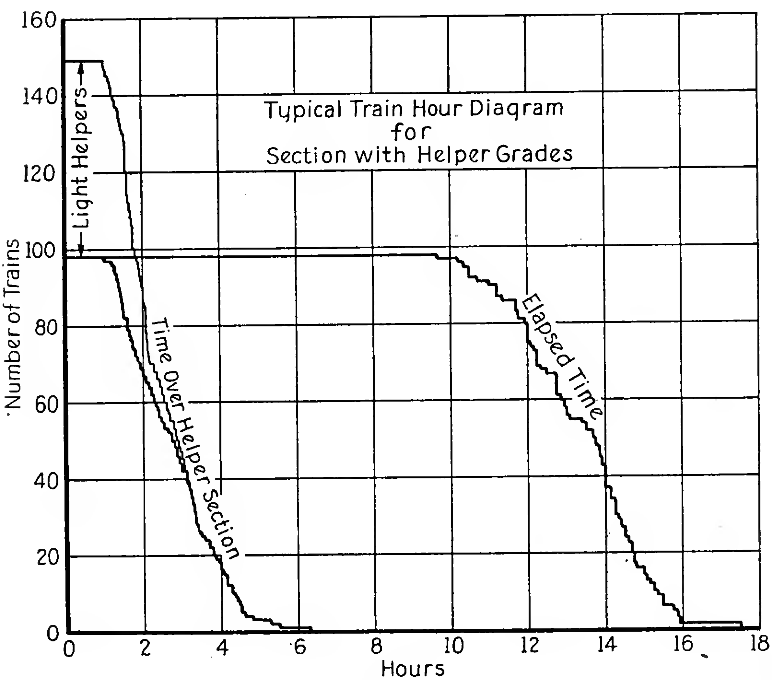


FIG. 12—MODEL OF CREW HOUR OR TRAIN HOUR DIAGRAM.



Typical Train Hour Diagram
Showing Characteristics of Actual Operation
Two Weeks Test Period
Number of Trains
Hours
a
b
120
100
80
60
40
20
0
0
2
4
6
8
10
12
14
16
18

FIG. 13.



Typical Train Hour Diagram
for
Section with Helper Grades
Light Helpers
Time Over Helper Section
Elapsed Time
Number of Trains
Hours
160
140
120
100
80
60
40
20
0
0
2
4
6
8
10
12
14
16
18

FIG. 14.

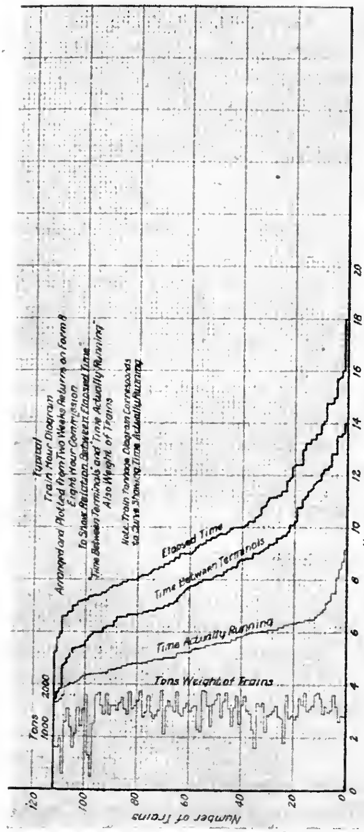


FIG. 15.

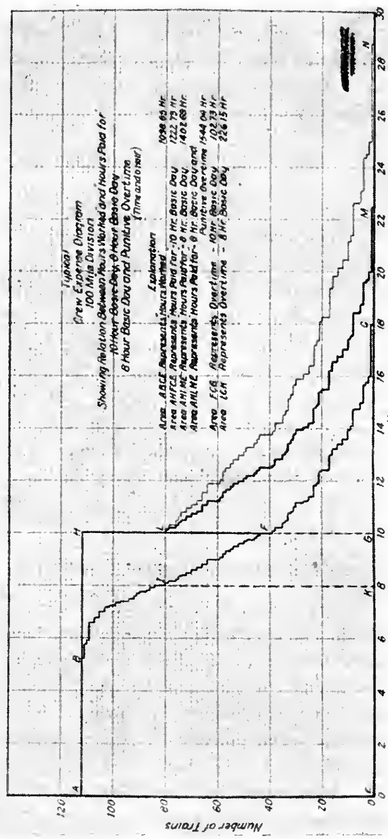


FIG. 16.

TYPICAL TRAIN HOUR AND CREW EXPENSE DIAGRAM.

Appendix C

EFFECT OF SPEED OF TRAINS ON COST OF OPERATION

WM. G. RAYMOND, J. B. BABCOCK, 3RD,
A. G. BOUGHNER, MOTT SAWYER,
J. M. BURT, J. E. TEAL,
C. C. WILLIAMS, Sub-Committee.

This Sub-Committee was divided into three groups, as follows: (1) Williams and Burt—effect of speed on maintenance of track; (2) Teal and Sawyer—effect of speed on transportation cost; (3) Boughner and Babcock—effect of speed on maintenance of equipment cost.

EFFECT OF SPEED ON TRACK MAINTENANCE

WILLIAMS AND BURT.

The object of this Sub-Committee is to obtain a quantitative estimate of the effect of speed on track maintenance.

Two distinct points of view must be recognized in any discussion of the effect of speed on track maintenance. First, the necessity of higher standards of maintenance under higher speeds, especially where the higher speeds represent passenger traffic, and second, the greater expenditure resulting from actual damage done by trains due to the increased speed. The former involves the question of how much better maintenance will be required for increased speeds of operation and how much the additional cost of the higher standard will amount to; the second inquiry is, what will be the additional cost to maintain a given standard of track condition under an increased speed.

Standard of Maintenance for High Speed Operation

On railroads having the ordinary proportions of freight and passenger traffic, it is probable that increasing the speed of operation of freight trains would not affect the standard of maintenance, for the successful operation of the passenger trains determines the class of maintenance required. Moreover, a study of maintenance costs indicates that the chief factor is the density of traffic rather than speed of operation in determining the cost of maintenance per mile.

However, the fact that superior maintenance is required for successful operation of passenger trains is evident from a comparison of maintenance costs on railroads that are primarily freight roads with those that are primarily passenger roads. Such a comparison between two groups of railroads in the Eastern District is given below, in Table I. The data were taken from I. C. C. reports and represent the average in each case for the three years, 1915-16-17. In the columns headed "adjusted," the data are reduced to the conditions of a density of traffic of 100,000 car miles per mile of line, assuming the proportions of the accounts which vary with the density of traffic to be as follows: Superintendence, 75 per cent.; ties, 25 per cent.; rails, 100 per cent.; O. T. M., 75 per cent.; ballast, 50 per cent.; track laying and surfacing, 75 per cent. These proportions seem to be roughly correct from a study of these accounts on various railroads.

TABLE 1

Railway	Car-miles Per Mile	Pct. Frt. Traffic of Whole	Superintendence Per Mile		Ties Per Mile		Rails Per Mile		O. T. M. Per Mile		Ballast Per Mile		Track Laying and Surfacing Per Mile	
			Actual	Adjusted	Actual	Adjusted	Actual	Adjusted	Actual	Adjusted	Actual	Adjusted	Actual	Adjusted
Long Island	92,000	28	205	218	537	551	108	118	141	149	30	31	738	785
Atlantic City	56,000	35	121	191	479	572	92	162	136	216	16	22	943	498
W. J. & S.	68,000	39	258	348	648	722	28	41	97	131	27	33	705	954
Average		....	195	252	555	615	76	107	124	165	24	29	795	1079
E. J. & E.	96,000	100	96	97	240	242	66	73	128	134	1	1	397	445
B. R. & P.	183,000	96	209	139	247	220	103	59	55	37	82	65	581	384
B. & L. E.	357,000	97	303	140	429	351	360	101	531	244	132	85	1459	674
W. & L. E.	131,000	95	139	115	381	360	79	60	288	237	22	20	603	497
Average			187	123	324	293	152	71	251	163	59	49	780	500
Ratio	High Speed / Low Speed	....	......	2.0	....	2.1	....	1.5	....	1 0	....	0.6	....	2.1

No classification of standards of maintenance has been adopted by the Association or other authoritative body and consequently no specific statement can be made as to the standard of maintenance required for any given operating conditions.

Attention should be called to the fact that the freight roads listed in Table 4 handle almost exclusively low grade freight and are not comparable with respect to their freight handling requirements with other roads which handle a mixed traffic where fast freight and livestock constitute a considerable part of the traffic.

Damage Done to Track Due to Increased Speed

Manifestly, the effect of speed in increasing the damage done to track will be dependent upon the character of equipment and rolling stock and upon the character and condition of the track. Passenger locomotives counterbalanced and maintained for high speeds cannot properly be compared with freight locomotives counterbalanced and maintained for lower speeds, nor can passenger coaches with a higher standard of maintenance of wheels, more perfectly centered wheels, better springs, etc., be properly compared with freight cars having their usual rough and eccentric wheels, flat spots, and unavoidably inferior spring adjustment. Moreover, the greater traction forces set up in the track under freight trains, amounting perhaps to three or four times those under passenger trains, render a direct comparison impossible. It is, therefore, necessary to consider the effect of increased speed in freight trains and in passenger trains separately.

Two modes of procedure in the investigation are possible: (1) by noting the results of experience in maintenance costs at high speed points and at low speed points, as at the bottom and at the top of grades, on high and low speed tracks, regions of restricted speed, etc., ascertaining the relative tie and rail renewals, low joints, amount of track labor required, etc., and (2) by analyzing track maintenance into its component parts and determining the effect of speed by tests or by inference on each of these elements and thereby on the total of track maintenance.

With regard to the direct observation of the effect of speed on maintenance costs, there is very little definite and reliable evidence in existing records, although the impressions of discerning trackmen should not be disregarded, even though they are vague. The opinion appears to obtain quite generally that speed in itself increases track maintenance costs, but no one has attempted to formulate a quantitative statement of this effect.

The Chicago, Burlington & Quincy Railroad pays careful attention to the speed of operation and limits the maximum speed of various classes of traffic, attempting to secure good speed operation by uniformity of speed rather than permitting high speeds at times and low speeds at other times. While the "Company has no definite data or observations that indicate quantitatively what the effect of speed is," their observations do indicate "that a freight engine counterbalanced for 30 miles per hour does a great deal of damage if permitted to run at 40 to 50 miles per hour, and certain types of engines cause greater damage than other types."

Observations on the New York Central where there was a partial segregation of traffic led to the belief that the cost of track maintenance varies with the speed and "at a given speed freight traffic is harder on track than passenger traffic."

Observations of Joint Deformation and Tie Cutting at High and at Low Speed Points

Observations were made on the conditions of joints and of ties at high and at low speed points near Lawrence, Kansas, on the Santa Fe and on the Union Pacific tracks with a view to determining the amount of permanent deformation of the joints and the cutting of the ties under the rails.

On the Santa Fe, the traffic is almost entirely passenger trains, consisting of eight passenger and two freight trains each way per day. Track and roadbed conditions are essentially the same at all three points of observation, viz., tangent single track, low embankment, rock ballast about 18 inches deep, 7 by 9 inch ties with 7½ by 9 inch Wolhaupter tie plates, on all ties, Weber joints, 90-lb. rail laid in 1916. The grade was essentially the same at all three points.

Location A was about 300 yards east of the station at Lawrence and sustains speeds of about 15 to 20 m.p.h. under passenger trains.

Location B was about one-half mile east of the station, where the prevailing passenger train speed is about 25 to 30 m.p.h.

Location C was about 1½ miles east of the station, where the passenger train speed is about 40 to 50 m.p.h.

The data of Table 2 show permanent deformation of the rail at the joint and at 6 and at 12 inches on either side, referred to the general rail level.

TABLE 2

Location	Speed mph	Average Deformation in Inches at				
		12 Inches	6 Inches	Joint	6 Inches	12 Inches
A..........	15–20	0.011	0.023	0.063	0 014	0.007
B..........	25–30	0.011	0.023	0.066	0.031	0.010
C..........	40–50	0.001	0.005	0.053	0 010	0.010
D..........	10–20	0.016	0.024	0.059	0.016	0.013
E..........	40–50	0.019	0.014	0.041	0.011	0.008

Similar observations were made on the Union Pacific track, which is subjected to heavy traffic, carrying the trains of both the Union Pacific and the Rock Island railroads. The line is tangent double track and the conditions of roadway and track are essentially the same at the two points of observation, viz., stone ballast about 12 inches deep, 7 by 9 ties with 5 by 7 Wolhaupter tie plates on each tie, 90-lb. A.R.A. rail laid in 1913, and continuous joints. In both locations the track is on a low embankment. The traffic consists of 13 passenger trains and 17 freight trains each way per day.

Location D was about 400 yards west of the station, where the speeds are about 20 to 25 m.p.h. for passenger trains and about 10 m.p.h. for freights.

Location E was about 2½ miles west of the station, where the prevailing speeds are about 40 to 50 m.p.h. for passenger and perhaps 20 m.p.h. for freights.

The permanent deformation of the rail at the joint referred to the general rail level is shown in Table 2.

At locations A, B and C on the Santa Fe the ties were date marked to a considerable extent and the following observations were made as to the average depth of cutting of the tie under the tie plates. The ties were yellow pine 7 by 9 inches in section with 7½ by 9 inch Wolhaupter tie plates.

TABLE 3

Location	Speed mph	Years of Service of Ties	Average Cutting Inches
A	15–20	11	0.24
C	40–50	11	0.19
A	15–20	12	0.23
C	40–50	12	0.23

These rather meager observations seem to indicate that on tangent track the effect of higher speeds in deforming rail ends or in cutting ties is not pronounced. If anything, the greater damage seemed to be done under the lower speeds, resulting probably from the greater traction effects in the track due to accelerating on leaving the station and braking on approaching the station. The above results would also seem to indicate that traction is a more potent factor in tie and rail deterioration on well-maintained track than is speed. Calipering the rail heads under high and low speed conditions did not indicate any greater wear at one point than at the other. These observations being at variance with the impressions generally held by trackmen, further investigation should be made before any conclusions can be drawn.

However, on the Santa Fe, with Weber joints there seemed to be a somewhat greater tendency to mashed or flattened rail heads at the joints under high speeds than under low. No difference in this respect could be observed on the Union Pacific tracks. On the latter, however, where the traffic is in one direction only on each track, a characteristic bending down of the receiving rail at the joint was noticed, and this condition seemed to be more pronounced under the high speeds than under the low, although a quantitative estimate of the difference could not be obtained.

Analysis of the Effect of Speed on Maintenance

In order to estimate the effect of speed of trains on maintenance of track, it is necessary to separate the items of maintenance expenses into their elements and then deduce how and to what extent each element is affected. The following analysis is intended more as a mode of attack than as a final conclusion, and it will be more reliable when more definite data become available. Moreover, the discussion is based on general averages, whereas to be of most value, the specific data for the railroad in question should be used.

Obviously the only accounts of track maintenance which may be affected by increased speed are: Superintendence, Ties, Rails, Other Track Material, Ballast, Track Laying and Surfacing, and Bridges, Trestles and Culverts. These items will have to be investigated for the following conditions:

(A) Passenger Traffic
- a. On tangent track.
- b. On curved track.

(B) Freight Traffic
- a. On tangent track.
- b. On curved track.

The elements of track maintenance mentioned above may be analyzed as follows with reference to their being affected by speed:

(A) Tie Renewals
- a. Proportion due to mechanical wear.
- b. Proportion due to spike killing.
- c. Proportion due to decay.

(B) Rail Renewals
- a. Proportion due to failures—head, web, base and broken.
- b. Proportion due to normal wear.
- c. Proportion due to rusting, etc.

(C) Other Track Material
- a. Proportion due to breakage.
- b. Proportion due to normal wear.
- c. Proportion due to rusting.

(D) Ballast Renewal
- a. Proportion due to pounding into roadbed, abrasion, etc.
- b. Proportion due to opening of gravel pits, overhead cost of machinery at pits, ballast on temporary tracks, etc.

(E) Track Laying and Surfacing
- a. Proportion due to applying ties.
- b. Proportion due to applying rails.
- c. Proportion due to applying O.T.M.
- d. Proportion due to applying ballast.
- e. Proportion chargeable to train service.
- f. Proportion chargeable to change of tracks.

(F) Superintendence
- a. Found to vary approximately as Track Laying and Surfacing.

(G) Bridges, Trestles and Culverts
- a. Proportion due to renewal and repair of floor and other parts that may be affected by speed conditions.
- b. Proportion due to painting, repairs to substructure, etc., which is independent of traffic conditions.

Only the proportions of the above accounts chargeable to main line would be affected by speed of trains as sidings and yard tracks would not be involved in any way.

Indices of the Effect of Speed on Maintenance

Certain observations have been made by various persons on the behavior of track under traffic as influenced by the speed of the passing trains which may be used as indices or measures of the effect of speed on the damage done to track, and consequently upon maintenance costs.

(a) Stresses in Rail.—The Special Committee on Stresses in Track (Proc., A.R.E.A., Vol. 19), after an extended investigation found that on the average, stresses in rail increase at the rate of three-fourths of one per cent. for each m.p.h. increase in speed above 5 m.p.h.

Tests made by Dean Turneaure of the University of Wisconsin (Trans., Am. Soc. C. E., Vol. 41) and by the Committee on Iron and Steel Structures (Proc., A.R.E.A., Vol. 12, Part 3) indicate that the dynamic stresses in bridges increase about two-thirds per cent. per m.p.h. and are about the same for passenger and freight equipment up to about 20 m.p.h., but for speeds of 50 m.p.h. the dynamic effect of freight equipment is about 20 to 30 per cent. greater than for passenger equipment. The Committee on Stresses in Track drew no conclusion as to the relative effects of speed in freight and passenger trains, but called attention to the increased stress resulting from a poorly adjusted locomotive equalizer. A study of the data submitted by the Committee indicates that the rate of increase in stress with speed under Mikado locomotives was about a fourth greater than under Pacific and Atlantic types.

(b) Pressures on Tie Plates.—A series of tests made by the Pennsylvania Railroad (Proc., A.R.E.A., Vol. 19, Special Monograph, p. 174 ff.) indicate that pressures on tie plates increase with speed about as follows:

1. On tangent track, maximum pressures increased 0.1 to 0.3 per cent. per m.p.h. increase in speed; average pressures increased about 0.1 per cent. per m.p.h. increase in speed.

2. On 2-deg. curve elevated 4 in. with measuring apparatus on the outer rail, maximum pressures and average pressures increased about as on tangent track.

3. On 6-deg. curve elevated 6 in. with the apparatus on the inner rail, the pressures decreased about 0.75 per cent. per each m.p.h. increase in speed, and principles of statics would indicate a corresponding increase of pressure under the outer rail.

These tests showed that equipment with rought or eccentric wheels may increase the pressure on tie plates at a rate of 20 per cent. or more above that induced by rolling stock with smooth wheels.

Note.—An engine pulling under steam was found to give somewhat higher pressures than when coasting at the same speed, although these results were questioned by the experimenters as the excess pressures were not greater than the range of experimental variation, only one such test having been made.

The pressures on tie plates on frozen roadbed averaged about 15 to 20 per cent. higher than on roadbed free from frost, although the percentages of variation with speed were unchanged.

(c) Lateral Thrust on Rails.—Tests made by G. W. Fowler (Railway Age Gazette, June 11, 1915) show that the lateral thrust on tangent track increases about 20 per cent. for an increase in speed from 30 to 60 m.p.h. or about two-thirds per cent. per m.p.h.

Other tests by Mr. Fowler (Railway Age Gazette, August 20, 1915) indicate that lateral thrust on rail on an 8 deg. 7 min. curve at 50 m.p.h. was about 2½ times that at 20 m.p.h. This result corresponds to the results of a theoretical analysis of the thrust, assuming that the thrust varies with the speed and the degree of curve.

(d) Deflection of Track.—Tests made by the Civil Engineering Department of the University of Kansas (Railway Age Gazette, July 16, 1915) and by the Department of Mechanics at the University of Nebraska (unpublished) indicate no greater deflection of track under high speed than under low speed for a given weight of wheel load.

(e) Theoretical Effect of Rate of Applying Load.—In laboratory experiments, it is a well-established fact that deformation of materials is less when the load is applied rapidly than when applied slowly (Textbook of Testing Materials, A. Martens, p. 242 ff.). That the opposite result is obtained under trains is due probably to impact effects caused by irregularities in track, imperfections in rolling stock, and to oscillations of rolling stock.

(f) Effect of Traction Forces.—Freight trains accelerate about 0.1 to 0.2 m.p.h. per second and decelerate at about the same rate, and passenger trains at two to three times this rate. For a freight train of 2,000 tons this would bring a traction force into the track of about 25,000 lbs., which would be about equaled by a passenger train of 700 tons. If speeds should be increased the rates of acceleration would probably be correspondingly increased. However, if the increased speed should be accompanied by a decreased train load, the traction forces in the track would remain unchanged, in so far as they are induced by acceleration. In general, traction forces under freight trains are much larger than under passenger trains.

Beyond the point of attaining normal speed, traction forces would vary essentially with the train resistance, which is about 75 per cent. greater at 50 m.p.h. than at 20 for freight trains and about 40 per cent. greater for passenger trains, the rate of increase being approximately twice as great for freight trains as for passenger. (Bulletins 43 and 110, Univ. of Ill. Eng. Exp. Sta.)

(g) Curve Resistance.—Experiments by the Department of Railway Engineering at the University of Illinois (Bulletin 92, Eng. Exp. Sta.) indicate that curve resistance increases about 3.5 per cent. per m.p.h. on 5-deg. and 10-deg. curves, due largely, doubtless, to increased flange pressure and grinding of flanges on the rail.

A. Tie Renewals.—The average of estimates given in the Proceedings of A.R.E.A., Vol. 9, p. 675, indicate the following weights to the causes of tie renewals:

Decay	86 per cent.
Rail cutting	7.5 per cent.
Spike killing	6.5 per cent.

Records kept on the Southern Pacific Lines for nine years indicate (Proc., A.R.E.A., Vol. 3, p. 104) that for well-ballasted track about 85 per cent. of ties removed due to "rottenness." Other data indicate that 70, 15 and 15, respectively, would be better figures to use for curved track. Assuming the former figures for tangent track and the latter for curved track, the effect of speed might be expected to manifest itself in the 14 or 30 per cent. of tie renewals resulting from destruction due to traffic. The pressures on tie plates and traction forces, i. e., the product of these two factors, may be taken as a measure of the variation in tie cutting, and the lateral thrust as a measure of spike pulling and consequently of spike killing.

Curves of 2 deg. and under may be considered as tangent track. The increase in the cost of ties on main line then would be for 50 m.p.h. over 20 m.p.h. for

Passenger Traffic

On tangent track, $(7.5 \times 0.015 + 6.5 \times 0.007) \times 30 = 3.4$ per cent.
On curved track, $15 \times 0.15 \times 30 + 15 \times 2.5 = 44.3$ per cent.

Freight Traffic

On tangent track, $3.4 \times 1.2 = 4.1$ per cent.
On curved track, $44.3 \times 1.2 = 53.2$ per cent.

(20 per cent. increase under freight assigned, because of greater tie pressures and greater traction effects.)

B. Rail Renewals.—Data collected by the Committee on Rail (Proc., A.R.E.A., Vol. 16) indicate that about 3 per cent. of rail renewals result from failures and the remainder from normal wear and rusting out, the latter being a small portion of the total, doubtless. Rail failures were classified as follows (Vol. 16, p. 219) for O. H. rails:

Head	47 per cent.
Web	9 per cent.
Base	9 per cent.
Broken	35 per cent.

The first three groups are the result largely of defective fabrication and the last class to defects and to stresses set up by loads. Failures due to defects occur almost regardless of the loads and would not be appreciably affected by the speed of trains. The 35 per cent. of failures may be assumed to vary as the stresses in the rails and the 65 per cent. as the pressures on the tie plates. In the absence of more definite information, the normal wear on tangent is assumed to vary with the pressure on tie plates.

On curves, assuming that the superelevation is properly adjusted, the wear on rails may be taken to vary as the pressure on the tie plates. If

2 per cent. of deterioration be assumed as due to rusting, this will leave 95 per cent. of renewals due to normal wear. For an increase of speed from 20 to 50 m.p.h. the effect on rail renewals would be, for

Passenger Traffic

On tangent track, $0.03\ (35 \times 0.007 + 65 \times 0.002 + 95 \times 0.001) \times 30 = 3.14$ per cent.

On curved track, $3.14 + 95 \times 0.0075 \times 30 = 24.5$ per cent.

Freight Traffic

On tangent track, $0.03\ (35 \times 0.009 + 65 \times 0.003 + 95 \times 0.001) \times 30 = 3.2$ per cent.

On curved track, $3.2 + 95 \times 0.0075 \times 30 = 24.6$ per cent.

C. Other Track Material.—The renewal of angle bars, bolts, frogs, crossings, guard rails, switch rails, tie plates, spikes, etc., may be assumed to vary similarly to rail renewal on tangent track. These constitute about half of the thirty-six items of the account and, as these are the main items, it is probably approximately correct to assume that they constitute about three-fourths of the entire amount. A study of Interstate Commerce Commission reports indicates that about three-fourths of the account varies with the density of the traffic, which roughly checks the assumption. The increase in lateral thrust being about five to seven times as great on curves as on tangent with a given increase in speed, and the pressures on tie plates two or three times as great, the deterioration of O. T. M. due to speed is assumed at five times as great on curves as on tangent track. The account would then be affected as follows for an increase of 30 m.p.h. for

Passenger Traffic

On tangent track, $0.75 \times 3.14 = 2.3$ per cent.

On curved track, $2.3 \times 5 = 11.5$ per cent.

Freight Traffic

On tangent track, $0.75 \times 3.2 = 2.4$ per cent.

On curved track, $2.4 \times 5 = 12.0$ per cent.

D. Ballast renewal results largely from the forcing of the ballast into the roadbed, pulverization under ties during surfacing and wear by traffic. A comparatively large portion of the ballast account consists of overhead charges on gravel pits, haulage equipment, rock crushers, etc., and this portion of the account is independent of small variations in the amount of ballast used.

Where the depth is of sufficient amount to distribute the train load, the pressure on the sub-grade does not exceed the normal supporting capacity of the soil usually, hence, forcing the ballast into the sub-grade results more from pumping the sub-grade up into the ballast than from a slight variation in pressure that might result from an increase in speed. This latter effect is due primarily to the amount and number of depressions of the track. Inasmuch as the observations on track depression mentioned above did not show any greater depression of track under high than under low speed for a given weight of wheel load, the forcing of the ballast into the sub-grade would probably not be affected greatly by speed. In the absence of better information, it is assumed that one-half of the ballast account is affected by a variation in speed due to pulverization under traffic and during surfacing. This 50 per cent. will be assumed to increase at the same rate as the pressures on the tie plates. For an increase in speed from 20 to 50 m.p.h. the ballast account would be increased for

Passenger Traffic

On tangent track, $0.50 \times 30 \times 0.2 = 3.0$ per cent.
On curved track, $0.50 \times 30 \times 0.75 = 11.3$ per cent.

Freight Traffic

On tangent track, $3.0 \times 1.2 = 3.6$ per cent.
On curved track, $11.3 \times 1.2 = 13.5$ per cent.

E. Track Laying and Surfacing.—In the report of the Committee on Economics of Railway Labor (Proc., A.R.E.A., Vol. 18, p. 420) a distribution of track labor on two test sections of different railroads is given, which, when grouped under the above maintenance accounts, gives the following proportions approximately:

Tie renewals	18 per cent. of total
Rail renewals	16 per cent. of total
O. T. M.	9 per cent. of total
Ballast	12 per cent. of total
Lining and surfacing	45 per cent. of total
	100 per cent.

Assuming the first four items to vary in the same proportion as the primary accounts, and the last to vary as all of these primary accounts (i. e., as the product of the factors), the increase for operation at 50 m.p.h. over 20 m.p.h. would be, for

Passenger Traffic

On tangent track, $18 \times 0.034 + 16 \times 0.31 + 9 \times 0.023 + 12 \times 0.03 + 45 \times 0.11 = 6.7$ per cent.
On curved track, $18 \times 0.44 + 16 \times 0.24 + 9 \times 0.11 + 12 \times 11 + 45 \times 0.98 = 58.0$ per cent.

Freight Traffic

On tangent track, $18 \times 0.041 + 16 \times 0.032 + 9 \times 0.024 + 12 \times 0.036 + 45 \times 0.14 = 8.8$ per cent.
On curved track, $18 \times 0.53 + 16 \times 0.24 + 9 \times 0.12 + 12 \times 0.135 + 45 \times 1.08 = 64.2$ per cent.

F. Superintendence.—A study of I. C. C. reports indicates that the Superintendence account varies about in the same proportion as the Track Laying and Surfacing account, as might be expected reasonably.

G. Bridges, Trestles and Culverts.—This account includes both sub-structure and super-structure. The major portion of the maintenance expense is chargeable to painting, repairing washouts, riprapping, cleaning channels, protection work, etc., which would be independent of traffic conditions. Renewals and repairs of floor and other members that might be affected by speed of traffic constitute a small portion of the total, and, in the absence of specific information, may be estimated at one-tenth of the total account. This tenth may be taken to vary about as impact in bridges varies, or about two-thirds per cent. per m.p.h. increase in speed. The effect of speed under freight traffic may be taken as 20 per cent. greater than under passenger. No information is available for making a distinction between bridges on tangent and those on curved track.

Summary.—The probable explanation of the increase in stress in rail, etc., under increased speeds is that the unevenness of the track interferes with the natural period of oscillation of the rolling stock and also to the fact that it causes a deflection of the rolling stock, both vertically and horizontally, from moving in a straight line.

According to the principles of theoretical mechanics, the force exerted by a moving body when deflected or brought to rest varies as the first power of the velocity, that is, inversely as the time in which the change occurs. Therefore, the force exerted by the track in deflecting the mass of the locomotive or car would vary as the first power of the velocity of the train. The tests on behavior of track under traffic also indicate that the variation is a direct one.

The equations for M. of W. & S. expenses may be written, therefore, in the following form:

Ties .... $Cost = A\ (1 + K_t\ V)$
Rails .... $Cost = B\ (1 + K_r\ V)$
O. T. M. .... $Cost = C\ (1 + K_m V)$
Ballast .... $Cost = D\ (1 + K_b\ V)$
Track Laying and Surfacing....... $Cost = E\ (1 + K_l\ V)$
Superintendence .... $Cost = F\ (1 + K_s\ V)$
Bridges, Trestles and Culverts...... $Cost = G\ (1 + K_v\ V)$

The perimeters A, B, C, etc., are the costs of the various items at any given speed of operation; the co-efficients K_t, K_r, etc., are the factors indicating the increase in the account per m.p.h. of increase in speed. Expressing these co-efficients from results obtained above, the values of K_t, K_r, etc., may be tabulated as follows:

Table 4

Co-efficient	For Passenger Trains		For Freight Trains	
	Tangent Track	Curved Track	Tangent Track	Curved Track
K_t	0.0011	0.015	0.0014	0.018
K_r	0.0010	0.0082	0.0031	0.0082
K_m	0.00080	0.0038	0.00080	0.0040
K_b	0.0010	0.0038	0.0012	0.0045
K_l	0.0022	0.019	0.0027	0.021
K_s	0.0022	0.019	0.0029	0.021
K_v	0.00067	0.00067	0.0009	0.0009

These co-efficients are predicated on observations made on well-constructed and well-maintained track and would be larger for inferior track.

As an illustration of the use of the above analysis, an estimate may be made of the increase in maintenance expenses due to an increase in the average speed of freight trains from 20 to 25 m.p.h. over a road consisting of 75 per cent. tangent and 25 per cent. curves. If the road is one carrying both passenger and freight traffic, the former will establish the standard of maintenance necessary, hence, the question of higher standard of maintenance will not be involved. The increase in main line expense for these accounts attributable to freight traffic would be as follows:

$100\,(0.0014 \times 0.75 + 0.018 \times 0.25) \times 5 = 2.8\%$	Tie expense.
$100\,(0.0031 \times 0.75 + 0.0082 \times 0.25) \times 5 = 2.2\%$	Rail.
$100\,(0.00080 \times 0.75 + 0.0040 \times 0.25) \times 5 = 0.8\%$	O. T. M.
$100\,(0.0012 \times 0.75 + 0.0045 \times 0.25) \times 5 = 1.0\%$	Ballast.
$100\,(0.0029 \times 0.75 + 0.021 \times 0.25) \times 5 = 3.7\%$	Track Laying and Surfacing.
$100\,(0.0029 \times 0.75 + 0.021 \times 0.25) \times 5 = 3.7\%$	Superintendence.
$100 \times 0.0009 \times 5 = 0.5\%$	Bridges, Trestles and Culverts.

On a certain railroad, an appropriate division of M. of W. & S. expenses gives 88 per cent. chargeable to main line and 85 per cent. allocable to freight traffic. On the above basis, the effect of increasing the speed of freight trains from 20 to 25 m.p.h. on this line would be as shown in Table 5.

TABLE 5

Account	Total	Main Line Exp. Chg. to Frt.		Increase	
		at 20 m.p.h.	at 25 m.p.h.	Dollars	Pct.
Superintendence	$ 26,867	$ 20,100	$ 20,900	800	3.0
Bridges, Trestles and Culverts	101,447	76,000	76,700	700	0.7
Ties	118,986	88,200	92,100	3900	3.3
Rails	181,653	135,000	140,000	5000	2.7
O. T. M.	93,146	69,600	71,000	1400	1.5
Ballast	72,811	54,500	55,400	900	1.2
Track Laying and Surfacing	305,478	238,400	247,000	8600	2.8
Totals	900,388	681,800	703,100	21300	

In this instance, the total increase in M. of W. & S. expense due to an increase in speed of freight trains from 20 to 25 m.p.h. would be about 2.4 per cent., or approximately 0.5 per cent. per m.p.h. increase in speed.

THE EFFECT OF SPEED OF TRAINS ON THE COST OF OPERATION

Teal and Sawyer.

The assignment of sections 2 and 3 of Sub-Committee was to determine the effect of speed of freight trains on the cost of transportation, accounts 371 to 420, inclusive, and maintenance of equipment, accounts 301 to 337, inclusive.

As there was not time or facilities available to analyze all accounts involved it was decided to confine the limits of this study to the effect of speed of freight trains on the cost of engine and train crew wages, accounts 392 and 401, locomotive fuel, account 394, and locomotive repairs, interest and depreciation, accounts 308, 309, 310. These are the largest individual accounts and represent approximately 50 per cent. of the total transportation and maintenance of equipment expenses.

In treating with locomotive repairs there has been no attempt to determine the effect of speed on wear and tear of the machine; the effect of speed on locomotive repairs is reflected in this study in the variable number of locomotive miles required to handle a given volume of traffic at different speeds. Interest and depreciation is determined by the time element. Engine and train crew wages and locomotive fuel were adjusted to actual conditions as nearly as possible.

After conferring with members of the Sub-Committee it was decided to take two freight divisions of the Baltimore & Ohio Railroad as a basis for conducting the study. The west and east end of the Cumberland Division was arbitrarily chosen in order to determine the relative effect the mountain grades would have with reference to the speeds of trains as compared with the comparatively light grades. The physical characteristics of these two freight divisions are briefly described in order to present the problem more clearly to those who are not familiar with the local operating conditions on this division of the Baltimore & Ohio Railroad.

The relation of this division to joining divisions is important. Trunk line business from the Southwest, including such points as Cincinnati and St. Louis, moves east through Grafton and Keyser, on the west end of the division, which is added to the business from Pittsburgh and Chicago from Northwest, all of which moves east from Cumberland and Patterson Creek to Tidewater. The condensed profile and track chart following will be helpful in bringing out some of the features adversely affecting the operation of these two freight divisions. (See Exhibit 1.)

The distance between Grafton and Keyser, the west end freight division, is 79.1 miles, of which 2.1 miles are in the yard at Grafton and 1.4 miles in the yard at Keyser. Freight train mileage is calculated on basis of 78 miles between terminals. Between East Grafton and West Keyser (75.6 miles) there are 37.6 miles of three track and 38 miles of two track. The yard capacity at Grafton is 1,240 cars, Piedmont 756 cars and Keyser 2,378 cars. There is also a small yard at Rinard, where tonnage trains are filled out. The west end is a mountain freight division; eastbound the total rise is approximately 2,200 feet and the total fall 2,400 feet. Curvature amounts to 10,036 degrees or an average of 133 degrees per mile, which is equivalent to a continuous curve of about 2 degrees and 30 minutes.

Reference to the track chart and profile will show the relative location of the two and three track system as compared with the mountain grades.

The distance, rated grades eastbound, engine ratings and car adjustment, are as follows:

	Distance	*Rated Grade*	*Rating for Mallet Locomotive*	*Adjustment per Car*
Grafton to Hardman...........	10 miles	0.5%	5,000	4
Hardman to Rinard Tower.....	29 miles	2.4%	1,250	4
Rinard Tower to Deer Park....	14 miles	0.4%	5,500	4
Deer Park to Altamont.........	4 miles	1.2%	2,750	4
Altamont to Keyser	21 miles	Desc.	5,500	4

The distance, rated grades westbound, engine ratings and car adjustment, are as follows:

	Distance	*Rated Grade*	*Rating for Mallet Locomotive*	*Adjustment per Car*
Keyser to Altamont	21 miles	2.4%	1,200	4
Altamont to Rinard Tower.....	18 miles	1.1%	2,850	4
Rinard Tower to Tunnelton....	20 miles	2.4%	1,200	4
Tunnelton to Grafton	19 miles	Desc.	2,850	4

The present standard operation for handling tonnage trains east from Grafton requires three Mallet lococomotives for the 2.4 per cent. grades. Three engine trains are usually rated at 3,750 tons under favorable weather conditions; however, this may be decreased according to prevailing temperature.

The east end freight run between Keyser and Brunswick is 112 miles in length via the Patterson Creek and Magnolia freight line cut-offs, of which 22 miles are four track, 59 miles are three track and 31 miles are two track. All eastbound traffic is handled via the Cherry Run low grade line, between Cherry Run and West Cumbo, while all westbound traffic is handled over the old line between the same points, which is approximately two miles shorter.

The capacities of yards are as follows: Keyser 2,378, Cumberland West 1,212, Cumberland East 3,412, Cherry Run 407, Cumbo 662, Martinsburg 867, Brunswick West 3,573, and Brunswick East 2,533 cars.

Freight train mileage is figured 112 miles eastbound and 110 miles westbound.

Eastbound the total rise is approximately 464 feet and the total fall 1012 feet. Curvature eastbound amounts to 6,810 degrees, or an average of 60 degrees 48 minutes per mile, which is equivalent to a continuous curve of 1 degree and 9 minutes.

The distance, rated grades eastbound, engine ratings and car adjustment, are as follows:

	Distance	*Rated Grade*	*Rating for Mikado Locomotive*	*Adjustment per Car*
Keyser to Rawlings	10 miles	Desc.	7,000	15
Rawlings to Knobley Tunnel....	6 miles	0.3%	6,000	15
Knobley Tunnel to Cherry Run.	56 miles	0.2%	7,000	15
Cherry Run to Opequon........	18 miles	0.3%	5,000	15
Opeqoun to Hobbs	8 miles	0.8%	2,500	15
Hobbs to Brunswick............	14 miles	0.2%	5,000	15

The eastbound tonnage trains are rated for a 0.2 per cent. grade. This requires helper engines for all full-rated trains on the hills between Rawlings and Knobley, Cherry Run and West Cumbo, and Opequon and Hobbs.

Westbound distance, rated grades, engine ratings and car adjustment are as indicated below:

	Distance	*Rated Grade*	*Rating for Mikado Locomotive*	*Adjustment per Car*
Brunswick to West Cumbo.....	30 miles	0.9%	2,200	7
West Cumbo to Patterson Creek	60 miles	0.6%	2,600	7
Patterson Creek to Keyser......	20 miles	0.8%	2,600	7

It will be noted that the ruling grade is 0.6 per cent. and helper engines are required for full-rated trains between Brunswick and the top of the hill on the main line just west of Cumbo and between Patterson Creek and Keyser.

Locomotives used in the operation of these two freight divisions are as follows:

West End.—Mallet type, class 2-8-8-0, compound superheated and provided with stokers and power reverse gear. The weight on drivers is 462,500 pounds, total weight of engine and tender 331½ tons, and the cylinder tractive power 104,000 pounds.

East End.—Mikado type, class 2-8-2, simple superheated stoker. Weight on drivers 222,000 pounds, total weight engine and tender 232 tons, and cylinder tractive power 58,800 pounds.

Locomotive rating charts were prepared for Mallet and Mikado types, as shown by Exhibits 2 and 3. These charts show the theoretical speeds and rating for various grades up to 3.0 per cent. and were calculated by using the adopted formula, published in the American Railway Engineering Association Manual.

Both freight divisions were then divided in accordance with the various rated grades and by the use of these charts the average speeds between stations were calculated for train ratings, stepped down from 5,000 tons to 250 tons on the west end and from 7,000 tons to 1,000 tons on the east end, at intervals of 250 tons each. By applying the average speed for the different train ratings between stations for each rate of grade the total moving time was readily calculated.

In considering the speed of freight trains on the mountain grades, west end, and at limiting points on the east end, it was necessary to conform with the time card speed restrictions. In this connection the 21-mile descending grade east from Altamont has two safety switches electrically interlocked in order to reduce the hazard of freight trains running away to a minimum.

The total crew time, including initial and terminal time, was next calculated and adjusted in accordance with the ratio of moving time to total crew time, which was obtained by taking the average performance from a number of selected days when the volume of traffic was heavy, indicating the conditions that confront the management in operating these two freight divisions under normal conditions.

Exhibit 4 shows the results of calculations for the west end eastbound movement. Under normal conditions this division is required to handle an average of 1,200 loads east from Grafton daily. The preponderance of traffic is coal from the Fairmont coal fields. The gross weight per car averages about 75 tons, including 4 tons adjustment, which will make a total of 7,020,000 gross adjusted ton miles handled daily. The maximum daily movement on this division in 1919 was 1,216 loads; however, this record was exceeded on August 20, 1920, when 1,449 loads were moved east from Grafton.

The westbound movement shown by Exhibit 5 practically balances the eastbound movement and as a greater number of cars moved are empty, the average gross weight per car is approximately 30 tons, including 4 tons per car adjustment. The daily average movement of 1,200 cars represents 2,808,000 adjusted gross ton miles.

The following units were used in arriving at cost figures shown in columns 10 to 16 inclusive.

1. Wages.—Standard 8-hour day, with time and half for overtime, the hourly rate for train crew is as follows:

Mallet Locomotives	*Rate per Hour*
Engineer	$1.13
Fireman	.85
Conductor	.80½
Three Brakemen	.64
Total straight time	$4.70
Total overtime	$7.05

2. Fuel.—$4.00 per ton, which is equivalent to approximately $12 per locomotive hour moving time. This figure conforms closely with the performance in September, 1920, with a charge of 86 cents per Mallet locomotive mile.

3. Repairs.—75 cents per locomotive mile. This figure was obtained by experience from present practice.

4. Interest and Depreciation.—$1.40 per locomotive hour crew time. This is calculated at 10 per cent. on capital value adjusted to average performance with present practice.

Exhibit 6 shows the results of calculations for the east end eastbound movement. For this study an average daily movement of 2,350 cars was taken. The gross weight per car averages approximately 78 tons, including 15 tons adjustment. This movement represents the average traffic taken from selected days and is an indication of the business this division is required to handle under normal conditions. The westbound movement of 2,100 cars daily, gross weight 33 tons per car, including 7 tons adjustment, represents the average balance of traffic. (See Exhibit 7.)

The daily gross adjusted ton miles eastbound is 20,529,000, westbound 7,623,000. The following units were used in arriving at the cost figures shown in columns 10 to 16, inclusive:

1. Wages.—Standard 8-hour day, with time and half for overtime, as follows:

Mikado Locomotives	*Rate per Hour*
Engineer	$ .98
Fireman	.75
Conductor	.80½
Two brakemen	.64
Total straight time	$3.81
Total overtime	$5.72

2. Fuel.—$4.00 per ton, which is equivalent to approximately $10 per locomotive hour moving time. This conforms closely with the September, 1920, performance of 66 cents for Mikado locomotive mile, present practice.

3. Repairs.—45 cents per locomotive mile. This figure was obtained from experience from present practice.

4. Interest and Depreciation.—75 cents per locomotive hour crew time. This is calculated at 10 per cent. on capital and adjusted to average performance present practice.

Freight car equipment costs that vary with time are not considered in this study. Such items as per diem and interest and depreciation would be affected.

Particular attention is called to the following columns on Exhibits 4, 5, 6 and 7:

1—Gross adjusted train load.
2—Number of trains per day.
8—Average miles per hour moving time.
13—Cost per 100 gross ton miles, engine and train crew wages.
14—Cost per 100 gross ton miles, locomotive fuel.
15—Cost per 100 gross ton miles, repairs, interest and depreciation.
16—Cost per 100 gross ton miles, total 13, 14 and 15.

A reduction in average miles per hour moving time and a reduction in unit cost per 100 gross ton miles will be noticed at each point where helper mileage was reduced, which is indicated on Exhibits by heavy black lines.

Columns 13 and 14, showing the cost per 100 gross ton miles for engine and train crew wages and locomotive fuel, are both direct transportation charges.

Comparing costs per 100 gross ton miles, column 16, with the total crew time, column 9, indicates that the most economical speeds are those that will consume 8 hours or more crew time, including terminal time. As the total crew time decreases under 8 hours the unit costs rapidly increase.

Exhibits 8 and 9, following, are curves showing the number of freight trains required to handle the normal business on the Cumberland Division for various speeds between terminals, moving time.

The curves are comparatively flat for slow speeds; however, they rapidly ascend as the speed increases, indicating that the number of trains required to handle normal traffic on the railroad would be excessive and not practical in operation. The frequent running of light trains at fast speed would soon create a congested condition in case of accident.

The balance of traffic should be taken into consideration in any method of operating the Cumberland Division in order to reduce light running of power to a minimum.

An examination of column 16 shows the most economical train load and average speed between stations in handling the business as follows (see Exhibits 4, 5, 6 and 7 for detail):

Item	Minimum Cost				To Balance Traffic			
	Train Loads Tons	Average Speed Moving Time	No. Trains Daily	Cost Per 100 GTM Cents Note	Train Loads Tons	Average Speed Moving Time	No. Trains Daily	Cost Per 100 GTM Cents
WEST END								
Eastbound	2500	13.2	36.0	17.44	3750	13.1	24.0	17.82
Westbound	5000	12.9	7.2	16.36	1500	16.6	24.0	21.48
EAST END								
Eastbound	5500	16.0	33.3	3.33	6000	15.2	30.6	3.55
Westbound	5000	14.4	13.8	8.67	2250	21.5	30.8	9.39

NOTE.—Does not include cost of moving light engines to balance power.

Exhibits 10 and 11, following, are curves, showing the tendency of freight train costs per 100 gross ton miles for various gross adjusted train loads on the Cumberland Division. The cost includes wages of engine and train crews, locomotive fuel, locomotive repairs and interest and depreciation.

The curves are comparatively flat for the larger train loads; they ascend very rapidly as the train load is decreased, permitting the average speed between terminals, moving time, to approach safe maximum for the division.

An examination of column 16, Exhibits 4, 5, 6 and 7, shows the most economical train load to be as follows:

Item	Minimum Cost		To Balance Traffic	
	Train Loads Tons	Cost Per 100 G. T. M. Cents Note	Train Loads Tons	Cost Per 100 G. T. M. Cents
WEST END				
Eastbound	2500	17.44	3750	17.82
Westbound	5000	16.36	1500	21 48
EAST END				
Eastbound	5500	3.33	6000	3.55
Westbound	5000	8.67	2250	9.39

NOTE.—Does not include cost of moving light engines to balance power.

The actual points were plotted on the diagram and the curves drawn to represent an average.

Exhibits 12 and 13, following, are curves showing the tendency of freight train costs per 100 gross ton miles for various speeds between terminals, moving time, on the Cumberland Division.

The cost includes wages of engine and train crews, locomotive fuel, locomotive repairs and interest and depreciation.

The curves indicate a minimum cost at the lower speeds and rapidly ascend at the average speed, moving time, approaches a maximum safe speed for operating freight trains on the division.

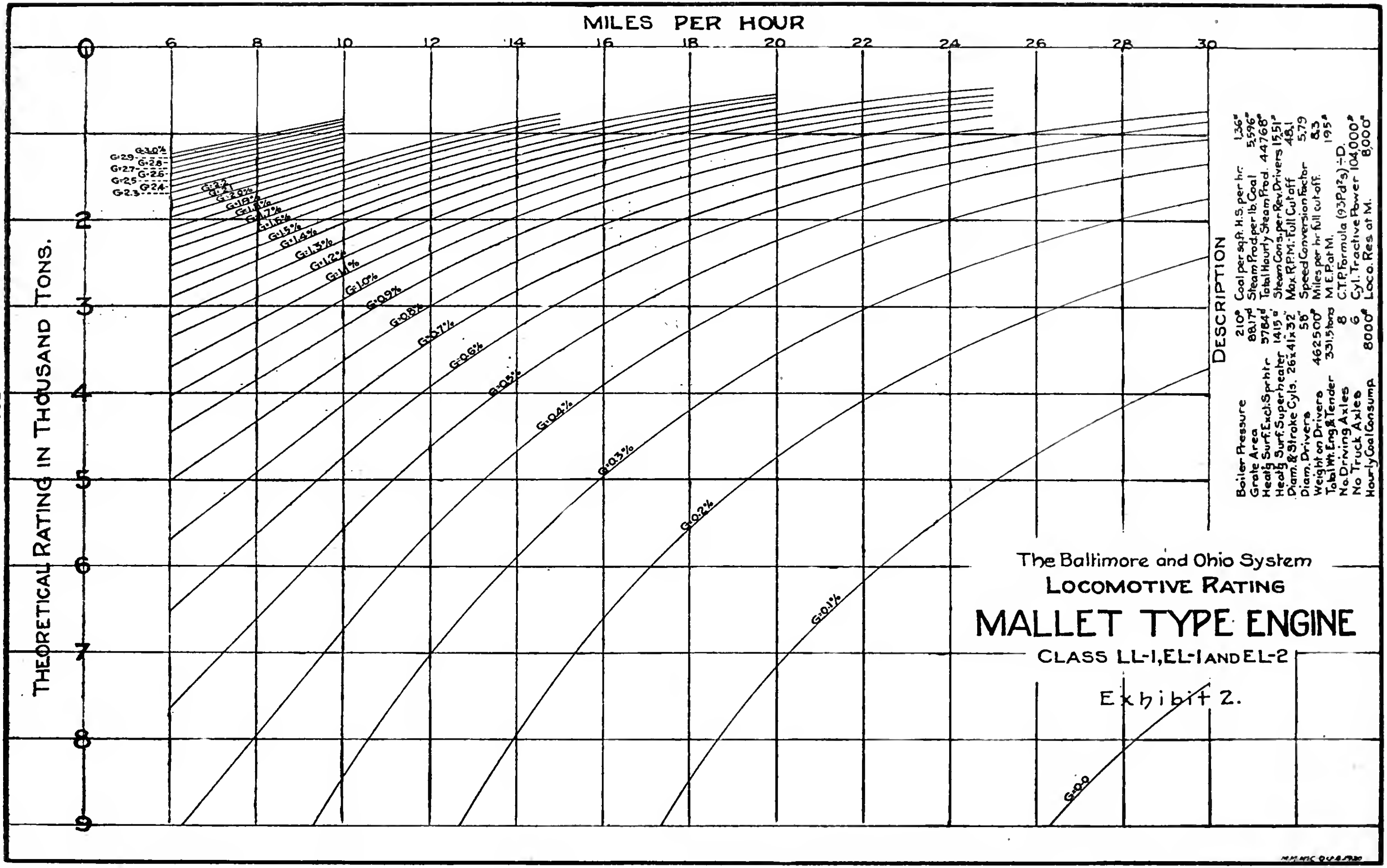
Speeds in excess of 20 miles per hour on the West End and 35 miles per hour on the East End are not considered practical for freight train operation on the Cumberland Division.

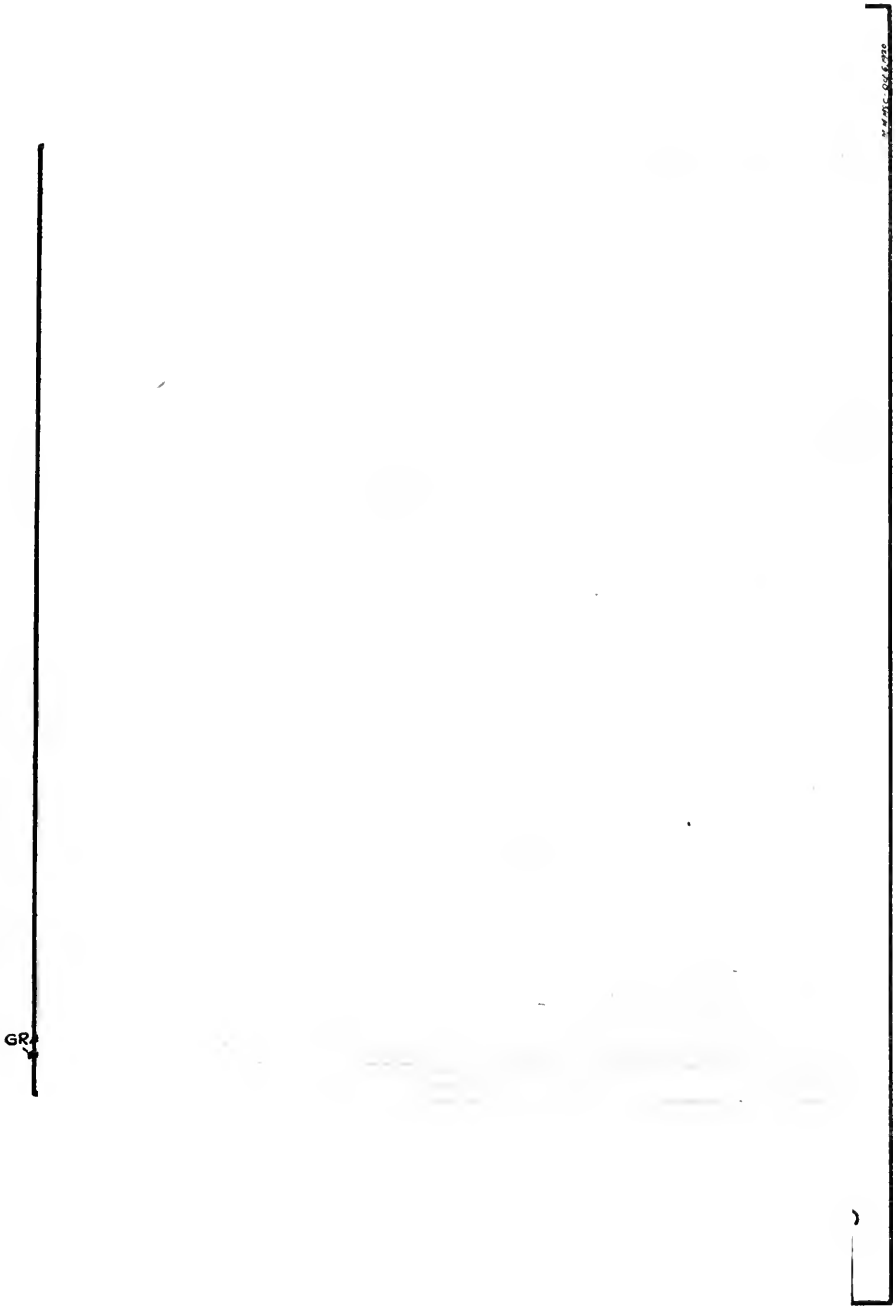
An examination of column 16, Exhibits 4, 5, 6 and 7, shows the most economical speed between terminals, moving time, to be as follows:

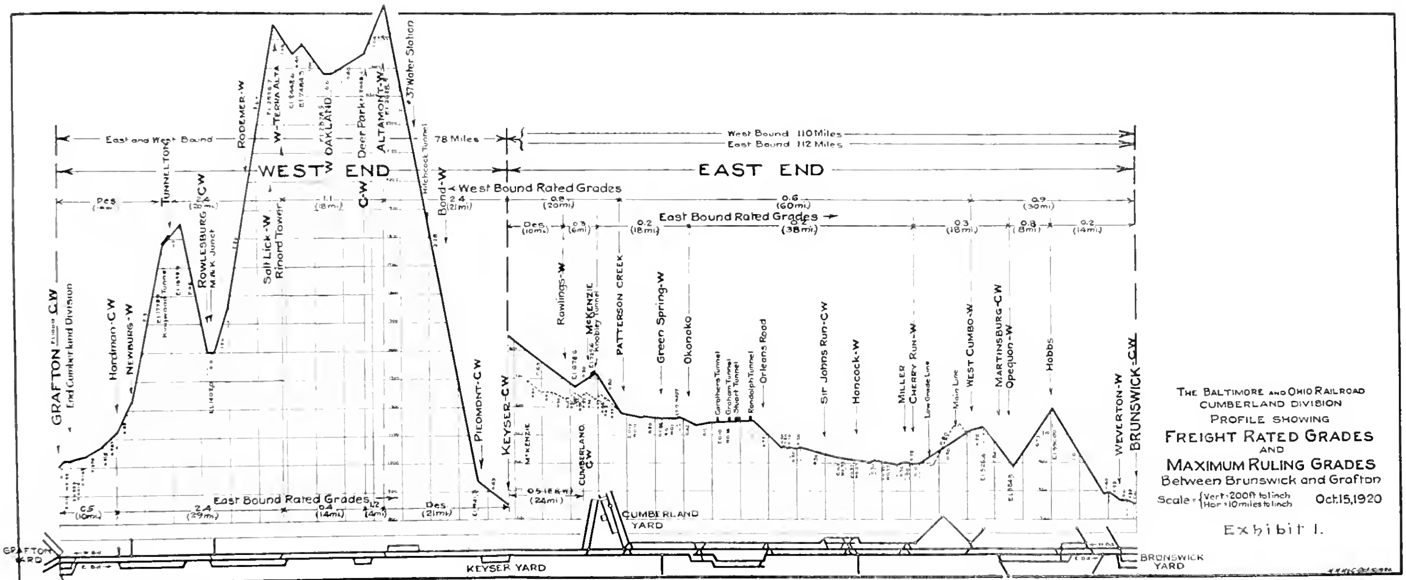
Item	Minimum Cost		To Balance Traffic	
	Average Speed Moving Time	Cost Per 100 G. T. M. Cents Note	Average Speed Moving Time	Cost Per 100 G. T. M. Cents
WEST END				
Eastbound	13.2	17.44	13 1	17.82
Westbound	12.9	16.36	16 6	21.48
EAST END				
Eastbound	16.0	3.33	15 2	3.55
Westbound	14.4	8.67	21.5	9 39

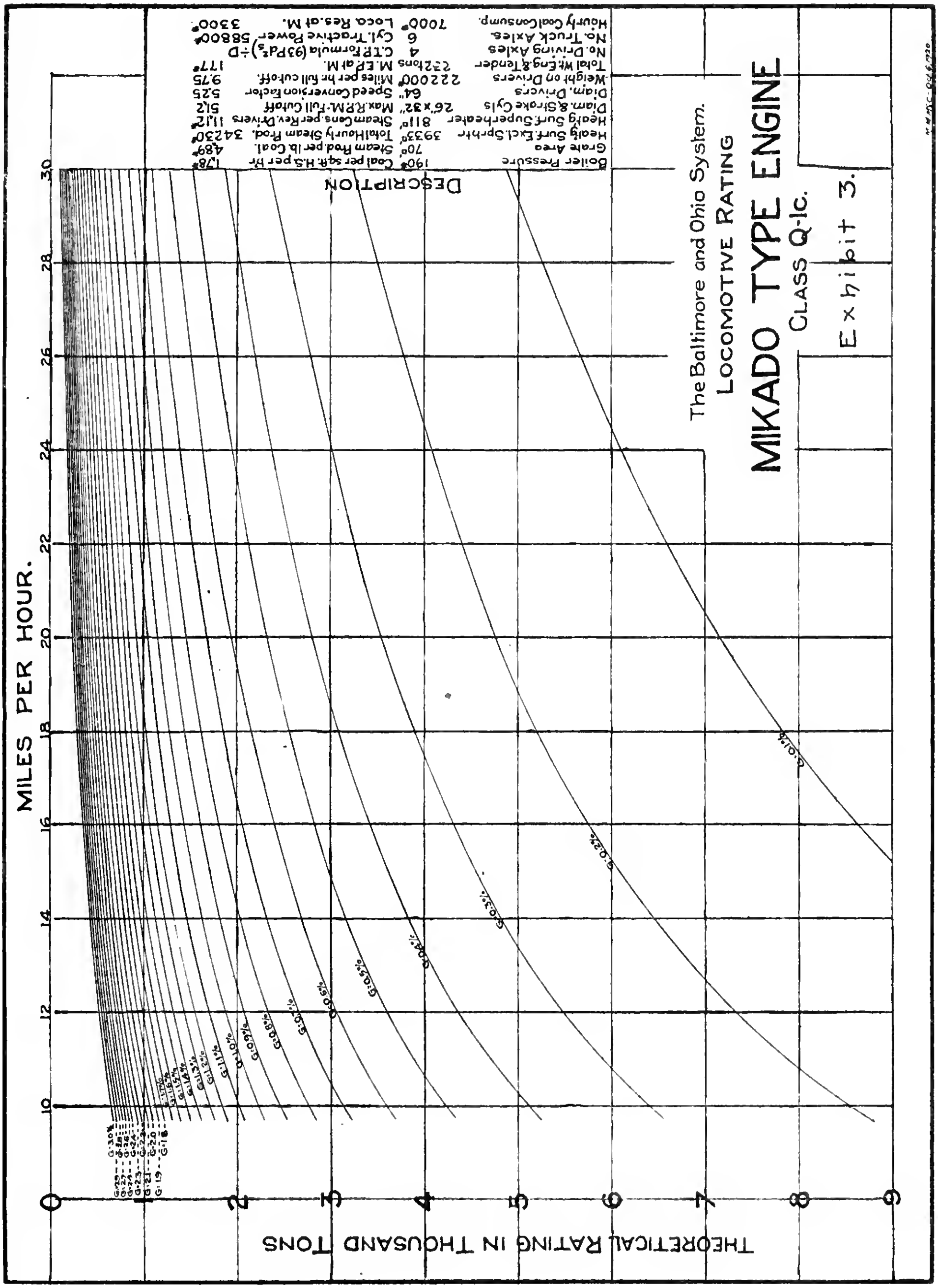
NOTE.—Does not include cost of moving light engines to balance power.

The actual points were plotted on the diagram and the curves drawn to represent an average.


MILES PER HOUR
THEORETICAL RATING IN THOUSAND TONS.
DESCRIPTION
Boiler Pressure 210# Coal per sq.ft. H.S. per hr. 1.36#
Grate Area 88.17 Steam Prod. per lb. Coal 5.596#
Heatg. Surf. Excl. Sprhtr. 5784 Total Hourly Steam Prod. 44768#
Heatg. Surf. Superheater 1415 Steam Cons. per Rev. Drivers 15.51#
Diam. & Stroke Cyls. 26x41x32 Max. R.P.M. - Full Cut off 48.1
Diam. Drivers 58" Speed Conversion Factor 5.79
Weight on Drivers 462500# Miles per hr. full cut-off 8.3
Total Wt. Eng. & Tender 331.5 tons M.E.P. at M. 195#
No. Driving Axles 8 C.T.P. Formula (93Pd²s)÷D.
No. Truck Axles 6 Cyl. Tractive Power 104,000#
Hourly Coal Consump. 8000# Loco. Res. at M. 8,000#
The Baltimore and Ohio System
LOCOMOTIVE RATING
MALLET TYPE ENGINE
CLASS LL-1, EL-1 AND EL-2
Exhibit 2.


N M MSC - Oct 6 1920
GR


The Baltimore and Ohio Railroad
Cumberland Division
Profile showing
Freight Rated Grades
and
Maximum Ruling Grades
Between Brunswick and Grafton
Scale = {Vert: 200 ft to inch / Hor = 10 miles to inch}
Oct. 15, 1920
Exhibit I.
East and West Bound
78 Miles
West Bound 110 Miles
East Bound 112 Miles
WEST END
EAST END
West Bound Rated Grades
East Bound Rated Grades
GRAFTON CW
End Cumberland Division
Hardman-CW
NEWBURG-W
TUNNELTON
ROWLESBURG
M&K Junct
RODEMER-W
Salt Lick-W
Rinard Tower
W-TERRA ALTA
OAKLAND
Deer Park
ALTAMONT-W
37 Water Station
Hitchcock Tunnel
Bond-W
PIEDMONT-CW
KEYSER-CW
Rawlings-W
McKENZIE
Knobley Tunnel
CUMBERLAND CW
PATTERSON CREEK
Green Spring-W
Okonoko
Carothers Tunnel
Graham Tunnel
Stuart Tunnel
Randolph Tunnel
Orleans Road
Sir Johns Run-CW
Hancock-W
MILLER
CHERRY RUN-W
Low Grade Line
Main Line
WEST CUMBO-W
MARTINSBURG-CW
Opequon-W
Hobbs
WEVERTON-W
BRUNSWICK-CW
CUMBERLAND YARD
KEYSER YARD
GRAFTON YARD
BRUNSWICK YARD
Des (10mi)
2.4 (21mi)
0.8 (20mi)
0.6 (60mi)
0.9 (30mi)
0.3 (6mi)
0.2 (18mi)
0.2 (38mi)
0.3 (18mi)
0.8 (8mi)
0.2 (14mi)
0.5 (10mi)
2.4 (29mi)
0.4 (14mi)
1.2 (4mi)
Des (21mi)
0.5 (EB W) (24mi)
1.1 (18mi)


The Baltimore and Ohio System.
LOCOMOTIVE RATING
MIKADO TYPE ENGINE
CLASS Q-1c.
Exhibit 3.
MILES PER HOUR.
THEORETICAL RATING IN THOUSAND TONS
DESCRIPTION

WEST END-CUMBERLAND DIVISION-GRAFTON TO KEYSER (Eastbound)

Freight Run-78 miles. Cars Handled Daily-1200. Adjusted Gross Ton Miles-Daily 7,020,000.

Gross Adjusted Train Load Tons of 2000 lbs.	Number of Trains per Day	Train Mileage	Gross Adjusted Ton Mileage per Train	Locomotive Mileage per Train			Average Miles per Hour Moving Time	Total Crew Time per Train including Term. Time	Total Wage Cost per Train	Cost per Loco. per Train		Cost per 100 Gross Ton Miles			
				Road	Helper	Total				Fuel @ $4.00 per Ton 12.00 P.L.H.	Repairs Interest Depreciat'n	Engine and Train Crew Wages	Locomotive Fuel	Locomotive Repairs Interest Deprec.	Total
								Hours	Dollars	Dollars	Dollars	Cents	Cents	Cents	Cents
5000	18.00	1405	390000	78	182	260	12.27	14.50	201.60	254.00	262.60	5.18	6.50	6.74	18.42
4750	18.95	1478	370000	78	182	260	12.73	13.70	189.80	245.00	259.00	5.13	6.62	7.00	18.75
4500	20.00	1560	351000	78	182	260	13.00	13.20	192.10	239.00	256.60	5.48	6.81	7.31	19.60
4250	21.17	1650	331500	78	182	260	13.45	12.50	171.30	232.00	253.20	5.17	7.00	7.64	19.81
4000	22.50	1755	312000	78	182	260	13.80	12.00	163.80	226.00	251.00	5.25	7.24	6.04	20.53
3750	24.00	1872	292500	78	124	202	13.06	12.50	138.90	185.50	196.90	4.75	6.34	6.73	17.82
3500	25.70	2005	273000	78	124	202	13.32	11.95	131.90	182.00	194.80	4.83	6.67	7.14	18.64
3250	27.70	2160	253500	78	124	202	13.85	11.28	123.50	175.00	192.40	4.87	6.90	7.59	19.36
3000	30.00	2340	234000	78	124	202	14.30	10.69	116.20	169.20	190.30	4.96	7.23	8.13	20.32
2750	32.75	2555	214500	78	124	202	14.75	10.15	109.35	164.50	188.30	5.10	7.68	8.78	21.56
2500	36.00	2810	195000	78	58	136	13.24	11.08	88.10	123.00	129.10	4.52	6.30	6.62	17.44
2250	40.00	3120	175500	78	58	136	13.70	10.50	82.50	119.00	127.60	4.70	6.78	7.27	18.75
2000	45.00	3512	156000	78	58	136	14.40	9.75	75.35	113.50	125.80	4.83	7.28	8.06	20.17
1750	51.40	4010	136500	78	58	136	15.00	9.18	69.80	108.60	124.40	5.11	7.96	9.11	22.18
1500	60.00	4680	117000	78	58	136	15.60	8.55	63.75	104.50	122.90	5.45	8.93	10.50	24.88
1250	72.00	5620	97500	78	58	136	16.05	8.10	59.40	102.00	121.80	6.09	10.46	12.50	29.05
1000	90.00	7020	78000	78	58	136	16.50	7.68	57.60	98.40	120.75	7.38	12.60	16.35	36.33
750	120.00	9360	58500	78	-	78	15.90	7.77	37.60	58.90	69.35	5.49	8.60	10.15	24.24
500	180.00	14050	39000	78	-	78	16.73	7.20	37.60	55.90	68.60	9.64	14.34	17.60	41.58
250	360.00	28100	19500	78	-	78	17.03	6.90	37.60	55.00	68.15	19.30	28.20	34.90	82.40
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

Remarks (17)

Mallet Loco. used for road movement and helpers.

Gross adjusted car load 75 tons incl. 4 tons adjustment per car.

Cost of fuel @ $4.00 per ton reduced to $12.00 per loco. hour moving time (Sept. performance of $.86 per loco. mile).

Cost of repairs @ $.75 per loco. mile as developed by experience.

Interest and depreciation 10% on Capital value of equipment and reduced to $1.40 for loco. hour crew time.

Wages of train crew based on standard 8 hour day with time and one-half for overtime; hourly rate, Engineer $1.13, Fireman $.85, Conductor $.80½, three Brakemen $.64, total straight time $4.70. Total overtime $7.05 per hour.

Freight car equipment costs that are variable with moving time are not considered. Such items as per diem, interest and depreciation would be affected by speed.

Exhibit 4

WEST END-CUMBERLAND DIVISION- KEYSER TO GRAFTON (Westbound)

Freight Run-78 miles Cars Handled Daily-1200 Adjusted Gross Ton Miles-Daily 2,808,000.

Gross Adjusted Train Load Tons of 2000 lbs.	Number of Trains per Day	Train Mileage	Gross Adjusted Ton Mileage per Train	Locomotive Mileage per Train			Average Miles per Hour Moving Time	Total Crew Time per Train including Term. Time	Total Wage Cost per Train	Cost per Loco. per Train		Cost per 100 Gross Ton Miles			
				Road	Helper	Total				Fuel @ $4.00 per Ton 12.00 P.L.H.	Repairs Interest Depreciation	Engine and Train Crew Wages	Locomotive Fuel	Locomotive Repairs Interest Deprec.	Total
								Hours	Dollars	Dollars	Dollars	Cents	Cents	Cents	Cents
5000	7.20	562	390000	78	160	238	12.88	13.80	179.25	221.50	237.50	4.59	5.68	6.09	16.36
4750	7.77	606	370000	78	160	238	13.42	13.02	166.50	212.50	234.00	4.50	5.74	6.32	16.56
4500	8.00	624	351000	78	160	238	13.75	12.50	159.15	207.50	231.90	4.53	5.92	6.61	17.06
4250	8.46	660	331500	78	160	238	14.26	11.85	149.75	200.00	229.10	4.52	6.04	6.92	17.48
4000	9.00	702	312000	78	160	238	14.63	11.30	142.05	195.00	226.80	4.55	6.25	7.30	18.10
3750	9.60	748	292500	78	116	194	13.70	11.85	126.55	169.75	186.80	4.33	5.81	6.39	16.53
3500	10.26	800	273000	78	116	194	14.25	11.18	118.20	163.25	184.40	4.33	5.98	6.76	17.07
3250	11.05	862	253500	78	116	194	14.85	10.50	109.80	156.50	182.00	4.33	6.18	7.18	17.69
3000	12.00	936	234000	78	116	194	15.38	9.95	103.15	151.25	180.15	4.40	6.46	7.70	18.56
2750	13.10	1020	214500	78	116	194	15.92	9.40	96.50	146.50	178.25	4.50	6.83	8.31	19.64
2500	14.40	1123	195000	78	72	150	14.46	10.10	85.00	124.25	139.70	4.36	6.37	7.16	17.89
2250	16.00	1247	175500	78	72	150	15.26	9.38	77.65	117.75	137.75	4.43	6.71	7.85	18.99
2000	18.00	1404	156000	78	72	150	16.07	8.70	70.65	112.00	135.90	4.53	7.18	8.71	20.42
1750	20.55	1603	136500	78	44	122	15.75	8.66	59.40	93.00	110.50	4.35	6.81	8.10	19.26
1500	24.00	1872	117000	78	44	122	16.55	8.04	53.80	88.50	109.10	4.60	7.56	9.32	21.48
1250	28.80	2246	97500	78	-	78	14.50	8.95	44.30	64.50	71.00	4.54	6.61	7.28	18.43
1000	36.00	2808	78000	78	-	78	16.07	7.89	37.60	58.20	69.55	4.82	7.46	8.91	21.19
750	48.00	3745	58500	78	-	78	17.25	7.16	37.60	54.25	68.50	6.43	9.28	11.70	27.41
500	72.00	5620	39000	78	-	78	18.10	6.64	37.60	51.75	67.80	9.64	13.27	17.38	40.29
250	144.00	11240	19500	78	-	78	18.37	6.37	37.60	51.00	67.40	19.30	26.15	34.55	80.00
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

Remarks (17)

Mallet Loco used for road movement and helpers

Gross adjusted car load 30 tons incl. 4 tons adjustment per car

Cost of fuel @ $4.00 per ton reduced to $12.00 per loco. hour moving time (Sept. performance of $.86 per loco. mile)

Cost of repairs @ $.75 per loco. mile as developed by experience.

Interest and depreciation 10% on Capital value of equipment and reduced to $1.40 for loco. hour crew time.

Wages of train crew based on standard 8 hour day with time and one-half for overtime; hourly rate, Engineer $1.13; Fireman $.85, Conductor $.80½, three Brakemen $.64, total straight time $4.20. Total overtime $7.25 per hour.

Freight car equipment costs that are variable with moving time are not considered. Such items as per diem, interest and depreciation would be affected by speed.

Exhibit 5

EAST END-CUMBERLAND DIVISION-KEYSER TO BRUNSWICK (Eastbound)

Freight Run-112 miles Cars Handled Daily-2350 Adjusted Gross Ton Miles-Daily 20,529,600

Gross Adjusted Train Load Tons of 2000 lbs.	Number of Trains per Day	Train Mileage	Gross Adjusted Ton Mileage per Train	Locomotive Mileage per Train: Road	Locomotive Mileage per Train: Helper	Locomotive Mileage per Train: Total	Average Miles per Hour Moving Time	Total Crew Time per Train including Term'l Time	Total Wage Cost per Train	Cost per Loco. per Train: Fuel @ $4.22 per Ton 10.00 P.L.H.	Cost per Loco. per Train: Repairs Interest Depreciation	Cost per 100 Gross Ton Miles: Engine and Train Crew Wages	Cost per 100 Gross Ton Miles: Locomotive Fuel	Cost per 100 Gross Ton Miles: Locomotive Repairs Interest Deprec.	Cost per 100 Gross Ton Miles: Total
								Hours	Dollars	Dollars	Dollars	Cents	Cents	Cents	Cents
7000	26.20	2935	784000	112	66	178	14.55	12.82	84.60	122.50	95.30	1.08	1.57	1.22	3.87
6750	27.15	3040	756000	112	66	178	15.20	12.30	80.50	117.20	94.65	1.07	1.55	1.25	3.87
6500	28.20	3160	728000	112	32	144	13.65	13.70	76.80	105.50	78.00	1.06	1.45	1.07	3.58
6250	29.35	3288	700000	112	32	144	14.55	12.83	71.00	99.00	77.15	1.02	1.42	1.10	3.54
6000	30.58	3460	672000	112	32	144	15.20	12.28	67.30	94.90	76.65	1.00	1.41	1.14	3.55
5750	31.90	3572	644000	112	32	144	15.94	11.72	63.50	90.40	76.10	.99	1.40	1.18	3.57
5500	33.35	3735	616000	112	16	128	16.00	11.66	57.20	80.00	67.60	.93	1.30	1.10	3.33
5250	34.90	3890	588000	112	16	128	16.90	11.05	53.40	75.80	67.07	.91	1.29	1.14	3.34
5000	36.70	4110	560000	112	16	128	17.78	10.50	49.80	72.00	66.22	.89	1.28	1.18	3.35
4750	38.60	4325	532000	112	16	128	18.82	9.92	46.45	68.00	66.10	.87	1.28	1.24	3.39
4500	40.75	4565	504000	112	16	128	20.03	9.32	42.65	63.90	65.60	.85	1.27	1.30	3.42
4250	43.15	4835	476000	112	16	128	21.27	8.78	39.38	60.20	65.12	.83	1.26	1.37	3.46
4000	45.85	5135	448000	112	16	128	22.67	8.24	36.03	56.50	64.67	.81	1.26	1.45	3.52
3750	48.90	5480	420000	112	16	128	24.18	7.72	34.35	52.90	64.22	.82	1.26	1.53	3.61
3500	52.40	5870	392000	112	16	128	25.72	7.25	34.15	49.70	63.82	.87	1.27	1.63	3.77
3250	56.40	6320	364000	112	16	128	27.50	6.78	33.90	46.50	63.42	.93	1.28	1.74	3.95
3000	61.10	6840	336000	112	16	128	29.20	6.40	33.70	43.90	63.08	1.00	1.31	1.88	4.19
2750	66.70	7470	308000	112	16	128	31.00	6.02	33.50	41.30	62.76	1.09	1.34	2.04	4.47
2500	73.40	8220	280000	112	16	128	32.00	5.83	33.40	40.00	62.60	1.19	1.38	2.24	4.81
2250	81.50	9130	252000	112	16	128	33.10	5.64	33.33	38.70	62.44	1.32	1.54	2.48	5.34
2000	91.70	10270	224000	112	16	128	34.15	5.47	33.23	37.50	62.29	1.48	1.67	2.78	5.93
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

Remarks (17)

Mikado Locomotives used for road movement and helpers.

Gross adjusted car load 78 tons including adjustment of 15 tons per car.

Wages of train crew based on standard 8 hour day with time and one half for overtime; hourly rate, Engineer $0.98, Fireman $.75, Conductor $.80½, two Brakemen $.64, total straight time $3.81. Total overtime $5.72.

Cost of Fuel $4.22 per ton; reduced to $10.00 per locomotive hour moving time based on September performance of $.66 per locomotive mile.

Cost of Repairs @ $.45 per locomotive mile as developed by experience.

Interest and Depreciation 10% on value of equipment and reduced to $.75 per loco. hour crew time.

Freight car equipment costs that are variable with moving time are not considered. Such items as per diem, interest and depreciation would be affected by speed.

Exhibit 6

EAST END-CUMBERLAND DIVISION-BRUNSWICK TO KEYSER (Westbound)

Freight Run-110 miles Cars Handled Daily-2100 Adjusted Gross Ton Miles-Daily 7,623,000.

Gross Adjusted Train Load Tons of 2000 lbs.	Number of Trains per Day	Train Mileage	Gross Adjusted Ton Mileage per Train	Locomotive Mileage per Train: Road	Locomotive Mileage per Train: Helper	Locomotive Mileage per Train: Total	Average Miles per Hour Moving Time	Total Crew Time per Train including Termi. Time (Hours)	Total Wage Cost per Train (Dollars)	Cost per Loco. per Train: Fuel @ $4.00 per Ton 1000 P.L.M (Dollars)	Cost per Loco. per Train: Repairs Interest Deprec. (Dollars)	Cost per 100 Gross Ton Miles: Engine and Train Crew Wages (Cents)	Cost per 100 Gross Ton Miles: Locomotive Fuel (Cents)	Cost per 100 Gross Ton Miles: Locomotive Repairs Interest Deprec. (Cents)	Cost per 100 Gross Ton Miles: Total (Cents)
7000	9.90	1088	770000	110	246	356	12.10	15.15	189.60	294.50	196.70	2.46	3.82	2.55	8.83
6750	10.25	1127	742500	110	246	356	12.60	14.58	182.20	282.50	195.40	2.45	3.8,	2.63	8.89
6500	10.65	1172	715000	110	246	356	13.07	14.04	175.10	272.50	194.10	2.45	3.8,	2.72	8.98
6250	11.08	1220	688000	110	246	356	13.64	13.45	166.70	261.00	192.65	2.42	3.79	2.80	9.01
6000	11.55	1270	660000	110	246	356	14.23	12.88	159.10	250.00	191.25	2.41	3.79	2.90	9.10
5750	12.05	1325	632500	110	246	356	14 89	12.32	151.70	239 00	189.90	2.40	3 78	2.99	9.17
5500	12.60	1385	605000	110	216	326	14.70	12.50	142.20	222.00	174.30	2.35	3.66	2.88	8.84
5250	13.20	1452	577500	110	216	326	15 30	12 00	135.80	213 00	173.15	2.35	3.69	3.00	9.04
5000	13.85	1524	550000	110	174	284	14.44	12 70	127.70	196.80	152.35	2.32	3.58	2.77	8.67
4750	14.60	1605	522500	110	174	284	15.21	12.05	120.30	186.70	151.05	2.30	3.57	2.89	8.76
4500	15.40	1695	495000	110	174	284	16 09	11.40	113.10	176.50	149.85	2.28	3.56	3.02	8.86
4250	16.30	1793	467500	110	174	284	17.00	10.78	106.00	167.20	148 60	2 27	3 58	3 18	9.03
4000	17.33	1905	440000	110	174	284	18 02	10.20	99.50	157.50	147.50	2.26	3 58	3.35	9.19
3750	18.48	2032	412500	110	174	284	19.27	9.52	91.90	147.50	146.17	2.23	3 58	3.54	9.35
3500	19.80	2178	385000	110	174	284	20.55	8.92	85.20	138.20	145.00	2.22	3 59	3.77	9.58
3250	21.30	2342	357500	110	174	284	22 10	8.30	81.25	128.50	143 82	2.27	3 59	4.02	9.88
3000	23.10	2540	330000	110	174	284	23 71	7.74	73.30	119.80	142.75	2.22	3.63	4.32	10.17
2750	25.20	2771	302500	110	174	284	25.57	7.18	70.20	111.00	141.65	2.32	3 67	4 68	10.67
2500	27 70	3050	275000	110	174	284	27.50	6.67	67 40	103 30	140.65	2.45	3 76	5.11	11 32
2250	30 80	3390	247500	110	72	182	21.50	8.54	54 90	84 80	92.60	2.22	3 43	3.74	9.39
2000	34.65	3811	220000	110	72	182	23 85	7.70	48.10	76.40	91.55	2.17	3.47	4.16	9.80
1750	39.60	3355	192500	110	72	182	26 60	6.86	46 20	68.50	90.52	2.40	3.56	4.70	10.66
1500	46 20	5080	165000	110	72	182	29 85	6 16	44.60	61.20	89.65	2.70	3.71	5.44	11.85
1250	55 40	6100	137500	110	72	182	32.59	5.64	43 40	55.90	89.00	3.16	4.07	6.48	13 71
1000	69 30	7625	110000	110	72	182	34.50	5.30	42.60	52.70	88.58	3 87	4.79	8.06	16 72
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

Remarks (17)

Mikado Locomotives used for road movement and helpers.

Gross adjusted car load 33 tons including adjustment of 7 tons per car.

Wages of train crew based on standard 8 hour day with time and one-half for overtime; hourly rate Engineer $0.98, Fireman $.75, Conductor $.80½, two Brakemen $.64. Total straight time $3.81. Total overtime $5.72

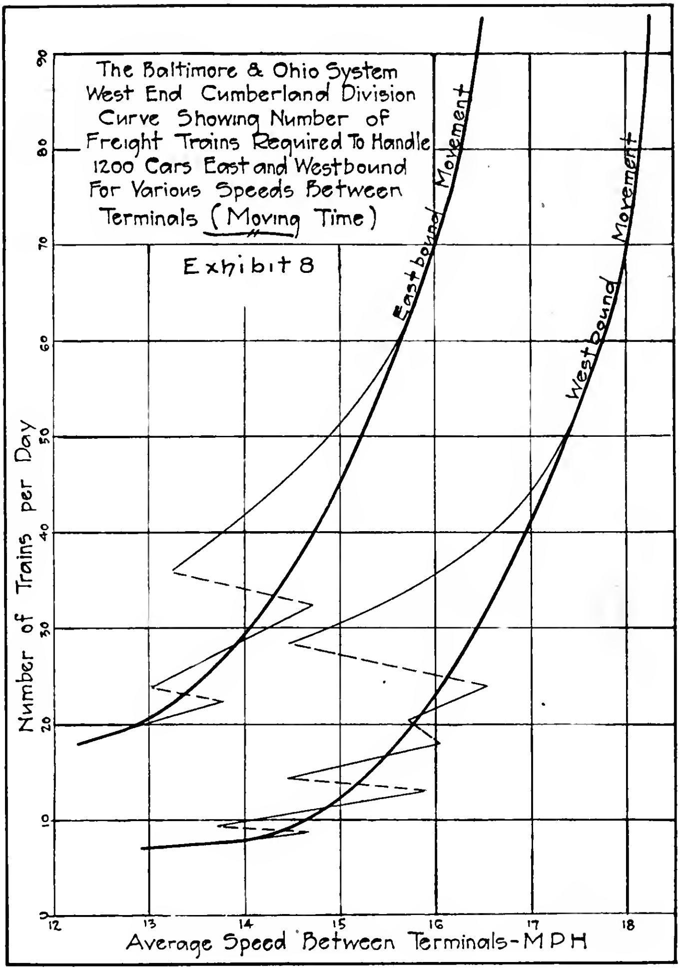
Cost of Fuel $4.00 per ton; reduced to $10.00 per locomotive hour moving time based on September performance of $.66 per locomotive mile.

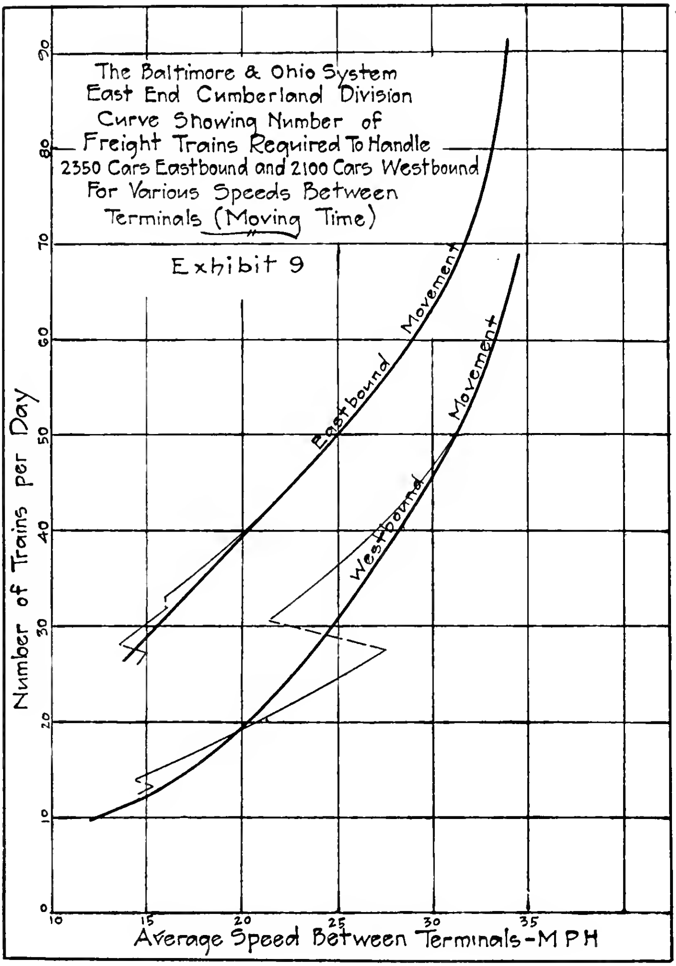
Cost of Repairs @ $.45 per locomotive mile as developed by experience.

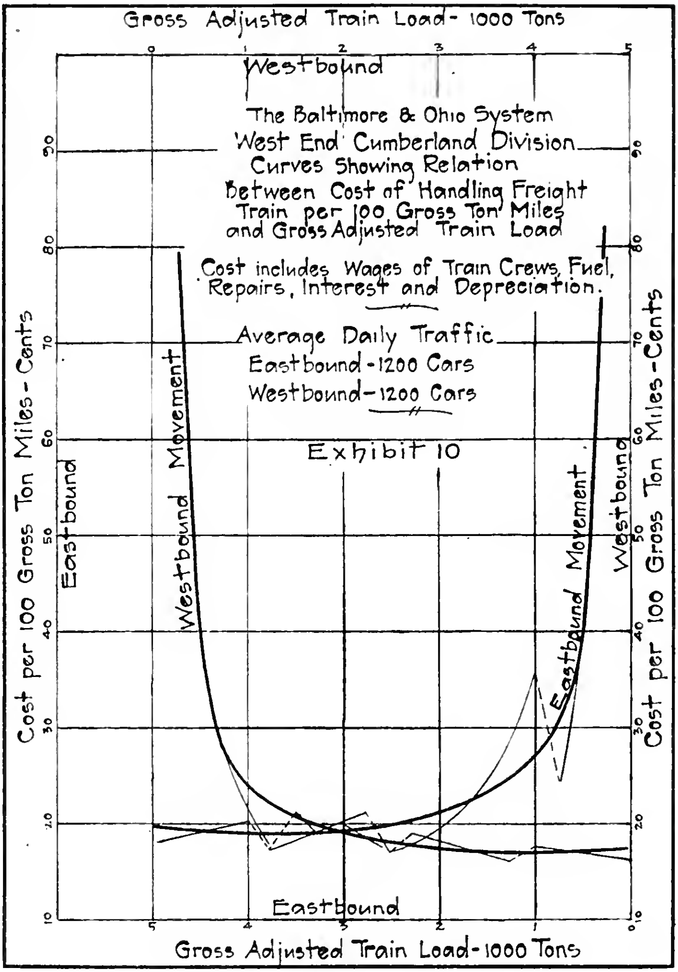
Interest and Depreciation 10% on value of equipment and reduced to $.75 per loco. hour crew time.

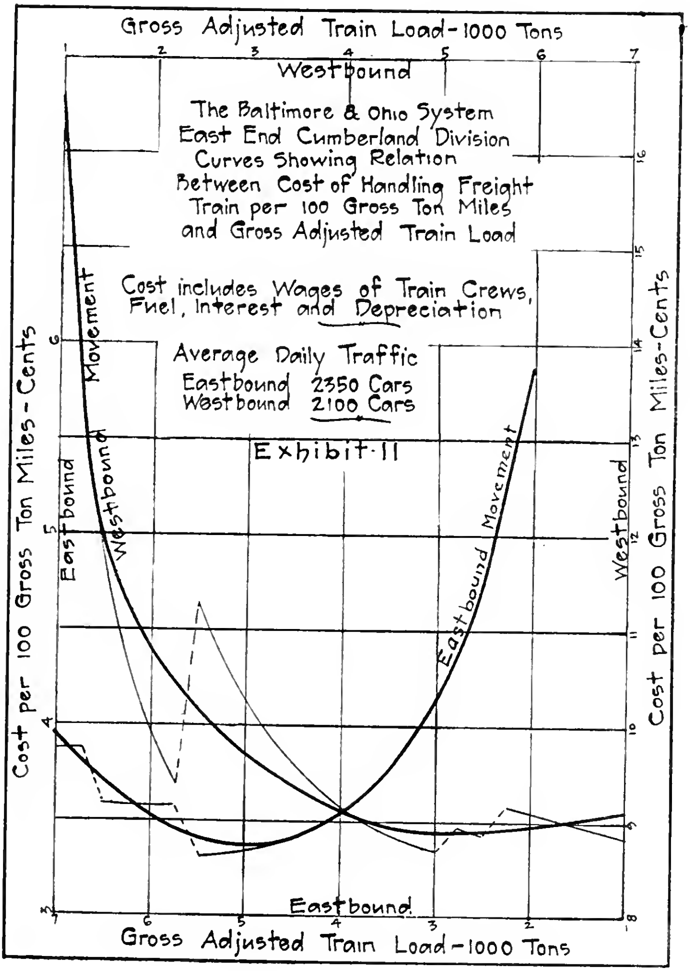
Freight car equipment costs that are variable with moving time are not considered. Such items as per diem, interest and depreciation would be affected by speed.

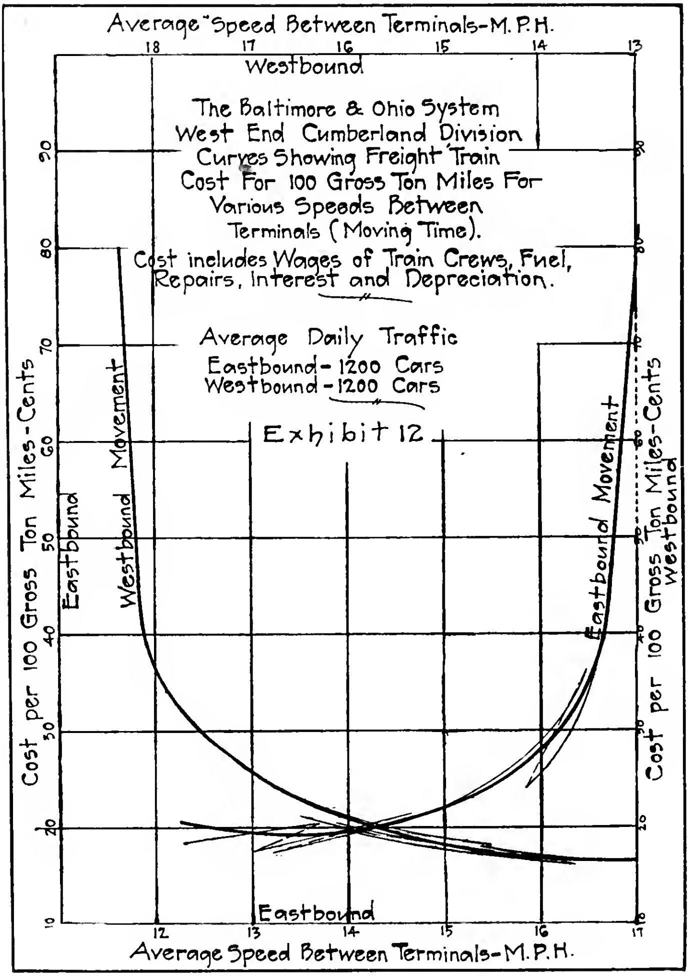
Exhibit 7


The Baltimore & Ohio System
West End Cumberland Division
Curve Showing Number of
Freight Trains Required To Handle
1200 Cars East and Westbound
For Various Speeds Between
Terminals (Moving Time)
Exhibit 8
Eastbound Movement
Westbound Movement
Number of Trains per Day
0
10
20
30
40
50
60
70
80
90
12
13
14
15
16
17
18
Average Speed Between Terminals-MPH

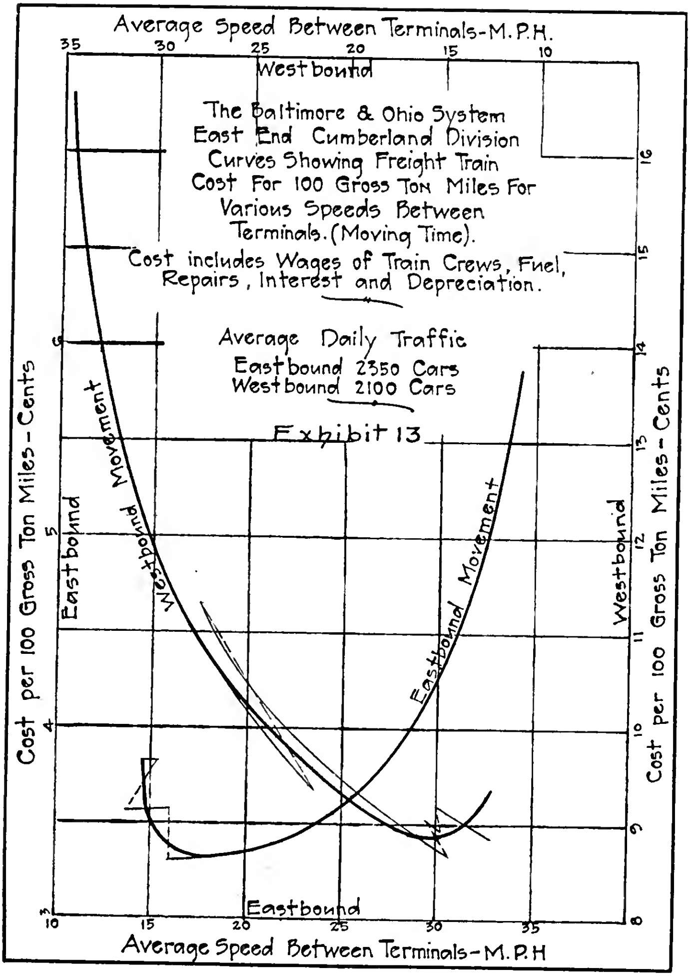

The Baltimore & Ohio System
East End Cumberland Division
Curve Showing Number of
Freight Trains Required To Handle
2350 Cars Eastbound and 2100 Cars Westbound
For Various Speeds Between
Terminals (Moving Time)
Exhibit 9
Eastbound Movement
Westbound Movement
Number of Trains per Day
Average Speed Between Terminals-M P H
0
10
20
30
40
50
60
70
80
90
10
15
20
25
30
35


Gross Adjusted Train Load - 1000 Tons
Westbound
The Baltimore & Ohio System
West End Cumberland Division
Curves Showing Relation
Between Cost of Handling Freight
Train per 100 Gross Ton Miles
and Gross Adjusted Train Load
Cost includes Wages of Train Crews, Fuel, Repairs, Interest and Depreciation.
Average Daily Traffic
Eastbound - 1200 Cars
Westbound - 1200 Cars
Exhibit 10
Westbound Movement
Eastbound Movement
Eastbound
Westbound
Eastbound
Cost per 100 Gross Ton Miles - Cents
Cost per 100 Gross Ton Miles - Cents
Gross Adjusted Train Load - 1000 Tons


Gross Adjusted Train Load-1000 Tons
Westbound
The Baltimore & Ohio System
East End Cumberland Division
Curves Showing Relation
Between Cost of Handling Freight
Train per 100 Gross Ton Miles
and Gross Adjusted Train Load
Cost includes Wages of Train Crews, Fuel, Interest and Depreciation
Average Daily Traffic
Eastbound 2350 Cars
Westbound 2100 Cars
Exhibit 11
Westbound Movement
Eastbound
Eastbound Movement
Westbound
Cost per 100 Gross Ton Miles - Cents
Cost per 100 Gross Ton Miles-Cents
Eastbound
Gross Adjusted Train Load-1000 Tons



Average Speed Between Terminals-M.P.H.
Westbound
The Baltimore & Ohio System
West End Cumberland Division
Curves Showing Freight Train
Cost For 100 Gross Ton Miles For
Various Speeds Between
Terminals (Moving Time).
Cost includes Wages of Train Crews, Fuel,
Repairs, Interest and Depreciation.
Average Daily Traffic
Eastbound - 1200 Cars
Westbound - 1200 Cars
Exhibit 12
Westbound Movement
Eastbound Movement
Cost per 100 Gross Ton Miles - Cents
Eastbound
Westbound
Cost per 100 Gross Ton Miles-Cents
Westbound
Eastbound
Average Speed Between Terminals-M.P.H.



Average Speed Between Terminals-M.P.H.
35 30 25 20 15 10
Westbound
The Baltimore & Ohio System
East End Cumberland Division
Curves Showing Freight Train
Cost For 100 Gross Ton Miles For
Various Speeds Between
Terminals.(Moving Time).
Cost includes Wages of Train Crews, Fuel,
Repairs, Interest and Depreciation.
Average Daily Traffic
Eastbound 2350 Cars
Westbound 2100 Cars
Exhibit 13
Eastbound Movement
Westbound Movement
Eastbound
Westbound
Eastbound Movement
Westbound
Cost per 100 Gross Ton Miles - Cents
3 4 5 6
8 9 10 11 12 13 14 15 16
Eastbound
10 15 20 25 30 35
Average Speed Between Terminals-M.P.H

REPORT OF COMMITTEE XII—ON RULES AND ORGANIZATION

W. C. Barrett, *Chairman;*
H. H. Edgerton, *Vice-Chairman;*
F. D. Anthony,
E. H. Barnhart,
H. L. Browne,
J. B. Carothers,
S. E. Coombs,
R. H. Gaines,
R. H. Hallsted,
H. H. Harsh,
B. Herman,
F. D. Lakin,
E. L. Martin,
Jos. Mullen,
W. H. Rupp,
P. T. Simons,
H. E. Stansbury,
R. E. Warden,
A. A. Woods,
Committee.

To the American Railway Engineering Association:

The following subjects were assigned the Committee on Rules and Organization for study and report:

1. Make thorough examination of the subject-matter in the Manual and submit definite recommendations for changes.
2. Prepare a "Manual of Instructions for the Guidance of Engineering Field Parties."
3. Prepare a "Manual of Rules for the Guidance of Employees of the Maintenance of Way Department."
4. Make final report, if practicable, on the "Science of Organization."

Committee Meetings

Meetings of the Committee were held as follows: Buffalo, June 8; St. Louis, July 14; Chicago, October 7.

Sub-Committees (1), (2) and (3), joint, St. Louis, July 13 and 14.

Sub-Committee (3), Cincinnati, August 24.

Sub-Committee (4). Work done by correspondence.

The work was divided among four Sub-Committees, their numbers corresponding to the numbers of the subjects assigned by the Board of Direction, as follows:

Sub-Committee (1)

J. B. Carothers, Chairman;
F. D. Anthony, Vice-Chairman;
S. E. Coombs,
H. E. Stansbury.
P. T. Simons,

Sub-Committee (2)

H. H. Edgerton, Chairman;
F. D. Lakin, Vice-Chairman;
H. L. Browne,
R. H. Hallsted,
H. H. Harsh,
P. T. Simons.

Sub-Committee (3)

E. H. Barnhart, Chairman;
Jos. Mullen, Vice-Chairman;
E. L. Martin,
A. A. Woods,
B. Herman,
W. C. Barrett.
R. E. Warden,

Sub-Committee (4)

S. E. Coombs, Chairman; R. H. Gaines, Vice-Chairman;
B. Herman, W. H. Rupp.
F. D. Anthony,

(1) Revision of Manual

The Committee's recommendation is given under the heading of Conclusions.

Our reason for this recommendation is that the two Manuals as submitted constitute a careful revision of everything now appearing in the Association Manual under the heading: "Rules and Organization."

(2) Manual of Instructions for the Guidance of Engineering Field Parties

The Committee submits its report in Appendix A. Its recommendation is given under the heading of Conclusions.

The Committee desires to direct the attention of the members of the Association to the Monograph on this subject prepared by its Vice-Chairman, Mr. H. H. Edgerton, which has been printed in Bulletin 229. This Monograph we believe to be a classic on the subject and well worthy the careful reading of every engineer, and especially the younger men.

The Manual presented in Appendix A is a resume of Mr. Edgerton's Monograph with condensations and revisions, so as to make the instructions brief and concise enough for a Manual.

(3) Manual of Rules for the Guidance of Employees of the Maintenance of Way Department

The Committee submits its report in Appendix B. Its recommendation is given under the heading of Conclusions.

The Committee spent much time and study on the preparation of this report. It is a compilation of all of the information secured by the Committee in former years, of the subject-matter now in the Manual, and of the rules and practices of many of the railroads represented in this Association.

The Committee has endeavored to make the Manual general rather than special, and to so frame the rules that any road could use the Manual as a foundation for a Book of Rules and insert special rules as desired.

The "General Notice" covers rules found in the Standard Code under the same heading.

Under "General Rules" the Committee has placed rules applicable to all employees, so as to avoid, as far as possible, repetitions under each class.

Under "Operating Rules" the Committee has placed those rules taken from the Standard Code and a few special rules which it is thought necessary and desirable for Maintenance of Way employees to know.

Under "Rules for the Government of Employees Working on or about the Track" the Committee has placed what are usually called "Safety Rules."

The Committee has included in the Manual, "Rules for the Operation of Motor, Hand, Velocipede and Push Cars."

Under "Divisional Maintenance Officers" the Committee has endeavored to cover the positions common to most railroads and the usual duties of each. Individual roads may not have all the positions mentioned, or may have others not mentioned, or may not use the same titles for the positions. The titles used by the Committee are typical and should be so considered in any discussion of the Manual.

Under "Conduct of Work" the Committee submits "Rules for the Conduct of Track Work," or work to be performed by the forces under the Supervisors of Track only. It was the judgment of the Committee that neither it nor the Association in convention assembled had sufficient time this year to properly consider more than this amount of material.

The Committee requests that it be permitted to submit "Rules for the Conduct of Bridge and Building, Signal, and Telegraph and Telephone Work" next year.

The Committee asks that the Association consider the "Manual of Rules for the Guidance of Employees of the Maintenance of Way Department" as a live document to be added to or changed in some details each year, as new methods or practices are developed, or present methods or practices become obsolete and better ones replace them.

(4) Science of Organization

The Committee submits its report in Appendix C. Its recommendation is given under the heading of Conclusions.

CONCLUSIONS

(1) The Committee recommends the adoption of the "Manual of Instructions for the Guidance of Engineering Field Parties" and the "Manual of Rules for the Guidance of Employees of the Maintenance of Way Department" and that these be substituted for all of the matter now appearing in the Association Manual under "Rules and Organization."

(2) The Committee recommends that the "Manual of Instructions for the Guidance of Engineering Field Parties," as submitted in Appendix "A," be approved for publication in the Manual.

(3) The Committee recommends that the "Manual of Rules for the Guidance of Employees of the Maintenance of Way Department," as submitted in Appendix "B," be approved for publication in the Manual.

(4) The Committee recommends that the report on "The Science of Organization," as submitted in Appendix "C," be approved for publication in the Manual.

Recommendations for Future Work

The Committee recommends that the following work be assigned for next year:

(1) Prepare rules for Conduct of Bridges and Buildings, Signal, and Telegraph and Telephone Work, to be added to the "Manual of Rules for the Guidance of Employees of the Maintenance of Way Department."

(2) Make study of use of mechanical appliances and tools, with organization of labor involved, in Maintenance of Way work.

Respectfully submitted,

THE COMMITTEE ON RULES AND ORGANIZATION,

W. C. BARRETT, *Chairman.*

Appendix A

MANUAL OF INSTRUCTIONS FOR THE GUIDANCE OF ENGINEERING FIELD PARTIES

H. H. EDGERTON, *Chairman*, Sub-Committee (2)

SECTION I

Size of Field Party

The size of the field party will depend upon the work to be handled. In all cases sufficient intelligent help should be employed to assure accuracy of results.

Minimum party:

Instrumentman.
2 Chainmen.

The party should be increased to meet the requirements of the work to be done.

SECTION II

Before Going Into the Field

The Chief of Party is responsible to his superiors for results and to his men in the field for their welfare. The Chief of Party should therefore familiarize himself as much as possible with the conditions to be met before starting out.

Transportation

The following items should be investigated or anticipated by the Chief of Party before starting on any expedition.

Which of the modes of travel will likely be used?

Steam railway,
Electric railway,
Automobile,
Motor car,
Horse and wagon train,
Pack train,
Boats,
Dog sleds, etc.

If one mode of travel is not used continuously, what source of supply can he depend on for other means of conveyance when the change comes, as, for instance, boats when the river is reached and automobiles are abandoned.

Availability of gasoline and oils for motor vehicles, if used.

Availability of forage for animals, if used.

Difficulties liable to be encountered with the mode of travel selected—difficulties with automobiles, dog teams or canoes.

Personnel of Field Party

The selection of the various members should rest with the Chief of Party.

The physical condition of the men selected for the work should be investigated. He should satisfy himself whether or not each individual will be able to stand the climate, the altitude, the swamps, etc.

Where local people are available for non-technical positions, they should be employed as members of the party to the greatest number possible, to gain the benefit of their information on local conditions.

Personal Supplies

The Chief of Party should instruct the men as to the amount and kind of clothing as a minimum, dependent upon the length of time they expect to be on the expedition, and the kind of climate and the extremes of temperature to be encountered, and the ability to secure such supplies en route. Also the maximum limit permissible in weight or bulk due to the transportation facilities.

Camp Equipment

With the advice and instruction of his superior the Chief of Party should decide upon the kind of equipment that will be necessary, depending upon methods to be used in housing and taking care of the men.

If in hotels, the spacing and capacity.

If in farm houses, the spacing of groups or settlements and the capacity.

If in camp cars, the number and kind required, and sufficient water supply to accompany.

If in tents, the strength and design necessary to combat storms, wild animals or insects. Also whether stoves, wooden floors, flies, etc., are needed in certain seasons. And in certain countries it will be necessary to consider fever protection, mosquito head nets and gloves, mosquito proof tents, snow shoes, snow glasses, portable boats, ropes for rafting and climbing, hammocks for sleeping, ant protection, etc.

Supplies

Under the instructions and advice of the Chief Engineer, the Chief of Party will be informed and prepare for the following:

The kind and amount of supplies required for some period of time considering the size of the party to be handled.

The mode of securing replenishment of supplies, so as to have only the actual quantity required on hand, and thus reduce transportation difficulties when moving camp.

First aid outfits and instructions for their use.

Additional medical supplies and instructions for their use; the quantity and assortment to depend upon the likelihood of the requirements and degree of civilization and density of population.

The source of provisions for food.

The methods to be employed for preserving foods of certain kinds or the necessity of eliminating certain foods on account of inability to preserve them, and the substitutes that can be used therefor.

Camp Locations

Something should be known of conditions likely to be met in camp locations and preparations made beforehand to meet them, having in mind the following:

Sanitary facilities required, dependent upon the duration of the stay at any one place, and the effect of stream pollution on the surrounding territory.

The methods of providing for such facilities.

The methods to be used in taking down, moving and setting up camp so as to lose the least amount of time.

The design of the camp to meet the local requirements.

Communication

Methods of securing mail and other sources of communication that can be arranged.

SECTION III

After Arriving in the Field

After the party arrives in the field, the Chief of Party should not be overburdened with details of the survey, but should have ample time to look forward and anticipate requirements to overcome the conditions that will be met, and he should detail the methods of handling the work covering the following items:

Organization

Duties of the various members.

The duties under different circumstances for the different periods of the day should be outlined, as far as practicable, such as:

What each member shall do when starting the day,

When completing the day,

When breaking camp,

When setting up camp, and

While in camp.

The assembling of the entire party or each sub-division at the close of the day's work, so all may return to camp together, and thereby avoid being lost in the woods or meeting with an accident, and none to assist them to camp.

Supplies and Equipment

The Chief of Party is expected to instruct in regard to the following:

That care is used in handling all supplies and equipment.

That wastefulness is avoided.

That extreme care is used in handling and transporting instruments.

Designate methods to be used when instruments and other equipment are left in the field over night.

That the personal equipment and clothing of the men bear individual markings or distinctive colors sufficient to keep one man's possessions from being mixed with others.

Treatment of Property Belonging to Others

The Chief of Party is responsible for:

The amount of care to be exercised when going through cultivated fields.

The general rules as to whether timber should be cut and when to triangulate around it.

The location at which hubs are to be set for permanency and the kind of stakes to be used through grain fields to avoid damage to farm machinery, or the removal of such stakes after the party has passed.

The cutting of stakes from timber, or material at hand, as the party passes along, so as to avoid using property upon which others may set a value.

Conduct of Party

Everything should be done to create a good feeling among residents, as you may want favors and may have to return; if not yourself, others on similar expeditions.

Violate no local customs, and take care not to run counter to any local prejudices, but conciliate the good feeling of the community.

When stopping at farm houses, you must realize the people are inconvenienced in order to accommodate you. Leave things as you find them.

Records

The method of keeping field notes should be uniform throughout the entire survey. Such details must be outlined in order to secure results.

The field notes should be kept in such a manner that they may be platted without loss of time and may be readily interpreted by others who may have to use them in the future. All notes should be indexed and titled, and the lines named, lettered, or numbered, and the whole carefully kept for future use.

Maps should be of the size and scale prescribed by the Chief Engineer.

Signs and symbols should conform with the Manual of the A.R.E.A.

Property lines should be tied in on the notes and the maps.

Abandoned lines should be crossed out and marked abandoned.

Maps and notes should have sufficient information to place them:

Name of the railroad.
Branch or division.
Town and state.
Object.
Date survey began; date finished.
Scale.
North point.

The name of the Engineer in charge and the person making the notes.

The start and ending of each day's work should be noted on the page of the book where the notes begin and end for that day's work.

Transit field notes should show:

Station.

Point.

Deflection.

Angle to right.

Angle to left.

Calculated course.

Magnetic course.

All in columns as stated from left to right.

Each page should have across the top the name of the line and the kind of survey. Notes should run up the page.

Topography notes:

Each page should have across the top the name of the line and the kind of survey.

Datum.

Interval.

Scale, should be plainly set out at the beginning and the end of each line.

Reference Points and Bench Marks

The Engineer will be judged by what he leaves behind him, and how he left it. These things which he leaves behind him are his notes, his maps and his reference points. It should be the purpose to use such judgment that the reference points are as permanent as possible.

When the line is finally established, bench marks should be placed on permanent locations, and a large number of alinement points should be referenced in a permanent manner. Iron posts or stone monuments buried along property lines and their location tied to other known corners are probably the best. Also prominent features on country residences are good, gables, chimneys, etc. They should be lined in by the three-point problem, three angles, three points, and the bearing calculated, if possible. The magnetic bearing should also be given.

Appendix B

MANUAL OF RULES FOR THE GUIDANCE OF EMPLOYEES OF THE MAINTENANCE OF WAY DEPARTMENT

E. H. Barnhart, *Chairman*, Sub-Committee (3)

GENERAL NOTICE

To enter or remain in the service is an assurance of willingness to obey the rules.

Obedience to the rules is essential to the safety of passengers and employees, and to the protection of property.

The service demands the faithful, intelligent and courteous discharge of duty.

To obtain promotion capacity must be shown for greater responsibility.

Employees, in accepting employment, assume its risks.

GENERAL RULES

1. Employees whose duties are prescribed by these rules must provide themselves with a copy.

2. Employees must be conversant with and obey the rules and instructions. If in doubt as to their meaning, they must apply to the proper authority for an explanation. Supervisory employees must know that the rules and instructions are understood and complied with by those under them.

3. Employees must pass the required examinations.

4. Any violation of the rules or instructions must be reported.

5. The use of intoxicants by employees while on duty is prohibited. Their use, or the frequenting of places where they are sold, is sufficient cause for dismissal.

6. In case of danger to the Company's property, employees must unite to protect it.

7. Safety is of the first importance in the discharge of duty. In all cases of doubt or uncertainty, the safe course must be taken.

8. Employees must do all in their power to prevent accidents, even though in so doing they may necessarily perform the duties of others.

9. No employee is allowed to contract any bill or other obligation on account of the Company or to use the Company's credit, unless authorized by the proper officer.

10. Assignment of wages by employees is prohibited and will be sufficient cause for dismissal. Employees failing or refusing to pay their just debts, or against whom bills are frequently presented to the Company for payment, or whose wages have been garnisheed, will, unless satisfactory reason be given, be dismissed from the service.

11. Employees must devote themselves exclusively to the service, and must not connect themselves with any other trade or business without permission from the proper officer.

12. Employees must not absent themselves from duty without permission. They must not exchange duties with others, or engage substitutes without proper authority.

13. The articles furnished by the Company for the use of employees must, on their leaving the service, be returned to the proper officer.

14. Employees subject to emergency call must keep their immediate superior and the train dispatcher informed as to their whereabouts at all times.

15. Each employee whose duties are in any way affected by it, must have a copy of the current time table and be familiar with the rules and regulations therein. He must have it with him when on duty and know the time of trains at whatever point he may be working.

Employees must carefully observe signals displayed by all trains, and assure themselves before obstructing the track that all trains and sections due have passed.

Employees are especially cautioned that extra and special trains may be run at any time and trains may run at any time upon any track in either direction, without notice to them. They must be governed accordingly and exercise proper care to avoid accident.

16. Employees are forbidden to ask or receive fees or contributions from subordinates, co-employees, or the public.

17. Employees will be subject to record discipline, suspension, or dismissal for cause.

18. Employees must know that the machinery, tools and appliances which they are expected to use and are about to use, are in suitable and proper condition for use.

19. Employees will be regarded as in line of promotion, or advancement, depending upon the faithful discharge of duty and capacity for increased responsibility.

20. A complete service and discipline record of all supervising employees should be kept in the office of ....

21. Employees must observe trains closely, and if anything dangerous is noted, must call attention of the trainmen to the fact by signal or wire.

22. When work, or other cause, renders the track or bridges unsafe for passage of trains, protection to trains must be provided in accordance with instructions.

When the track is safe for trains to pass, but at reduced speed, protection must be provided by displaying the proper signals from each end of the section of track on which the speed is restricted. Resume signals should be displayed to indicate where the normal speed may be resumed. On multiple tracks each track involved must be protected in the same manner as if it were single track.

The Superintendent must be notified at once by wire of the speed to be observed over the track protected by "Slow" signals. Where the obstruction of a track is continued during the night, proper night signals must be displayed.

23. In case of impassable or obstructed track, flagging is the first duty and repairs must wait, if necessary, until signals have been displayed.

24. No work that will interfere with the safe passage of trains at full speed must be undertaken during fogs or blinding storms, except in emergency.

25. Disregard of stop or caution signals, excessive speed of trains, or failure to answer signals properly must be reported, with a full statement of facts.

26. Employment of minors will not be permitted, except as allowed by law, and then only after written consent and release on the proper form has been obtained from parents or guardians.

27. When a train is approaching or passing, employees must not unlock a main track switch nor stand within .... feet of such a switch.

Immediately upon closing and locking a main track switch, the employee doing so will observe if the points fit properly, and must call the attention of those with him in words equivalent to the statement: "I have closed and locked the switch." This statement must be acknowledged in words by one of the employees to whom it is addressed.

28. Motor, hand, velocipede and push cars must be used for Company business only, and must be operated in accordance with the special rules governing their use.

29. In case of injury, however slight, to himself or to any one under his supervision, or in case of injury to others which has not been reported by other employees, the Foreman must immediately make a report by wire to his Supervisor, followed by a written report on the prescribed form.

30. The Company should be informed promptly regarding contemplated public improvements or enacted ordinances which would in any way affect its interests. Supervisors, Foremen and other employees must make prompt report and forward at once to their immediate superiors any printed public notices or other matter, with all the information available.

31. Employees must not use the telegraph unnecessarily. All messages should be as brief as is consistent with a clear understanding of their meaning.

32. Employees must not permit, except by proper authority, experimental trials of appliances or devices, nor give out information of the results of any such trial.

33. Employees shall conform to the prescribed standards, plans and specifications in the execution of work under their supervision.

OPERATING RULES

(Any rule preceded by a number in parentheses is a Standard-Code rule of the American Railway Association of that number.)

Standard Time

34. (1) Standard time obtained from .... observatory, will be transmitted to all points from designated offices at ....M. daily.

35. (2) Watches that have been examined and certified to by a designated inspector must be used by conductors, enginemen and .... The certificate in prescribed form must be renewed and filed with the .... every ....

(Form of Certificate)

Certificate of Watch Inspector

This is to certify that on.., 19....
the watch of..
employed as ....
on the ....R.................
was examined by me. It is correct and reliable, and, with proper care should run within a variation of thirty seconds per week.
Name of Maker...
Grade ....
Number of Movement..
Open or Hunting Case..
Metal of Case...

Signed...
Inspector.
Address................................

36. (3) Watches of conductors, engineman and .... must be compared before commencing each day's work, with a clock designated by time-table as a standard clock. The time when watches are compared must be registered on a prescribed form.

37. If access to a standard clock is not possible comparison will be made with a responsible employee who has compared with a standard clock.

38. (7) Employees whose duties may require them to give signals, must provide themselves with the proper appliances, keep them in good order, and ready for immediate use.

39. (8) Flags of the prescribed color must be used by day, and lights of the prescribed color by night.

40. (9) Day signals must be displayed from sunrise to sunset, but when day signals cannot be plainly seen, night signals must be used in addition. Night signals must be displayed from sunset to sunrise.

41. (10) *Color-Signals.*

Color	Indication
(a) Red.	Stop.
(b) ———	Proceed with caution and for other uses prescribed by the rules.
(c) ———	Proceed, and for other uses prescribed by the rules.
(d) Green and White.	Flag Stop. See Rule 58 (28).
(e) Blue.	See Rule 56 (26).
(f) Purple.	Stop (night indication for dwarf signals.

42. (11) A train finding a fusee burning on or near its track must stop and extinguish the fusee, and then proceed with caution prepared to stop short of train or obstruction.

43. Maintenance of Way employees must not disturb burning fusees on or near the track placed there by trainmen.

44. (12) *Hand, Flag and Lamp Signals.*

Manner of Using	Indication
(a) Swung across the track.	Stop.
(b) Held horizontally at arm's length, when the train is moving.	Reduce speed.
(c) Raised and lowered vertically.	Proceed.
(d) Swung vertically in a circle at half-arm's length across the track when the train is standing.	Back.
(e) Swung vertically in a circle at arm's length across the track, when the train is running.	Train has parted.
(f) Swung horizontally above the head when the train is standing.	Apply air brakes.
(g) Held at arm's length above the head when the train is standing.	Release air brakes.

45. (13) Any object waved violently by anyone on or near the track is a signal to stop.

46. (14) *Engine and Motor Whistle Signals.*

Note.—The signals prescribed are illustrated by "o" for short sounds; "—" for longer sounds. The sound of the whistle should be distinct, with intensity and duration proportionate to the distance signal is to be conveyed.

Sound	*Indication*
(a) o	Apply brakes. Stop.
(b) — —	Release brakes. Proceed.
(c) (one long) o o o	Flagman protect rear of train.
(d) — — — —	Flagman may return from west or south, as prescribed by Rule 64 (99).
(e) — — — — —	Flagman may return from east or north, as prescribed by Rule 64 (99).
(f) — — —	When running, train parted, to be repeated until answered by the signal, as prescribed by Rule 44 (12), (e).
(g) o o	Answer to Rule 44 (12), (e).
(h) o o o	Answer to any signal not otherwise provided for.
(j) o o o o	When train is standing, back. Answer to Rule 44 (12), (d).
	Call for signals.
(k) — o o	To call the attention of yard engines, extra trains or trains of the same or inferior class or inferior right to signals displayed for a following section. If not answered by a train, the train displaying signals must stop and ascertain the cause.
(l) — — o o	Approaching public crossings at grade.
(m) ———	Approaching stations, junctions, railroad crossings at grade and ....
(n) — — o	Approaching meeting points.
(o) o —	Inspect train line for leak.
(p) Succession of short sounds.	Alarm for persons or live stock on the track.

47. (15) The explosion of two torpedoes is a signal to reduce speed and lookout for a train ahead or obstruction. The explosion of one torpedo will indicate the same as two, but the use of two is required.

48. (17) The headlight will be displayed to the front of every train by night, but must be concealed when a train turns out to meet another and has stopped clear of main track, or is standing to meet trains at the end of double track or at junctions. When an engine is running backward a white light must be displayed by night on the rear of the tender.

49. (18) Yard engines will display the headlight to the front and rear by night. When not provided with a headlight at the rear, a white light must be displayed. Yard engines will not display markers.

50. (19) The following signals will be displayed, one on each side of the rear of every train, as markers, to indicate the rear of the train: By day, green (or yellow) flags, or marker lamps (not lighted). By night, green (or yellow) lights to the front and side and red lights to the rear; except when the train is clear of the main track, when green (or yellow) lights must be displayed to the front, side and rear.

51. (20) All sections except the last will display two green flags, and, in addition, two green lights by night, in the places provided for that purpose on the front of the engine.

52. (21) Extra trains will display two white flags and, in addition, two white lights by night, in the places provided for that purpose on the front of the engine.

53. (22) When two or more engines are coupled, each engine shall display the signals as prescribed in Rules 51 (20), 52 (21).

54. (23) One flag or light displayed where in Rules 50 (19), 51 (20) and 52 (21) two are prescribed will indicate the same as two; but the proper display of all train signals is required.

55. (24) When cars are pushed by an engine, except when shifting or making up trains in yards, a white light must be displayed on the front of the leading car by night.

56. (26) A blue signal, displayed at one or both ends of an engine, car or train, indicates that workmen are under or about it; when thus protected, it must not be coupled to or moved. Workmen will display the blue signals and the same workmen are alone authorized to remove them. Other cars must not be placed on the same track so as to intercept the view of the blue signals, without first notifying the workmen.

Use of Signals

57. (27) A signal imperfectly displayed, or the absence of a signal at a place where a signal is usually shown, must be regarded as the most restrictive indication that can be given by that signal, and the fact reported to the .... Conductors and enginemen using a switch where the switch light is imperfectly displayed or absent, must also, if practicable, correct or replace the light.

58. (28) A green and white signal will be used to stop a train only at the flag stations indicated on its schedule. When it is necessary to stop a train at a point that is not a flag station on its schedule, a red signal must be used.

59. (29) When a signal, except a fixed signal, is given to stop a train, it must, unless otherwise provided, be acknowledged as prescribed by Rule 46 (14) (h).

60. (30) The engine-bell must be rung when an engine is about to move and while approaching and passing public crossings at grade.

61. (31) The whistle must be sounded at all places when required by rule or by law.

62. (33) Watchmen stationed at highway crossings must use stop signals when necessary to stop trains. They will use .... signals to stop highway traffic.

63. (35) The following signals will be used by flagmen:
Day Signals—A red flag, torpedoes, and fusees.
Night Signals—A red light, a white light, torpedoes, and fusees.

64. (99) When a train stops under circumstances in which it may be overtaken by another train, the flagmen must go back immediately with flagmen's signals a sufficient distance to insure full protection, placing two torpedoes, and when necessary, in addition, displaying lighted fusees.

When signal 46 (14), (d) or 46 (14), (e) has been given to the flagman and safety to the train will permit, he may return. When the conditions require he will leave the torpedoes and a lighted fusee.

The front of the train must be protected in the same way, when necessary, by the ....

When a train is moving under circumstances in which it may be overtaken by another train, the flagman must take such action as may be necessary to insure full protection. By night, or by day when the view is obscured, lighted fusees must be thrown off at proper intervals.

When day signals cannot be plainly seen, owing to weather or other conditions, night signals must also be used.

Conductors and enginemen are responsible for the protection of their trains.

65. Motor, hand, velocipede and push cars, when in use, must be protected as prescribed by rule 64 (99).

RULES FOR THE GOVERNMENT OF EMPLOYEES WORKING ON OR ABOUT THE TRACK

66. It is the duty of every employee working on or about the track, to exercise care to avoid injury to himself and others.

67. On the approach of a train, employees who are working on or about the track, must move to a place of safety, standing clear of all running tracks. They must not work or stand on the tracks, except when necessary for the proper performance of their duties.

68. Watchmen, Patrolmen, Trackwalkers and others on duty, which makes it necessary for them to be on the track, where there are two or more tracks, should, when practicable, travel against the current of traffic, keeping sharp lookout in both directions for approaching trains.

69. Foremen or others in charge of employees, working on or about the tracks, must instruct their men to be alert, watchful, and to keep out of danger; and will take the necessary precautions to see that all men working under their immediate supervision receive warnings of approaching trains in time to reach a place of safety.

70. Foremen, Watchmen and others in charge of gangs or squads of workmen, should provide themselves with a whistle and should use same in warning the men of approaching trains, or when it is necessary for them to clear the tracks and move to a place of safety.

71. When large numbers of inexperienced men are working on the track, it is desirable to divide them into small squads, and place each squad in charge of an experienced man, and take such other additional precautions as will provide for the safety of the men.

72. In handling rails, ties and other heavy materials, special care must be used to avoid injury.

73. Employees working in a tunnel or near the end of same, when a train approaches from either direction, must stand clear of all tracks, and if in the tunnel should occupy the man holes. If there is insufficient clearance or no man holes, arrangement must be made to work under flag protection.

74. Employees are required to carry lights when passing through any tunnel where men cannot readily be seen. When an entire gang is working close together, an adequate number of lights should be used, but not less than two.

75. Motor, hand, velocipede or push cars must not be used when approaching trains cannot readily be seen by reason of fog, storm or snow, except under proper protection.

76. Any employee, who while on duty, is careless about the safety of himself or others or who disregards warnings, will be disciplined.

77. Foremen, Watchmen and others in charge of gangs or squads of workmen, should consider it their personal duty to assist in keeping the tracks, yards and foot paths along them free of any obstacle which might be the cause of injury to others.

RULES FOR THE OPERATION OF MOTOR, HAND, VELOCIPEDE AND PUSH CARS

78. Employees to whom cars are assigned are responsible for the proper use and condition of cars in their charge. A report must be made to their superior officer if the car is in need of repairs or is, in their opinion, unsafe to operate.

79. No one except a responsible employee who has been properly qualified will be allowed to operate motor, hand or velocipede cars upon the main track.

80. Before cars are used, an inspection must be made to be sure that the running gear, brakes, etc., are in good operating condition; that a sufficient supply of gasoline is in the tank of motor cars and that the car is properly lubricated. After the car is started, the brakes must be tested immediately to be sure that they are in working condition.

81. Motor, hand and velocipede cars are to be used only for transporting workmen and tools. Heavy material must not be carried on them, except in emergency. Push cars must be used to transport such heavy materials as ties, rails, frogs, etc.

82. Employees must not get on or off a moving car from the front or side. The use of seats on the ends of hand or push cars is forbidden.

83. Tools must be placed on cars with care. Track jacks or other tools must not be carried on the front of the car.

84. Employees operating motor, hand or velocipede cars must provide themselves with whistle or other device, which must be sounded at all highway grade crossings and at all other points when necessary to warn workmen or others of the approach of the car.

85. Employees operating cars on main tracks shall, when practicable, obtain information regarding trains, but such information will not relieve them from the responsibility of protecting their cars. They will see that their cars are clear of the main track for regular scheduled trains and, when blocked by an operator or the dispatcher, will report clear when out of the block or clear of the main track. No open telegraph office should be passed without stopping and ascertaining the location of all trains.

86. Where practicable, cars should be run on outside main tracks or on sidings in the direction of traffic. A sharp lookout should be maintained in both directions, where possible.

87. When approaching road crossings at grade, the car must be under complete control, and the employee in charge must know that highway travelers will not be endangered, before going on the crossing. If the crossing is protected by flagman, the operator must get signal from him before proceeding. When required by rule or law, a proper warning must be given approaching all highway crossings at grade.

88. Cars must not exceed a speed of *8 miles per hour* when passing through stations or yards, over switches or through interlocking, over frogs, railroad, highway or farm crossings at grade. At all other points, hand cars are restricted to *10 miles per hour* and motor cars to *20 miles per hour*. Cars must be stopped, when practicable, during passage of a train on an adjacent track.

89. Cars must be operated with care in passing trains receiving or discharging passengers at stations and must not be run between such trains and the station.

90. Motor cars should not be run through the spring rail side of frogs. Main track switches must not be opened to use siding for cars except when loaded too heavy to lift over the rails. When necessary to open the switch for a loaded car, the employee in charge of the car shall personally unlock and lock the switch as provided in Rule 27.

91. Cars must not be attached to engine or trains nor run closer than 500 feet behind moving trains.

92. The space between two or three hand cars when running should not be less than 300 feet; that between two or three motor cars or a hand car and a motor car should not be less than 600 feet. A car in advance must not be stopped until the following car has been signaled. The employee in charge of two or three cars so run, must ride on the second car. When more than three cars are run, they must be divided

into groups of three or less, the front car of each group being run not less than 1,200 feet behind the last car of the preceding group, and each group being run as specified above.

93. When motor, hand, velocipede or push cars are operated at night or during fog, storm, snow or through tunnels, they must be equipped with a white light in front and a red light to the rear.

94. Cars must be removed from the track or protected by flag when not in use. When they cannot be removed from the track to clear an approaching train, they must be protected as required by Rule 64 (99).

95. A copy of the current timetable must be carried on all hand and motor cars and, in addition, the following signal equipment:

— torpedoes
2 red flags
2 red lanterns
2 white lanterns
— fusees

96. Torpedoes exploded by motor, hand, velocipede or push cars must be replaced.

97. Cars must not be overloaded. Brakes should be applied gradually, and emergency stops should be made only when absolutely necessary.

98. Hand and push cars should not be run with motor cars, but if necessary to do so, they must be coupled behind and never pushed ahead. When hand or push cars are coupled, the speed of the motor car must be reduced to the maximum speed provided for hand cars in Rule 88.

99. Employees in charge of motor cars must not permit occupants to sit in insecure or careless positions, nor permit any smoking or uncovered lights around motor cars when tanks are being filled or gasoline handled. Motor cars must not be inspected with matches or torches. All moving parts should be guarded.

100. Motor cars must not be shipped on trains unless absolutely necessary. When necessary to ship them, the gasoline tanks must be drained.

101. Only insulated cars should be used where there are track circuits.

102. When cars are removed from the track they must be placed not less than five feet from the near rail, and so located that they cannot foul the track. They must not be set off or left standing within the full legal width of highway or private road crossing at grade, except in cases of emergency. When necessary, on account of emergency, in clearing trains, cars may be set off at crossings but must be protected by an employee and immediately removed when the emergency is passed. They must be kept locked when not in sight of the men in charge and, at night, and at other times, when not in use, should be kept under cover.

ORGANIZATION

DUTIES OF DIVISIONAL MAINTENANCE OFFICERS

103. On a division some one officer is usually in charge of the Maintenance of Way Department and reporting to him are subordinate officers who are directly responsible for the maintenance of:

Tracks and Roadway
Bridges and Buildings
Signals and Interlocking
Telegraph and Telephone (where owned)

The duties of these officers, as hereinafter outlined, are typical and of general application to the respective positions, regardless of the title the individual occupying the position may have. The divisional officer in charge of the Maintenance of Way Department is the Division Engineer to whom report:

The Supervisor of Track
The Supervisor of Bridges and Buildings
The Supervisor of Signals
The Supervisor of Telegraph and Telephone

These subordinate divisional officers, each in his respective department, have Foremen and others reporting to them. The Foreman, usually, is the officer under whose immediate supervision the skilled and unskilled labor perform their work.

DIVISION ENGINEERS

104. Division Engineers report to and receive instructions from the ....

105. They are responsible on their respective divisions for such Maintenance of Way matters as are assigned them. They will have supervision over the persons employed in their department, see that they understand and obey the rules and regulations in force, and that the work is carried on in a proper, careful and economical manner; that the records of time and material are correctly and properly kept, and that the necessary and required reports, covering the time worked and the material used, are promptly and properly made.

SUPERVISORS OF TRACK

106. Supervisors of Track report to and receive instructions from the Division Engineer.

107. They are in charge, in their respective districts, of the maintenance of tracks, their appurtenances and of the employees engaged thereon.

108. They shall have immediate supervision of work train service for the maintenance of tracks, using such service only when properly authorized by the Division Engineer.

109. They must make the prescribed inspections of track, roadway, station grounds, and driveways under their charge and when necessary arrange for prompt repairs of any defects or improper conditions found.

110. They must know that the Foremen, track laborers and others under their supervision fully understand and properly perform their duties; keep account of, and report their time in the manner prescribed and discipline them when necessary.

111. They must know that the Foremen are supplied with tools and material necessary for the efficient performance of their duties and that these are properly used.

112. They shall keep themselves informed in regard to all work performed upon tracks and roadway in their districts, by Contractors or others, who may not be under their supervision; see that the work is done in such a way as not to endanger the safety of tracks or roadway and report promptly to the proper officer, if the work is not being done in accordance with the plans and specifications or according to prescribed standards.

113. In case of damage to tracks or roadway, they shall promptly assemble men and material, proceed to the place of accident, as quickly as possible and make the necessary repairs. They shall investigate all accidents to track and roadway and report promptly to the proper officer on the prescribed form.

114. They must know that the vicinity of all bridges and trestles is clear of combustible matter, and that the bridge seats, tops of the piers and other readily accessible portions of bridges and trestles are clear of cinders and dirt, and that the water barrels are kept full of water.

115. They shall see that the waterways and the approaches and outlets thereto are free from obstructions.

116. They shall not permit encroachment upon or occupancy of any portion of the Company's buildings, right-of-way or station grounds, except upon proper authority.

SECTION FOREMEN

117. Section Foremen report to and receive instructions from the Supervisor of Track.

118. Unless otherwise directed, Section Foremen will have immediate charge of, and be responsible for the safe condition of tracks, roadway, and right-of-way on their sections, and for the economical use of labor and material in their maintenance. They must do no work thereon that will interfere with the safe passage of trains, except under proper protection.

119. Each Foreman must go over his section, or send a competent, reliable man with suitable tools, at designated intervals, to make a thorough inspection, and see that the track, culverts, highway crossings, bridges, fences, etc., are in safe condition. If, in his judgment, the track or any bridge or culvert is not safe, he must at once put out

proper signals to warn approaching trains, notify the Supervisor of Track, Division Engineer and the Superintendent of the condition and do everything in his power to make the necessary repairs.

120. Section Foremen will have full charge of all forces under them, and shall employ the number of men the Supervisor of Track directs. They must see that their men properly perform their duties, and shall discipline those who are incompetent or neglectful. They must keep the records and make the required reports of the time of their men, and of the receipt, distribution, and use of the material furnished them.

121. In case of accident, Section Foremen must immediately proceed to the scene and render all assistance in their power, whether the accident occurs on their own or a neighboring section.

In the absence of the Supervisor or other ranking officer, the Section Foreman on whose section the accident occurs, will have charge of the assembled track forces, and shall be responsible for the character of the repairs made. He must not allow the track to be used until it is known to be safe.

122. Section Foremen shall investigate all accidents resulting in derailment or in damage to the track, roadway, or structures on their sections, and report on the prescribed form, giving the cause, as nearly as they are able to ascertain it.

123. They must keep themselves informed in regard to work performed on their sections by Contractors or others who do not come under their charge, and see that nothing is done by them that will interfere with the safety of tracks or the safe passage of trains.

124. They shall make a personal inspection of their sections at designated intervals, examining particularly main track switches and frogs, looking for concealed defects or breaks.

125. They must give special attention to points where obstructions are likely to occur, examine the slopes of cuts, and promptly remove all earth, trees, rocks, or anything likely to fall or slide upon the track, reporting such conditions to the Supervisor of Track.

126. Section Foremen shall maintain surface ditches in such a manner that the surface water is carried beyond the cut.

127. Section Foremen must keep the ditches and waterways leading to and from bridges and culverts clear within the limits of the right-of-way. They must remove accumulated drift and obstructions from trestles, culverts, and bridges after each storm, calling for assistance, when needed.

128. During heavy storms or high water, whether by day or night, whereby tracks or structures are liable to be damaged, Foremen and such of their forces as they deem necessary, must be on duty. At such times, they must go over their sections to make sure that the track is safe, taking stop signals with them.

129. They must see that Watchmen are properly detailed to patrol the track, watch bridges, or perform other duties, whenever necessary, for the safety of track and structures.

130. They must keep a careful lookout for fires along the track, and prevent, if possible, the destruction of buildings, fences, telegraph poles, timber, or other material, and the spread of fires to adjoining property. They must not permit fires to be started unless they have sufficient force to keep them under control.

Fires discovered on adjoining property must be promptly extinguished, if possible, and a report of the damage and origin, if it can be ascertained, made on the prescribed form.

131. They must keep the ground under and near buildings, bridges and trestles cleared of vegetation and combustible matter. Where water barrels are in use, they must keep them filled with water. They must keep bridge seats, tops of piers, and other readily accessible portions of bridges and trestles free from cinders, dirt and vegetation.

132. They must keep interlocking pipe lines and trunking free from grass and weeds, and switches, frogs and movable parts of interlocking plants free from snow, ice, and other obstructions. They must give special attention to drainage through interlocking plants and where track circuits are used.

133. When track work is to be done which may disturb interlocking or signal apparatus, there shall be co-operation between the Section Foreman and the Signal Maintainer or Foreman.

134. They must give special attention to the maintenance of road crossings, both as to safety and quality of track and as to the safe and comfortable accommodation of the highway travel on the crossing and approaches.

135. They must not permit any encroachment upon the Company's property or occupancy of any portion of the Company's buildings or grounds without proper authority.

EXTRA OR FLOATING GANG FOREMEN

136. Extra or Floating Gang Foremen, in charge of trackmen, report to and receive instructions from the Supervisor of Track.

137. They will have full charge of all forces under them, perform such duties and employ the number of men the Supervisor of Track directs.

WATCHMEN

138. Track, Bridge* and Tunnel Watchmen report to and receive instructions from the Section Foremen.

139. Track Watchmen must carefully examine the track and roadbed and see that they are in safe condition and that all switches are properly set and locked for the main track. They must examine buildings and other property of the Company and protect them from theft and fire. Should the track be obstructed, the Watchman must display stop signals in either direction from which trains may approach, and immediately notify the .... and the Section Foreman.

*Refers to watchmen patrolling bridges, not to structure watchmen.

140. Bridge Watchmen must keep a supply of water or sand on the bridges at all times and be prepared to extinguish fires. They shall keep the coping of the abutments and piers clean, remove combustible materials from near the bridges and frequently examine the bridge and report any defects found. Should they observe any obstruction of a dangerous character, they must display stop signals in either direction from which trains may approach, and immediately notify the ....

141. Tunnel Watchmen must make frequent trips through the tunnels, observing the condition of the tracks, particularly the rails, and also observe the walls of the tunnel, removing in winter all icicles which may become dangerous to traffic. In case obstructions occur which would endanger trains, they must at once display stop signals in either direction from which trains may approach and immediately notify the ....

142. When the time of Track, Bridge, or Tunnel Watchmen is not fully occupied with watching, they will perform such other duties as may be assigned them.

SUPERVISORS OF BRIDGES AND BUILDINGS

143. Supervisors of Bridges and Buildings report to and receive instructions from the Division Engineer.

144. They are in charge, on their respective districts, of the maintenance of bridges and structures, and of the employees engaged thereon.

145. They shall have immediate supervision of work train service for the maintenance of bridges and structures, using such service only when properly authorized by the Division Engineer.

146. Supervisors of Bridges and Buildings must make the prescribed inspections of the structures and appliances under their charge, and make the required reports.

147. They must know that the Foreman and others under their supervision fully understand and properly perform their duties; keep account of and report their time in the manner prescribed and discipline them when necessary.

148. They must know that the Foremen are supplied with tools and material necessary for the efficient performance of their duties and that these are properly used.

149. They shall keep themselves informed in regard to all work performed, upon bridges and structures in their districts by Contractors, or others, who may not be under their supervision; see that the work is done in such a day as not to endanger the safety of tracks, bridges or structures, and report promptly to the proper officer, if the work is not being done in accordance with the plans and specifications or according to prescribed standards.

150. In case of damage to bridges or structures they shall promptly assemble men and material, proceed to the place of accident, as quickly as possible, and make necessary repairs. They shall investigate all

accidents to bridges and structures, and report promptly to the proper officer on the prescribed form.

151. They shall know that water barrel or sand box rests on all timber bridges and trestles are in repair and supplied with barrels and buckets, and that station and other structures are equipped with the necessary water barrels, buckets and other appliances for use in case of fire.

GENERAL FOREMEN

152. General Foremen in the Bridge and Building Department report to and receive instructions from the Supervisor of Bridges and Buildings. All rules for the guidance of Supervisors of Bridges and Buildings apply to General Foremen in that Department.

153. They will have charge, under the Supervisor of Bridges and Buildings, of all bridges and structures in their respective districts; will have general oversight of the work being performed on such bridges and structures and will perform such other duties as may be assigned them by the Supervisor.

BRIDGE AND BUILDING FOREMEN

154. Bridge and Building Foremen report to and receive instructions from the Supervisor of Bridges and Buildings.

155. They are responsible for the safe, proper, and economical performance of the work assigned to them. They must do no work on a bridge or structure which will interfere with the safety of trains, except under proper protection.

156. They will have full charge of all forces under them and shall employ such forces as the Supervisor of Bridges and Buildings directs. They must see that these men properly perform their duties, and shall discipline those who are incompetent or neglectful. They must keep the records and make the required reports of the time of their men, and of the receipt, distribution, and use of material, furnished them.

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

158. The completion of any work includes the cleaning of the premises, proper disposition of debris, and removal of usable materials.

MASON FOREMEN

159. Mason Foremen report to and receive instructions from the Supervisor of Bridges and Buildings.

160. They are responsible for the safe, proper, and economical performance of the work assigned to them. They must do no work on a bridge or structure which will interfere with the safety of trains, except under proper protection.

161. They will have full charge of all forces under them and shall employ such forces as the Supervisor of Bridges and Buildings directs.

They must see that these men properly perform their duties, and shall discipline those who are incompetent or neglectful. They must keep the records and make the required reports of the time of their men, and of the receipt, distribution, and use of material furnished them.

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

163. The completion of any work includes the cleaning of the premises, proper disposition of debris, and removal of usable materials.

PAINTER FOREMEN

164. Painter Foremen report to and receive instructions from the Supervisor of Bridges and Buildings.

165. They are responsible for the safe, proper, and economical performance of the work assigned to them. They must do no work on bridges or structures which will interfere with the safety of trains, except under proper protection.

166. They will have full charge of all forces under them and shall employ such forces as the Supervisor of Bridges and Buildings directs. They must see that their men properly perform their duties and shall discipline those who are incompetent or neglectful. They must keep the records and make the required reports of the time of their men, and of the receipt, distribution, and use of material, furnished them.

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

168. Painter Foremen must examine the rigging and exercise care in the erection of rigging and scaffolding, and must know that they are safe before permitting them to be used.

169. The completion of any work includes the cleaning of the premises, proper disposition of debris, and removal of usable materials.

WATER STATION AND PLUMBER FOREMEN

170. Water Station and Plumber Foremen report to and receive instructions from the Supervisor of Bridges and Buildings.

171. They are responsible for the safe, proper and economical performance of work assigned to them. They must do no work which will interfere with the safety of trains, except under proper protection.

172. They will have full charge of all forces under them and shall employ such forces as the Supervisor of Bridges and Buildings directs. They must see that their men properly perform their duties, and shall discipline those who are incompetent or neglectful. They must keep the records and make the required reports of the time of their men, and of the receipt, distribution, and use of material furnished them.

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

174. They will have charge of, and are responsible for the maintenance of water stations, pipe lines, tanks, water columns, heating plants, plumbing and piping and of the installation of boilers for such plants, when so directed. They shall report any abuse or improper operation of the machinery under their charge.

175. They shall know that duplicate parts of such plants in their charge as are subject to exceptional wear or liability to breakage are available at all times.

176. When assistance is necessary to make repairs to water supply units, request must be made on the Supervisor of Bridges and Buildings.

177. When necessary to take any water tank, water column or any facility affecting the operation of other departments out of service, either temporarily or permanently, the Foremen will notify the Supervisor of Bridges and Buildings and must not, except in emergency, proceed with the work until authority is obtained. If an emergency exists, he shall notify the Superintendent, Division Engineer and Supervisor of Bridges and Buildings, by wire. When the facility is restored to service, proper notice must be given.

178. The completion of any work includes the cleaning of the premises, proper disposition of debris, and removal of usable materials

BRIDGE INSPECTORS

179. Bridge Inspectors report to and receive instructions from the Supervisor of Bridges and Buildings.

180. They will be governed by the instructions for the inspection of bridges, as adopted by the A.R.E.A., and will conform to the instructions issued by the ....

181. They will perform such duties as may be assigned them by the Supervisor of Bridges and Buildings.

SUPERVISOR OF SIGNALS

182. Supervisors of Signals report to and receive instructions from the Division Engineer.

183. They are in charge, on their respective districts, of the maintenance of all automatic and mechanical signals and plants and of the employees engaged thereon.

184. They must make frequent inspection of all signals and plants under their charge and make the required reports.

185. They must know that Foremen, Maintainers and others under their supervision, fully understand and properly perform their duties; keep account of and report their time in the manner prescribed and discipline them when necessary.

186. They must know that Foremen and Maintainers are supplied with tools and material necessary for the efficient performance of their duties and that these are properly used.

187. They shall keep themselves informed in regard to all work performed upon automatic and mechanical signals, plants and appliances in their districts, by Contractors or others, who may not be under their supervision; see that the work is done in such a way as not to endanger the proper operation of such signals, plants or appliances, and report promptly to the proper officer if the work is not done in accordance with plans and specifications, or according to prescribed standards.

188. In case of damage to automatic or mechanical signals, plants or appliances, they shall promptly assemble men and material, proceed to the place of accident, as quickly as possible, and make the necessary repairs. They shall investigate all accidents to automatic and mechanical signals, plants and appliances, and report promptly on the prescribed form.

189. They must investigate failures or improper working of interlocking and signal apparatus, see that repairs are made promptly and make the prescribed reports.

190. They must know that signal apparatus is tested frequently in order, if possible, to discover defects or irregularities which might lead to failures.

191. They must not make or permit to be made any alterations or additions to the interlocking or signal apparatus without proper authority. Such authorized changes or additions as are made must be reported to the proper authority immediately upon their completion, so that the other departments affected may have such information.

SIGNAL FOREMEN

192. Signal Foremen report to and receive instructions from the Supervisor of Signals.

193. They are responsible for the safe, proper and economical performance of the work assigned to them.

194. They will have full charge of such forces as the Supervisor of Signals directs. They must see that these men properly perform their duties and shall discipline those who are incompetent or neglectful. They must keep the records and make the required reports of the time of their men, and of the receipt, distribution and use of material furnished them.

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

196. When any part of an interlocking plant is to be repaired, an understanding must be reached with the signalman on duty, in order to insure safe movement of trains and engines during repairs. The signalman on duty must be notified when the repairs are completed.

197. Signal Foremen must notify the Supervisor of Signals, in advance of any work requiring the removal from service of any part of signal or interlocking apparatus, and such apparatus must not be taken out of service until proper authority is obtained.

198. The completion of any work includes the cleaning of the premises, proper disposition of debris, and removal of usable material.

SIGNAL MAINTAINERS

199. Signal Maintainers report to and receive instructions from the Supervisor of Signals.

200. They are responsible for the safe condition and proper maintenance of the interlocking or signal apparatus in their territory and for the economical use of material in their maintenance.

201. They will have full charge of such forces as the Supervisor of Signals directs. They must see that these men properly perform their duties. They must keep the records and make the required reports of the time of their men, and of the receipt, distribution and use of the material furnished them.

202. When any part of an interlocking plant is to undergo repairs an understanding must be reached with the signalman on duty, in order to insure safe movement of trains and engines during repairs. If it is necessary to disconnect any switch, movable point frog or derail, it must be securely spiked in proper position before permitting trains or engines to pass over it.

203. Signal Maintainers must notify the Supervisor of Signals before taking any signal or interlocking apparatus out of service, and authority must be obtained, except in emergency, before such apparatus is taken out of service. Should an emergency arise which requires removal from service of any apparatus, signals must display their most restrictive indication; switches, movable point frogs and derails must be securely spiked in correct position and Supervisor of Signals, Division Engineer and Superintendent immediately notified by wire.

204. In case of accident or serious damage to interlocking or signal apparatus in their territory, Signal Maintainers must immediately proceed to the place, asking for such assistance and material as may be required, and make repairs promptly.

205. If an accident is caused or alleged to have been caused by any defect in the interlocking or signal apparatus, a thorough examination must be made before any apparatus is disturbed; a record of the position of the levers shall be made, and a written statement of conditions found shall be sent to the Supervisor of Signals.

206. Signal Maintainers must co-operate with track forces in work pertaining to the maintenance of such track appliances as affect the operation of signals.

207. They must make such inspection and repairs of signal apparatus under their charge as will secure proper operation. They must inspect the signal lights on their territories at regular intervals and make report to the Supervisor of Signals.

208. They must make the usual standard tests for condition and efficiency of interlocking switches, derails, etc., keep them adjusted, and make the required reports.

SUPERVISORS OF TELEGRAPH AND TELEPHONE

209. Supervisors of Telegraph and Telephone report to and receive instructions from the Division Engineer.

210. They are in charge, on their respective districts, of the maintenance of all telegraph and telephone lines and apparatus and of the employees engaged thereon.

211. They must make frequent inspection of all telegraph and telephone lines and apparatus under their charge and make the required reports.

212. They must know that Foremen, Maintainers and others under their supervision fully understand and properly perform their duties; keep account of, and report their time in the manner prescribed and discipline them when necessary.

213. They must know that Foremen and Maintainers are supplied with tools and material necessary for the efficient performance of their duties and that these are properly used.

214. They shall keep themselves informed in regard to all work performed upon telegraph and telephone lines and apparatus in their districts by Contractors and others who may not be under their supervision; see that the work is done in such a way as not to endanger the proper operation of the telegraph and telephone lines and apparatus, and report promptly to the proper officer, if the work is not being done in accordance with the plans and specifications or according to prescribed standards.

215. In case of damage to wires or apparatus, they shall promptly assemble men and material, proceed to the place of accident as quickly as possible, and make the necessary repairs. They shall investigate all accidents to wires and apparatus and report promptly to the proper officer on the prescribed forms.

216. They must investigate failures or improper working of telegraph or telephone apparatus, see that repairs are made promptly and make the prescribed reports.

217. They must know that telegraph and telephone wires and apparatus are tested frequently in order, if possible, to discover defects or irregularities which might lead to failures.

218. They must not make or permit to be made, any alterations or additions to the telegraph or telephone wires or apparatus, without proper authority. Authorized additional changes or additions, when made, must be reported to the proper authority immediately upon their completion, so that the other departments affected may have such information.

TELEGRAPH AND TELEPHONE FOREMEN

219. Telegraph and Telephone Foremen report to and receive instructions from the Supervisor of Telegraph and Telephone.

220. They are responsible for the safe, proper and economical performance of the work assigned to them.

221. They will have full charge of such forces as the Supervisor of Telegraph and Telephone directs. They must see that these men properly perform their duties and discipline those who are incompetent or neglectful. They must keep the records and make the required reports of the time of their men and of the receipt, distribution and use of material furnished them.

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

223. When any part of the telegraph or telephone apparatus, which affects the movement of trains, is to be repaired, an understanding must be reached with the operator on duty to insure safe movement of trains and engines during repairs. The operator on duty must be notified when the repairs are completed.

224. Telegraph and Telephone Foremen must notify the Supervisor of Telegraph and Telephone in advance of any work requiring the removal from service of any part of the Telegraph or Telephone wires or apparatus, and such apparatus must not be taken out of service until proper authority is obtained.

225. The completion of any work includes the cleaning of the premises, proper disposition of debris, and removal of usable material.

TELEGRAPH AND TELEPHONE MAINTAINERS

226. Telegraph and Telephone Maintainers report to and receive instructions from the Supervisor of Signals.

227. They are responsible for the safe condition and proper maintenance of the Telegraph and Telephone wires or apparatus in their respective territories and for the economical use of material in such maintenance.

228. They will have full charge of such forces as the Supervisor of Telegraph and Telephone directs. They must see that these men properly perform their duties. They must keep the records and make the required reports of the time of their men, and of the receipt, distribution and use of the material furnished them.

229. When any part of the Telegraph or Telephone wires or apparatus, which directly affects the movement of trains, is to undergo repairs, an understanding must be reached with the operator on duty in order to insure the safe movement of trains and engines during repairs.

230. Telegraph and Telephone Maintainers must notify the Supervisor of Telegraph and Telephone before taking out of service any part of the Telegraph or Telephone wires or apparatus, and authority must be obtained, except in emergency, before such wires or apparatus

are taken out of service. Should an emergency arise, which requires the removal from service of any part of Telegraph or Telephone wires or apparatus, the Supervisor of Telegraph and Telephone, Division Engineer and Superintendent must be immediately notified by wire.

231. In case of accident or serious damage to Telegraph or Telephone wires or apparatus in their territory, Telegraph and Telephone Maintainers must immediately proceed to the place, asking for such assistance and materials as may be required, and make repairs promptly.

232. If an accident is caused or alleged to have been caused by any defect in the Telegraph or Telephone wires or apparatus, a thorough examination must be made before any wires or apparatus are disturbed. A record shall be made and a written statement of the conditions found shall be sent to the Supervisor of Telegraph and Telephone.

233. Telegraph and Telephone Maintainers must make such inspections, tests, and repairs of the Telegraph and Telephone wires and apparatus under their charge as will secure proper operation.

CONDUCT OF WORK

Right-of-Way

Care of

234. Section Foremen shall keep their sections in a neat and orderly condition, and shall devote sufficient time to cleaning and putting things in order around section toolhouses, station grounds, yards, sidings, highway and farm crossings, and the right-of-way generally.

Fencing

235. Section Foremen are responsible for the proper inspection of the fences on their respective sections. They shall report to the Supervisor any defects found, making such temporary repairs as possible, and endeavoring to keep stock from getting upon the right-of-way or tracks, until permanent repairs can be made. They should endeavor to keep all gates closed, securing so far as possible, the co-operation of the adjacent landowners in this effort.

Mowing

236. The amount of mowing done will depend upon local conditions and Federal, State or County laws or regulations. Where the railroad runs through forest lands, fire regulations must be complied with.

237. Section Foremen, under the direction of the Supervisor, are responsible for compliance with all the laws, rules and regulations in effect in their respective districts, with reference to mowing and fire protection.

General Cleaning

238. Section Foremen should for reasons of economy, as well as neatness, gather up scrap and usable material from the right-of-way, disposing of the same as directed by the Supervisor. They should see that no trees which by their location or condition might endanger trains

or the Telephone or Telegraph wires, are left standing on the right-of-way or adjacent thereto, getting permission to cut those trees not on the right-of-way, if possible to do so. They should endeavor to keep the tracks and right-of-way in a neat and tidy condition.

ROADBED

Drainage

General

239. Thorough drainage of the roadbed is absolutely necessary before good track can be secured or maintained, and it is of the first importance that this matter be given careful detailed consideration at all points.

Surface Drainage

240. Ditches should be kept open at all times so as to divert the water from the roadbed quickly. They should be dug out thoroughly and restored to full size in the spring and late fall. Side ditches should be dug uniformly and parallel to the track, and conform to the standard roadbed sections.

241. Intercepting ditches should be constructed along the top of the bank, for the protection of cuts, where the drainage area would be likely to collect sufficient water during heavy rains, from the higher ground adjacent, to wash the slopes.

242. The end of a ditch should be diverted from the track, so that the scouring action of the water will not weaken or wash away the roadbed.

243. Waterways leading to and from bridges and culverts should be kept clean within the limits of railroad property. All culverts should be kept open for the free and unobstructed passage of water at all times.

244. In regions of heavy snows, ditches should be cut through the snow, wherever a sudden thaw would be likely to flood the track, and all ditches should be cleaned when the snow is melting in the spring.

245. Cross drains should be put in at proper intervals, where directed.

Underground Drainage

246. In wet or narrow cuts, where side ditches cannot be effectively maintained, sub-drains will be provided as directed by the ...., who will determine the size and character of drains to be used. Such drains must be laid to a true grade and in conformity with standard plans.

CARE OF ROADWAY

247. The cross-section of the roadway shall conform to the standard plans. No deviation from the sections shown shall be made without proper authority.

248. Growth of vegetation on the slopes of cuts and embankments should be encouraged to prevent erosion.

TRACK

Ties

Storage of

249. Ties stored along the right-of-way should be piled to conform to the standard plan. (The standard plan should show the minimum distance to the nearest rail.)

250. Ties intended for treatment should not be inspected before being brought to the shipping point. As soon as such ties are brought to the shipping point by the producer, they should be inspected and loaded promptly for shipment to storage yards at treating plants.

Renewals—Inspection for

251. The ties in track must be inspected at stated times each year and those which will not last until the next inspection marked for renewal. This inspection should be made preferably by the Supervisor personally, accompanied by the Section Foreman. The Supervisor should report to the Division Engineer, on the proper form, the number of ties marked for renewal on each mile and each section. This report should be carefully checked by the Division Engineer and where any unusual or unfavorable condition is indicated, a thorough investigation should be made to insure proper renewals.

Renewals—Method of

252. The renewal of ties should be started when directed by the Division Engineer. All defective ties removed from track shall each day be placed for burning or loading on cars. The Supervisor shall frequently inspect ties removed from track to see if any have been removed which might have remained in the track, with safety, until the next inspection.

253. Ties shall be spaced according to the standard plan. All ties shall be placed square to the line of rails. The outside ends on double tracks, and the ends on one side throughout on single track should be lined parallel with the rail.

254. Ties should be laid so as to obtain the best bearing. The side nearest the heart of the tree should be placed down whenever possible. Twisted or badly hewn ties should have the bearings made true with an adze. It is good practice to adze ties requiring treatment before the preservative is applied.

Use of Tie Plugs

255. Whenever spikes are drawn from ties, wooden tie plugs should be driven into all holes, except in ties which are to be renewed that season. In replacing spikes, they should be driven into the plugs.

Records of

256. Full and accurate records of tie renewals and all data of value in connection therewith should be kept on suitable forms. Forms recommended by the A.R.E.A. are most convenient and satisfactory.

Rail

Renewals

257. The most expensive and the most easily damaged part of the track structure is the rail, therefore care should be exercised in the unloading and handling of it. In unloading from cars, rails should be skidded or otherwise carefully lowered to prevent injury. Where it is necessary to drop them, both ends must be dropped at the same time, and the greatest care taken to avoid their falling on hard or uneven surfaces. Rails received in gondola cars should be unloaded with some approved device to prevent injury.

258. Rails should be distributed, as far as practicable, where they can be laid with the least amount of handling. Unless the rail is to be laid at once, it should not be distributed through yards and station grounds where trainmen and others may stumble over it.

259. Rail laying may be done in the winter months, or at such seasons of the year, depending on the climate, as are not favorable for doing other track work.

260. Where practicable, rail should be laid one at a time. Standard expansion shims should be used. The openings between 33 ft. rails should be as follows:

—20° to 0°	5/16 inch
0° to 25°	1/4 inch
25° to 50°	3/16 inch
50° to 75°	3/8 inch
75° to 100°	1/16 inch

Over 100° rail to be laid close.

Care should be taken that the openings between the rails be not more than the above limits, as too much expansion in the joints will spoil the rail quicker than any other error or defect in the method of laying, especially under heavy traffic.

261. Care should be exercised by those in charge of rail laying gangs to see that adzing is carefully done and the rail left in proper line, gage and surface. Shims should be used if the track is frozen and the ties cannot be lifted to eliminate low spots. It is desirable to place tie plates and anticreepers the same day the rail is laid. It is especially important to prevent any running of the rail by using a sufficient number of anticreepers at once, as any running of the rail changes the expansion in the joints, making some joints wide and others close, resulting in battered joints, and in the hot weather danger from buckling of the track where the joints are tight.

262. Except for very sharp curves, sharper than are usually found in main line tracks, rail should not be curved before laying.

263. All kinked or crooked rails should be straightened before being laid; if surface bent, they must either be removed or straightened.

264. In making temporary connections in main tracks, an old rail should be cut and fastened to the new rail, using compromise joints when necessary.

265. When replacing rail of approximately the same width of base, so that the tie plates need not be changed, but two lines of spikes should be drawn. When a different tie plate is required, all spikes must be drawn. Where no tie plates are in use but three lines of spikes need be drawn for any change in the width of the base of rail.

266. All spikes should be driven vertically with the face in contact with the base of the rail. They should not be straightened while being driven. The rail must be full spiked, and the spikes should be staggered so that the outside spikes will be on the same side of the tie, and the inside spikes on the opposite side. Where shoulder tie plates are used, a third spike may be driven on the inside of the rail, with the back of the spike against the base of the rail. Good second-hand spikes can be used for the third spike.

267. All joint bars should be securely fastened with the full number of bolts. At permanent connections of rails of different sections, compromise joints should be used.

268. For the preservation of the rail, and to secure the best bearing for carrying the loads, and distributing the weight of the rolling stock uniformly over the rail and to the roadbed, the ties should be spaced a uniform distance, face to face. Approximately eleven (11) inches apart will give, with average ties, twenty (20) ties to a thirty-three (33) foot rail and eighteen (18) ties to a thirty (30) foot rail.

269. The rail joint should be so designed as to obviate any necessity for special spacing of the joint ties. With properly designed joints, respacing of ties when the rail is renewed is unnecessary.

Bonding

270. Where track circuits are used for operation of signals or other purposes, bonding of the rails is necessary and this feature should receive proper consideration and the work be carefully and efficiently performed. Where air, electricity or other power is available, any mechanical arrangement which will operate drilling machines successfully is desirable and economical.

Replacement—Inspection of Rail in Track

271. A complete record should be kept by miles and sections, of the manufacturer, section, year, position and rail letter, of all new rail laid in track. This record should be kept in book form; one copy in the Division Engineer's office, one copy covering his section, by each Section Foreman. This record should be kept absolutely up to date, each and every change, whether of individual rails or many rails, being immediately recorded in the books and the old record removed.

272. Track walkers should be properly instructed to look for broken or defective rails, and report same, when discovered, to the Section Foreman, taking proper precautions to protect traffic, if necessary, on account of the condition of the rail found.

273. Where rail failures become numerous, especially if transverse fissures develop, a special rail inspection should be arranged. This can

be facilitated by the use of a mirror attached to a short wire handle for examining the inside and underside of the head of the rail. A good magnifying glass with which minute defects or hair line cracks can be inspected, is desirable. This method of inspection, if properly conducted, will result in the discovery of a large percentage of transverse fissures before the rail breaks in the track, and such rails can be removed. When one rail of an ingot fails in track by reason of a transverse fissure, all the remaining rails of that ingot should be removed from main line passenger tracks. Such rails may be relaid in side tracks or in yards.

Broken Rails

274. A broken rail found in the main track must be protected immediately by a flagman and no trains allowed to pass over it until it is found that the rail is in such condition as will permit the train to pass in safety. If it is decided trains may pass over the rail safely, all trains must be stopped before reaching the break, and then allowed to proceed at slow speed. If a suitable rail is available, the broken rail should be replaced immediately; otherwise, if it can be done, the broken ends of the rail should be connected by joint bars, the rail drilled and the joint bars full bolted, after which the resumption of traffic may be permitted.

Joint Bars

275. Rail joints should be as simple and of as few parts as possible to be effective.

276. The joints should be kept well oiled, both as a preservative from rust and to facilitate expansion and contraction of the rail.

277. Insulated joints should be installed only on rails conforming to the section for which they are designed. Care must be taken, when installing such joints, to properly place the insulation, and not to damage the fiber or bushings. The ties under and adjacent to insulated joints must be kept well tamped.

Track Bolts

278. As large track bolts should be used as the rail and joint bars will permit.

279. It is essential to the preservation of the rail and joint bars that track bolts be kept tight. The use of proper nutlocks, keeping the bolts well oiled, and careful inspection and systematic tightening of all bolts is required of Section Foremen.

280. Track bolts should be gone over and re-tightened after new rail has been laid, as soon as traffic has worn the mill scale and rust off the joint bars and settled the bars into place.

281. Care should be exercised in the design of wrenches for tightening track bolts. The jaws should fit the nut as closely as possible and the handle should be long enough so one man can tighten the nuts, but not long enough so one man can twist or stretch the bolts.

Nutlocks

282. Spring nutlocks of approved design should be used on all track bolts.

Track Spikes

283. Care should be exercised in driving spikes to keep the spike vertical, so as not to necessitate straightening the spike by striking the back of the head with a hammer when it is partly driven. Spikes should be driven until the heads are in contact with the base of the rail, but not driven too far, thereby bending the neck and causing the head to crack or break off.

284. Badly bent, crooked, or neck-cut spikes should not be used, especially in main tracks. Good spikes, which are bent, should be sent to a reclaiming plant and straightened.

Anticreepers

285. Anticreepers should be applied where instructed by ....

The number of anticreepers per rail will depend upon the physical characteristics of the track, and the amount and character of the traffic.

286. In the application of anticreepers care should be exercised to use proper tools, to properly apply the anticreepers, and not to damage any of their parts. The use of spikemauls, or heavy hammers, should be discouraged.

Tie Plates

287. Tie plates will be used where directed by the ....

288. Shoulder tie plates, so punched that special joint plates are unnecessary, should be used.

289. When applying tie plates care should be exercised to see that the plates have a full even bearing on the ties, that the track is in correct gage before they are spiked to the tie and that the shoulder of the plate rests against the base of the rail for the full width of the plate. The shoulder of the plate must not be permitted to remain under the base of the rail. Rough or crooked ties should be adzed when necessary to give a level bearing and all old spike holes should be plugged.

BALLAST

Cross-Section

290. The cross-section of the ballast should conform to the standard plans.

Unloading

291. 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.

Ballasting

292. It is not possible to maintain good riding track under heavy traffic with insufficient ballast. The purpose of ballast is to provide a uniform support for the track, distribute the weight of the trainload to the roadbed, hold the track in position, and assist in the drainage.

293. 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.

294. Where directed by the Division Engineer, preparatory to the distribution of new ballast, all the old ballast and unsuitable material will 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 embankments or other purposes. At the same time, all ties requiring renewal should be replaced and the ties properly spaced, if necessary.

295. 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 rail up to grade.

296. Foremen should be sure they are properly protected by slow order, caution signs, or flag, or all of these, if necessary, when raising track, and should, except in emergency, raise against the current of traffic, where there is more than one track. A long easy runoff should always be prepared ahead of fast passenger trains.

297. In gravel or broken stone ballast, it is recommended as good practice to tamp the ties solid from 15 in. inside the rail out 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.

298. Where the track is electrically bonded, the ballast must be kept at least 1 in. 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 ft. each side of the rails.

299. The following tools should be used: For broken stone or furnace slag ballast: Shovel, tamping pick and stone fork. For gravel, chats, chert or cinder ballast: Shovel, tamping pick or tamping bar.

300. Mechanical tie tampers have been developed, which are efficient and economical, and these may be used for heavy main line work in any kind of ballast.

301. There are a number of devices and machines now being manufactured for use in cleaning ballast, and any device which is efficient and economical should be used.

LINE AND SURFACE

302. Good line and surface are the first essentials for good riding track. If sufficient ballast is furnished at the proper time and properly distributed, and tie renewals are kept up to date, the proper attention to line and surface will insure good riding track.

303. As early in the spring as the weather and track conditions will permit, the entire section should be gone over and smoothed up. At this time special attention should be given to those portions of the section on which no tie renewals or ballasting is expected to be done, during the season, and this track put in 100 per cent. condition. Where tie renewals are to be made, or ballasting is to be done, no unnecessary work should be done, the aim being to keep these portions of the section sufficiently smooth for safe and comfortable riding, until the work of renewing ties or ballasting can be accomplished.

304. Where the track shows evidence of being badly out of line on curves, and there is opportunity to do so, it is recommended that line stakes be set by Engineers. But ordinarily the Section Foreman, assisted, if necessary, by the Supervisor, can line the track very accurately and secure practically perfect riding curves by the use of a string.

305. By using a string 62 ft. long, holding the ends against the gage side of the high rail and measuring the distance from the middle of the string to the gage of the rail, the approximate degree of curve can be found—each inch of distance representing 1 deg. of curve.

306. When raising or surfacing track, Foremen must not trust to their eyesight alone, but must use the track level boards and sighting boards. Track level boards must be tested frequently.

307. When not surfacing out of face, as in case of picking up joints or other low places, the general level of the track should not be disturbed.

Shimming

308. Wooden shims placed under the rails should be used to maintain the proper surface of the track, when the surface is disturbed by the action of frost, or when other conditions make tamping impracticable.

309. When shimming, the track level and track gage must always be used.

310. Shimming should be done on top of the tie. No shimming should be done under the tie, except in emergency and shims so placed should be removed as soon as possible.

311. Shims must be the same thickness throughout, and not wedge shaped. They must have an even bearing on the tie.

312. Where shims are used the rails must be securely braced to prevent spreading. Tie plates with one end placed against the outside under the head of the rail, and the other end spiked to the tie make good braces.

313. Section Foremen must watch track which has been shimmed very closely, testing frequently with the gage and level board to make

sure that shims are in place and tight and that track does not get out of gage or surface.

314. When the frost is leaving the track, shims must be changed frequently replacing thick shims with thinner, until the necessity for shims has passed. As soon as the frost is entirely out of the track, all shims should be removed and the track surfaced, if necessary. Care should be exercised, however, that track surfacing is not done before the frost has all gone.

GAGING

315. Uniform gage is essential to good track and must be maintained.

316. The standard gage is 4 ft. 8½ in. Curves of 8 deg. and under should be standard gage. Gage should be widened ⅛-in. for each 2 deg. or fraction thereof, over 8 deg., to a maximum of 4 ft. 9¼ in. for tracks of standard gage. Gage, including widening due to wear, should never exceed 4 ft. 9½ in.

317. The installation of frogs on the inside of curves is to be avoided whenever practicable. Where this is unavoidable the gage of the track at the frog should be standard.

318. Where track is lined and surfaced the gage should always be checked and made standard at the same time. If the track is allowed to remain out of line or out of surface for any length of time, bad gage is very likely to result therefrom, and for this reason Foremen should always check the gage and make any necessary corrections when lining and surfacing the track.

319. Track gages should be checked frequently with a standard gage to assure that all gages are correct. This may be done each year in the winter months, and the gages should be painted a new standard color each time tested.

Elevation of Curves and Easements at Ends of Same

320. The elevation on curves and the easements at the ends of same should be in accordance with the requirements and according to prescribed standards.

321. Where the maximum speed allowed by timetable is higher than the maximum standard elevation will safely permit, the speed should be reduced accordingly. Signs should be placed at the beginning of each curve where the speed must be reduced below the maximum allowed by the timetable. The signs should show in plain figures the maximum permissible speed.

322. The maximum elevation on any curve must not exceed seven and one-half inches. It should be remembered that speed is the principal factor in elevation on curves, and that the degree is a secondary factor only. Foremen should be cautioned not to carry too much elevation where speed is slow, even if the curvature is sharp. Where there is considerable freight traffic and passenger traffic is not so important, it

is advisable to keep the elevation low on the curves, and slow down the passenger trains to meet the conditions.

323. Where possible, posts should be placed at the side of the track for the guidance of Section Foremen. These posts, indicating the elevation in inches and fractions thereof, should be set at the beginning of the easement; at the beginning and end of the regular curve, and at the end of the easement or point of the tangent. Posts should also be set at the points of compound and at each end of easements, between compound curves.

FROGS AND SWITCHES

324. The proper installation and maintenance of frogs and switches is essential both for safety and economy.

325. It is especially important to keep the track in good line and surface through frogs and switches, and Foremen must give these features special attention.

326. Switches and frogs must be inspected frequently to see that they are in proper working order, and that all nuts, bolts and other fastenings are in place and properly tightened. Any broken or damaged parts should be replaced promptly.

327. Switch points must fit closely and accurately to the stock rail, which must be bent in accordance with the prescribed standards. When renewing a switch point, the stock rail should also be renewed, if necessary to secure a proper fit of the point. In like manner a new stock rail should not be used with a worn point, as there is grave danger of derailment, if the stock rail is higher than the switch point.

328. Frogs must be protected by guard rails, constructed and placed in accordance with standard plans. The tops of the guard rails should be level with the main running rails, and should be securely held in place.

329. Guard rails should be so placed that the gage distance from the frog point to the flangeway side of the guard rail will be at least 4 ft. 6¾ in., and the distance between the flangeway sides of the wing rail and guard rail shall not exceed 4 ft. 5 in.

330. Switch rod and connecting rod bolts must be equipped with cotter pins. The bolts should be inserted with the nut on top for convenient inspection.

331. Switches must be kept free from obstructions at all times and free from ice and snow in winter. The slide plates should be kept well oiled.

332. Switch stands must be kept firmly spiked to the head-block ties, must be set plumb, and with the target square with the track.

333. Automatic switch stands should be inspected frequently for lost motion. They must be kept well oiled. Head-block ties must be kept firmly tamped.

334. The switch stand should be placed, wherever possible, on the side of the track where the connecting rod will be in tension when the

switch is set for the main track. The switch banners and lamps should be placed on the right hand or Engineer's side of the track approaching facing point switches.

335. All switch stands and facing point switches on multiple tracks and all main track switches on single track should be equipped with switch lamps of approved design, which will show the proceed color when the switch is set for the main track and the stop color when the switch is open.

336. Unless otherwise provided for, the Section Foreman is responsible for the proper care and maintenance of switch stands and lamps and must give these devices careful attention. Switch stands must be kept tight on the head-blocks and adjusted to give the switch the proper throw and to keep the points tightly against the rails, when the switch is closed, either for the main track or the turnout.

337. Switch lamps must be kept clean, supplied with oil, properly adjusted, and firmly placed on the switch stand, so they will not jar out when the switch is used.

338. Main track switches, not interlocked, must be kept locked at all times except when in actual use by trains, or when being inspected. Foremen must report immediately main track switches found unlocked or with the lock missing.

SWITCH TIES

339. Switch ties should be used for all permanent turnouts, crossovers and railroad crossings, and should conform to the standard specifications for material, sizes and workmanship. They should be placed in track in accordance with the standard plans.

340. For temporary work, track ties may be used, lapping them in place of switch ties, but switch ties should be used for head-blocks and for at least three or four ties under the frog and guard rails.

TRACK SIGNS AND POSTS

341. Track signs and posts must be provided and placed in accordance with standard plans and special instructions.

342. Section Foremen must see that all track signs and posts are in their proper places and are kept plumb, and that weeds and other vegetation are not permitted to obstruct the view of same.

343. All track signs and posts, so far as possible, should be made of metal or other suitable material which will not quickly deteriorate. If made of metal, the posts of small signs can be made of old boiler flues, which have been scrapped. All track signs and posts should be kept painted.

ROAD CROSSINGS

344. Section Foremen are responsible on their respective sections for the proper care and maintenance of public and private road crossings.

345. Road crossings should be constructed and maintained according to standards, and conform to legal requirements. Plankless crossings are more easily maintained and more satisfactory to travelers on the highways. These are constructed of clean stone, of the smaller sizes used for road construction, with a good asphaltum binder for the top coat.

346. Road crossing signs where required by law, must be maintained. Such signs should be properly placed and kept clear of obstructions which would interfere with the view of travelers on the highway. Where possible, the permission of adjacent landowners should be secured, if necessary, and all brush or trees, obscuring the view of approaching trains, removed.

TRACK TOOLS

347. A sufficient number of the proper kind of tools, in serviceable condition, is essential for economy and efficiency in the performance of any kind of track work.

348. All track tools are furnished by and remain the property of the Company.

349. Section and other Foremen in charge of men will be held responsible for the proper care and use of tools. They must know that they have at all times a sufficient supply, in serviceable condition. They should see that tools are not lost or broken, and that, when in use, they are not left where they are liable to be struck by trains or derail trains.

350. When not in use, all tools should be collected and properly protected from the weather and from being stolen. Where it is not practicable for Foremen to take all tools to the toolhouse each evening, suitable tool boxes, equipped with substantial locks, should be provided, and all tools placed therein each night.

351. Labor saving devices and appliances should be used wherever such use can be shown to be economical.

352. The use of heavy sections of rail makes the handling and laying of such by hand, laborious and costly. Rail handling and laying machines, or locomotive cranes, should be used for such work where available.

Appendix C

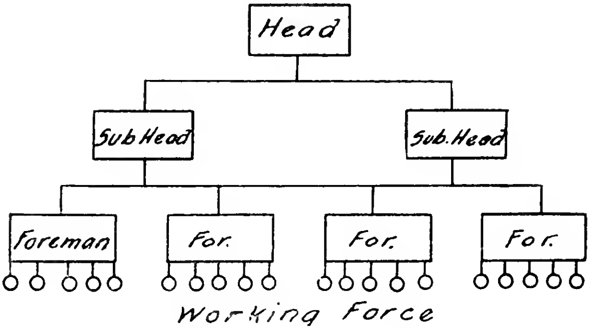
THE SCIENCE OF ORGANIZATION

S. E. Coombs, *Chairman,* Sub-Committee (4).

Up to the present, Organization has developed as an art rather than a science and has brought out two general types, viz., the *Line* Type and the *Staff* Type.

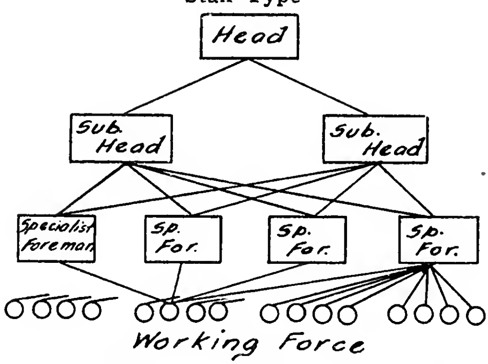
Line Type is exemplified in the army, in which there is a direct connection from the head through each subordinate to the next lower until the worker, if we may so call him, is reached.

Line Type



Staff Type is exemplified in manufacturing concerns, where there are specialists who may direct the worker in any part of his work that may be of a nature to be covered by the specialist's knowledge or authority.

Staff Type



Nearly all organizations are combinations or modifications of these two types.

In the Organization of the Engineering forces of a railroad the types work out into what is known as Departmental and Divisional Organizations, which are modified Line Types, in the manner shown in Exhibits "A" and "B."

Fundamentals of Organization

1. An organization must have its object clearly defined.
2. In its simplest form Organization consists of Head and Working Force.
3. Subdivisions, combinations, extensions and modifications of this form may be made to any extent and may be most readily shown and understood by means of charts.
4. The Head or Executive must
   (a) understand his objective.
   (b) plan and direct all activities.
   (c) select and educate working force.
   (d) receive results.
5. Executive must have complete authority over working force.
6. Executive may subdivide or delegate his authority, in which case each sub-head must know exactly his duties and responsibilities and there must be an invariable sequence without any conflict in, nor division of, authority and responsibility.
7. There must be harmony in all relations of different sub-heads.
8. There must be interchange of ideas and information between all types of executives.
9. Working force consists of equipment, tools and men, and the economic relations between these must be balanced.
10. Correct discipline is an essential feature of organization.
11. Compensation must follow the human effort in just proportion.
12. Not only physical force is available in any human organization but proper results from 10, 11 and 4c should develop in such a body an *esprit de corps*.
13. Co-ordination and correlation of work as to time, place and materials must not only be planned by executive, but he must know that it is accomplished.
14. Sub-heads in the smaller spheres must apply all principles used by the higher executives.
15. Standardization of methods and means must be intelligently applied.
16. Organization charts give the simplest and most readily comprehended means of expressing the system in use.

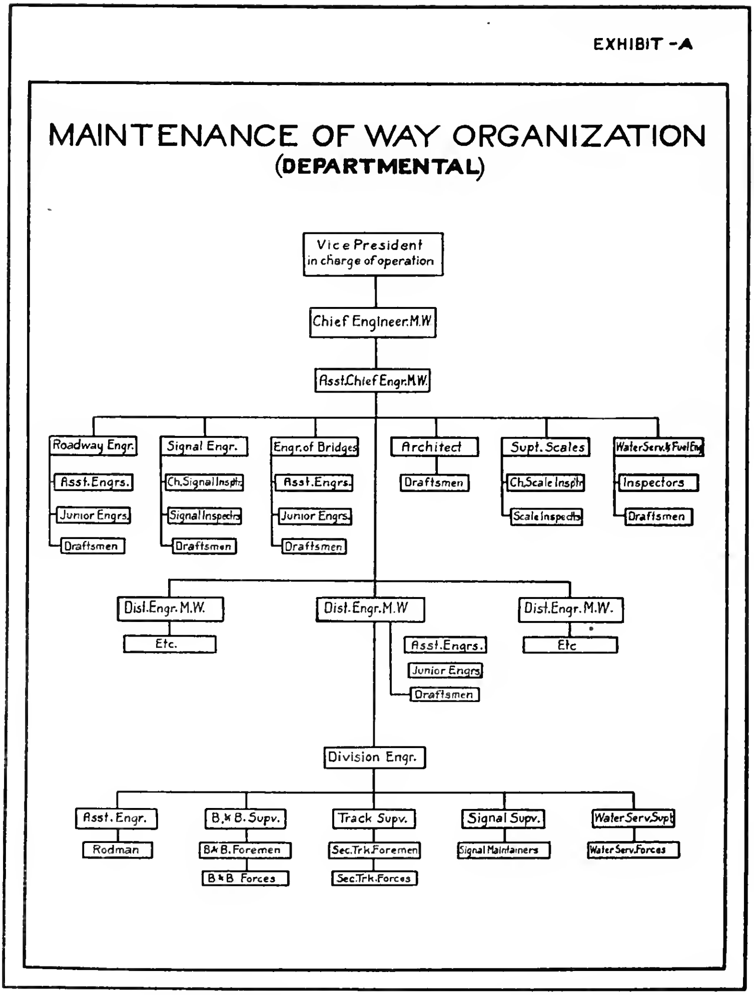


EXHIBIT -A
MAINTENANCE OF WAY ORGANIZATION
(DEPARTMENTAL)
Vice President in charge of operation
Chief Engineer M.W
Asst.Chief Engr.M.W.
Roadway Engr.
Asst.Engrs.
Junior Engrs.
Draftsmen
Signal Engr.
Signal Inspectrs
Draftsmen
Engr.of Bridges
Asst.Engrs.
Junior Engrs.
Draftsmen
Architect
Draftsmen
Supt. Scales
Ch.Scale Inspt'r
Scale Inspectrs
Inspectors
Draftsmen
Dist.Engr.M.W.
Etc.
Dist.Engr.M.W
Asst.Engrs.
Junior Engrs
Draftsmen
Dist.Engr.M.W.
Etc
Division Engr.
Asst. Engr.
Rodman
B.& B. Supv.
B& B. Foremen
B & B Forces
Track Supv.
Sec.Trk.Foremen
Sec.Trk.Forces
Signal Supv.
Signal Maintainers
Water Serv.Supt.
Water Serv.Forces

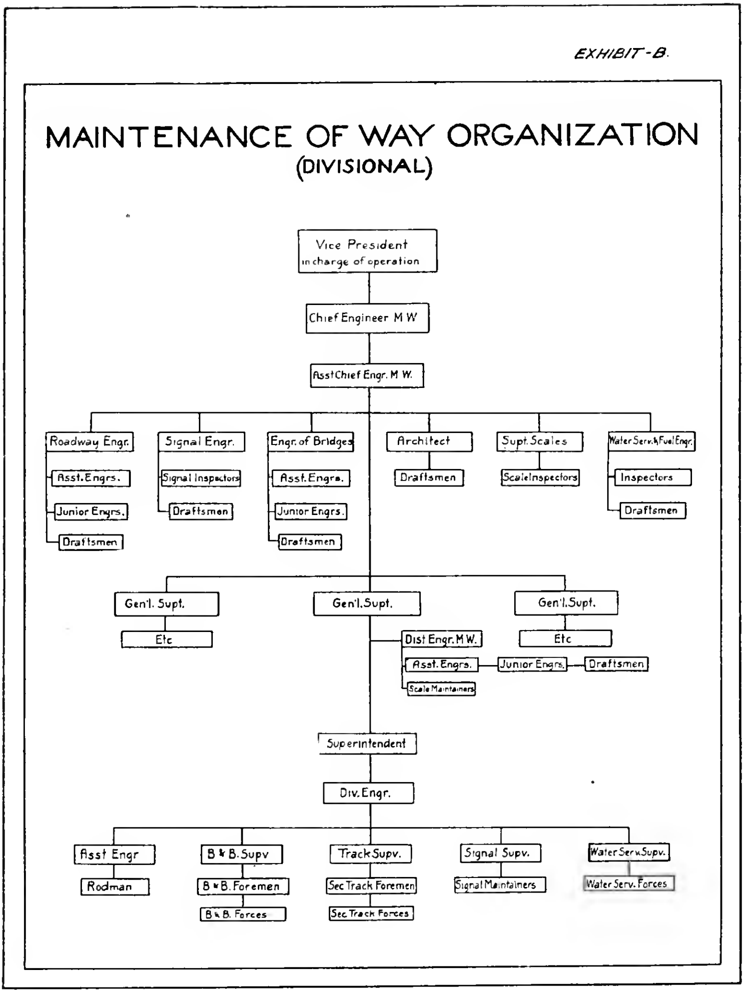


EXHIBIT-B.
MAINTENANCE OF WAY ORGANIZATION
(DIVISIONAL)
Vice President in charge of operation
Chief Engineer M W
Asst Chief Engr. M W.
Roadway Engr.
Asst. Engrs.
Junior Engrs.
Draftsmen
Signal Engr.
Signal Inspectors
Draftsmen
Engr. of Bridges
Asst. Engrs.
Junior Engrs.
Draftsmen
Architect
Draftsmen
Supt. Scales
Scale Inspectors
Water Serv. & Fuel Engr.
Inspectors
Draftsmen
Gen'l. Supt.
Etc
Gen'l. Supt.
Dist Engr. M W.
Asst. Engrs.
Junior Engrs.
Draftsmen
Scale Maintainers
Gen'l. Supt.
Etc
Superintendent
Div. Engr.
Asst Engr
Rodman
B & B. Supv
B & B. Foremen
B & B. Forces
Track Supv.
Sec Track Foremen
Sec Track Forces
Signal Supv.
Signal Maintainers
Water Serv. Supv.
Water Serv. Forces

(A)

REPORT OF COMMITTEE VI—ON BUILDINGS

W. T. Dorrance, *Chairman;*
J. W. Orrock, *Vice-Chairman;*
F. L. Beal,
J. B. Gaut,
G. A. Belden,
A. M. Griffin,
Eli Christiansen,
F. F. Harrington,
D. R. Collin,
F. R. Judd,
W. H. Cookman,
G. A. Mitchell,
A. Crable,
R. V. Reamer,
W. L. Darden,
C. W. Richey,
K. B. Duncan,
G. A. Rodman,

Committee.

To the American Railway Engineering Association:

The Committee on Buildings submits the following report of its work for the past year.

The following subjects were assigned:

(1) Make thorough examination of the subject-matter in the Manual and submit definite recommendations for changes, with especial reference to appropriate definitions.

(2) Report on a Classification of Buildings on the basis of "Specification Types," and upon the use of the "Cubic Foot," "Square Foot" and "Bill of Particulars" methods for ascertaining the approximate cost of new construction.

(3) Report on Ice Houses and Icing Stations.

(4) Report on Design of Freight Houses, conferring with Committee on Yards and Terminals.

(5) Study and report on "Specifications" for Buildings for Railroad Purposes.

Committee Meetings

Meetings of the Committee were held in Chicago on May 25th; Montreal, October 26th, and New York, December 7th and 8th.

The work was divided to sub-committees, one sub-committee being selected for each subject assigned.

Subject 1, Manual: Careful review and study was made of the subject-matter in the Manual and rearrangement of this was determined on so that the recommended practice would appear in more logical order. This to be done when the new Manual is printed; no change or revision of the text is recommended.

Subject 2, Classification of Buildings: Considerable study was given this and investigations made. Report on this subject appears as Appendix A to this report.

Subject 3, Ice Houses and Icing Stations: Very little work was done on this as decision was reached to devote our efforts largely to completing Subject 2 and getting a good start on Subject 5. This latter subject being one which will require several years to complete.

Subject 4, Design of Freight Houses: Some attention was given to this, but the progress was so slight that it was not felt necessary to consult with the Committee on Yards and Terminals.

Subject 5, Specifications: Specifications and methods in use were secured from various railroads covering various sections of this country and Canada. Careful study of the subject was made and decision reached that it was advisable to prepare separate specifications on the loose-leaf principle covering each class of work entering into railroad buildings. This would enable selecting the specifications required for any building desired and binding together to form a specification for that building. The subjects for these separate specifications are covered by the following list:

(1) General Conditions (to be attached to all specifications).
(2) Excavation, Filling and Back Fill.
(3) Sewers and Drains.
(4) Concrete.
(5) Brick Work.
(6) Carpentry and Millwork.
(7) Lathing and Plastering.
(8) Hardware.
(9) Painting and Glazing.
(10) Roofing.
(11) Plumbing.
(12) Lighting.
(13) Heating (Steam).
(14) Heating (Hot water).
(15) Heating (Hot air).
(16) Scope of the Work—In addition to the above specifications for the various trades, a specification should be drawn for each job defining definitely the scope of the work.

Eight of these were completed and are given as Appendix B to this report.

The Committee feels that it is practically impossible to write a specification that could be used without change by every railroad, but feels that the specifications submitted can be used as a guide, each road making slight modifications to fit local conditions.

RECOMMENDATIONS

The Committee recommends:

(a) The adoption of its conclusions on Subject 1.

(b) The acceptance of its report on Subject 2.

(c) That study of Subjects 3 and 4 be continued.

(d) The approval of method determined for Subject 5, with a discussion of the specifications presented herewith at this convention, and the expectation of having them presented for final approval at next year's convention.

(e) Preparation of balance of proposed specifications for discussion at next year's convention.

(f) The assignment to this Committee for a report on the general subject of Floors.

Respectfully submitted,

THE COMMITTEE ON BUILDINGS,

W. T. DORRANCE, *Chairman.*

Appendix A

CLASSIFICATION OF BUILDINGS ON THE BASIS OF "SPECIFICATION TYPES," AND UPON THE USE OF THE "CUBIC FOOT," "SQUARE FOOT" AND "BILL OF PARTICULARS" METHODS FOR ASCERTAINING THE APPROXIMATE COST OF NEW CONSTRUCTION

The subject assigned to the Committee indicates that only a method be outlined and that no attempt be made to establish costs due to varying prices of labor and material, and differences in types of construction. It is manifestly impossible to set up any actual costs on one road that would apply to other roads in a different locality, or even in some cases to different portions of the same road.

We are asked to report on three different methods for estimating as follows:

(A) Bill of Particulars Method.
(B) Square Foot Method.
(C) Cubic Foot Method.

Bill of Particulars Method

The "Bill of Particulars" method calls for simply a detailed estimate as is now the common practice of engineers and contractors for arriving at cost of construction. This is the most accurate and is perhaps the most satisfactory method which can be devised where only one or a very few buildings are to be estimated. Where there are a number of structures similar in type the burden of making so many detailed estimates would be large and it is advisable to use some short cut of reasonable accuracy.

Square Foot Method

The "Square Foot" method necessitates first making up a series of bill of material estimates or applying known costs of existing buildings on the various types of buildings selected, and plotting these estimates and costs so that curves can be drawn establishing a square foot price. The application of it is very approximate due to the fact that buildings of the same type will vary in height and other particulars, but the "Square Foot" method is satisfactory for approximate estimates.

Cubic Foot Method

The "Cubic Foot" method must also be built up by first making bill of material estimates or plotting known costs and establishing a price per cubic foot in the same way for the various types of buildings selected. The application of this method is more accurate, as it takes into account the different heights of buildings, varying cubage of roof construction, etc.

The following method which is based on specification type is by no means perfect and is not the only one that can be used, but it has been used satisfactorily on a number of railroads in connection with government valuation with various modifications. Briefly the method is as follows:

First, set up certain types of buildings, based on specifications, separating the different types of construction and different utilities, giving for each type a specification sheet showing briefly the principal details of construction. It is advantageous to make as few types as possible, consistent with local conditions. Each type may cover the complete structure, including normal foundation, plumbing, heating and lighting, but for accurate results it is recommended that the building type cover only the shell, setting up the foundation as a separate type and adding plumbing, heating and lighting at a cost per unit.

Following this latter scheme, we would first set up type standards to cover the following foundations—the type description to show the depth, general dimensions, class of masonry, etc., as follows:

(1) Timber post, 8 in. x 8 in.—5 ft. C-C, 7 ft. long.
(2) Masonry pier, 12 in. x 12 in., brick on concrete footings.
(3) Trench walls, 20 in., rubble or concrete wall.
(4) Trench walls, 30 in., rubble or concrete wall.
(5) Cellar, 20 in., rubble or concrete walls, with 12 in. x 30 in. footing concrete floor; 1 flight plank stairs; coal bin—windows with areas and gratings.

The following types for superstructure are suggested and will probably answer the purpose on most roads:

Frame passenger station	3 types
Brick passenger station	3 types
Stone passenger station	1 type
Concrete passenger station	1 type
Frame freight house	3 types
Brick freight house	3 types
Concrete freight house	1 type
Frame shop, 1 and 2 story	2 types
Brick shop, 1 and 2 story	2 types
Frame engine house	1 type
Brick engine house	1 type
Concrete engine house	1 type
Frame section house	2 types
Frame yard buildings	3 types
Signal towers	4 types
Dwellings	5 types
Office buildings	3 types

The above schedule of types is suggested for use in connection with valuation of existing buildings. For new work it would probably be advisable for any one road to limit the number of types to a minimum.

Each superstructure type to show the kind and style of framing, size of principal members, description of flooring, wall covering, ceiling, outside covering, roof, over-hang, chimneys, and other building items, as per specimen type sheet as follows:

SPECIFICATION FOR BUILDING OF TYPE NO. 1

Frame Passenger Station—Type No. 1

FRAME: Spruce sills, 6x8 in. Floor joist, 3x10—16 in. C-C. Posts, 4x6 in. Studs, 2x6—16 in. C-C. Plate, 4x6 in. Rafters, 2x10—20 in. C-C.
FRAMING: Full mortise and tenon.
EXTERIOR WALLS: Sheathed and clapboarded with paper between (or covered with wood shingles or tin shingles).
EXTERIOR TRIM: Cypress, corner boards, water table, belt course, facia and cornice.
INTERIOR WALLS: No. 1 planed, matched and beaded Nor. Car. pine sheathing with wainscot 3 ft. 6 in. high.
CEILING: No. 1 planed, matched and beaded Nor. Car. pine (or 2 coats plaster).
FLOORS: 1 in. Rift hd. pine on 1 in. under floor.
INTERIOR TRIM: Cypress, all stock shapes.
ROOF: 1 in. boarding with building paper, tin, wood or asphalt shingles.
GUTTER: Wood or galvanized iron.
CONDUCTION AND FLASHINGS: Galvanized iron.
OVERHANG: 6 ft. wide on four sides, sheathed underneath, with brackets.
DOORS AND WINDOWS: All stock shapes and sizes.
HARDWARE: Iron, bronzed finish or brass.
PAINTING: 3 coats lead and oil. Inside filled and varnished.
INTERIOR FITTINGS: 1 ticket shelf, 1 telegraph shelf, 200 ft. B. M. of pine shelving; iron wire grill in ticket window.
CHIMNEYS: Two 4 in. brick walls, 8x12 in. flue lining.

Additions should be made for slate or tile roof, concrete or terrazzo floor, special sizes and shapes of doors and windows, fireplace or mantel of elaborate design.

NOTE.—A specimen sheet is attached illustrating various buildings conforming to this type.

Plumbing

Various types should be set up to cover the principal classes of fixtures used by the carrier, and a price per fixture estimated for each type. This price is to include the proportional part of the total cost of such items as sewer and water connections, meters, soil pipe, etc. The following types for plumbing fixtures will answer most purposes:

Closet with wood stall complete.
Closet with slate stall complete.
Urinal, flat back.
Urinal, with slate stall.
Urinal, full porcelain stall.
Wash bowl.
Sink, 18 in. x 30 in., cast iron with back, legs and fittings.

Heating

We believe that the best method of typing and pricing heating systems is on the basis of cubic foot of space heated—the system to be complete in itself, including boiler, radiators, and piping. Type to be set up to cover the following units:

Hot air furnace.
Steam—One- or two-pipe system. Cast iron radiators.
Steam—One- or two-pipe system. Pipe coils.
Hot water—Two-pipe system. Cast iron radiators.
Hot water—Two-pipe system. Pipe coils.

Lighting

This can be computed on either a cubic foot basis or price per fixture, but from experience we believe that the price per fixture is most accurate and easiest to apply. The price per fixture to include connection with city lines, meters, switches, and all wiring and fixtures inside the buildings, throwing everything into a type with the exception of very elaborate or expensive fixtures which should be priced separately. The following types are suggested:

Electric lights with wall brackets—plug or drop.
Electric lights with chandelier, 2 to 4 lights.
Gas—wall brackets.
Gas—chandelier, 2 to 4 lights.

Furniture

The furniture in a building usually varies considerably even in buildings of the same general type, and we believe that a better method is to make a complete inventory and price each article separately, although such buildings as section houses and small railroad stations can be handled by assigning a typical outfit and putting one lump sum price on the whole outfit.

After setting up these various types, pricing curves should be plotted to cover foundation and superstructure, and for illustration, sample sheet is attached. The illustration is based on cubic foot basis. A similar procedure is followed if square foot basis is desired.

On the left-hand margin the cubic contents of the building is shown: this is the total actual cubage including roof area. On the top and bottom margins are shown price per cubic foot.

In order to establish the curve for any particular date, several structures conforming to the type are selected—taking the largest, the smallest and several intermediate sizes—a complete bill of matrial estimated and priced, and from this is computed the total estimated cost of the shell, and the cost per cubic foot. These points are plotted on the sheet and in addition all available contract costs and costs of structures built by company forces, which conform to this type, also plotted. With these various points an average curve is drawn. These curves can be used for either pricing buildings for valuation purposes or for estimating the cost of new work, as of the one given date.

Due to the rapidly changing labor and material prices, some method must be devised for modifying cost figures so that comparison can be made between similar types built at different dates. A specimen curve sheet is attached showing the cost of construction from 1904 to 1920, taking 1914 as normal and plotting the average for each year.

It is found that the pricing curves for the various types of buildings all follow the same general shape and after establishing the form of the curve it is only necessary to figure about three buildings of any one type in order to give the curve the proper location on the pricing sheet.

The method of applying this scheme in practice is to figure the cubic contents of the building—pick off the price per cubic foot from the curve sheet, and apply it to the cubage. In the same way figure the cost of foundation, then add the number of units of plumbing, heating and lighting at the type price, add such items as furniture, grading, outside drainage, platforms, etc.

In this way estimates can be made very quickly and accurately; the principal difficulty being in assigning the particular building under discussion to the proper type. This necessitates considerable familiarity with the type book and also with the construction features of the building. This practically confines the use of this method of estimating to a building expert.

This system will not cover special and elaborate structures, and where there are only a few of one type they can probably be estimated on a "bill of particulars" with less work than to set up type and pricing sheets. Where the particular building conforms, in a general way, to the type description, but has a few departures from the type, it can be handled under the typing system, making additions or deductions for departures from the type. This method has been followed by several roads in connection with valuation work with very good results.

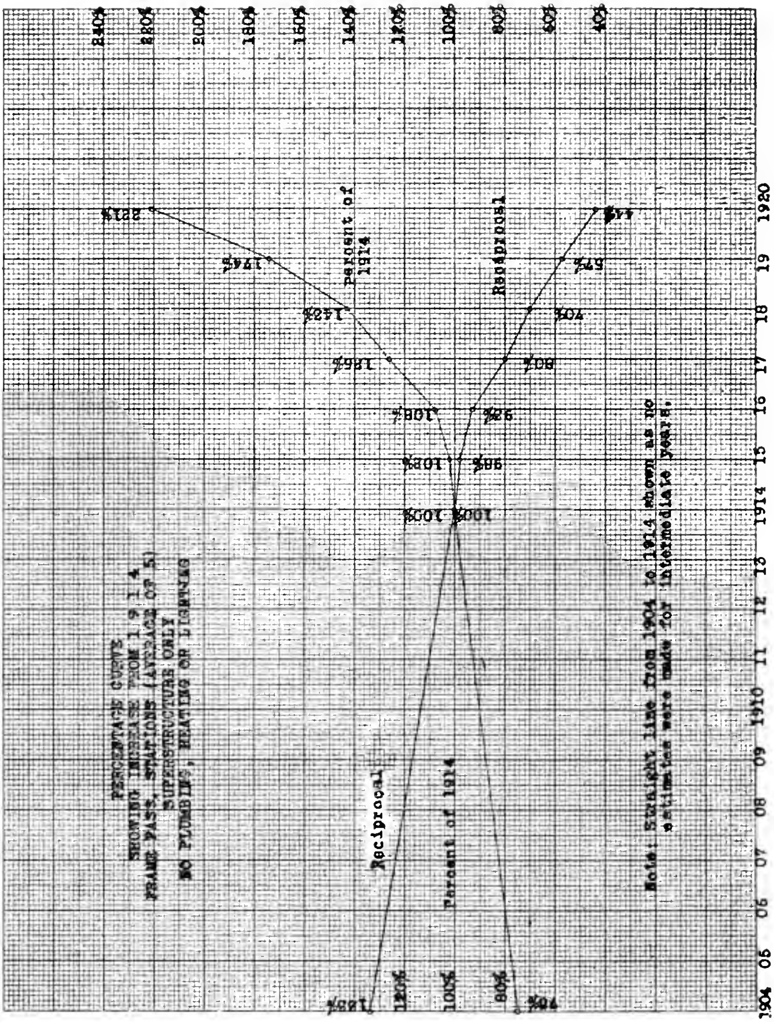

PERCENTAGE CURVE
SHOWING INCREASE FROM 1914
SUPERSTRUCTURE ONLY
NO PLUMBING, HEATING OR LIGHTING
Percent of 1914
Reciprocal
Note: Straight line from 1904 to 1914 shown as no estimates were made for intermediate years.
1904 05 06 07 08 09 1910 11 12 13 1914 15 16 17 18 19 1920

FIG. 1.

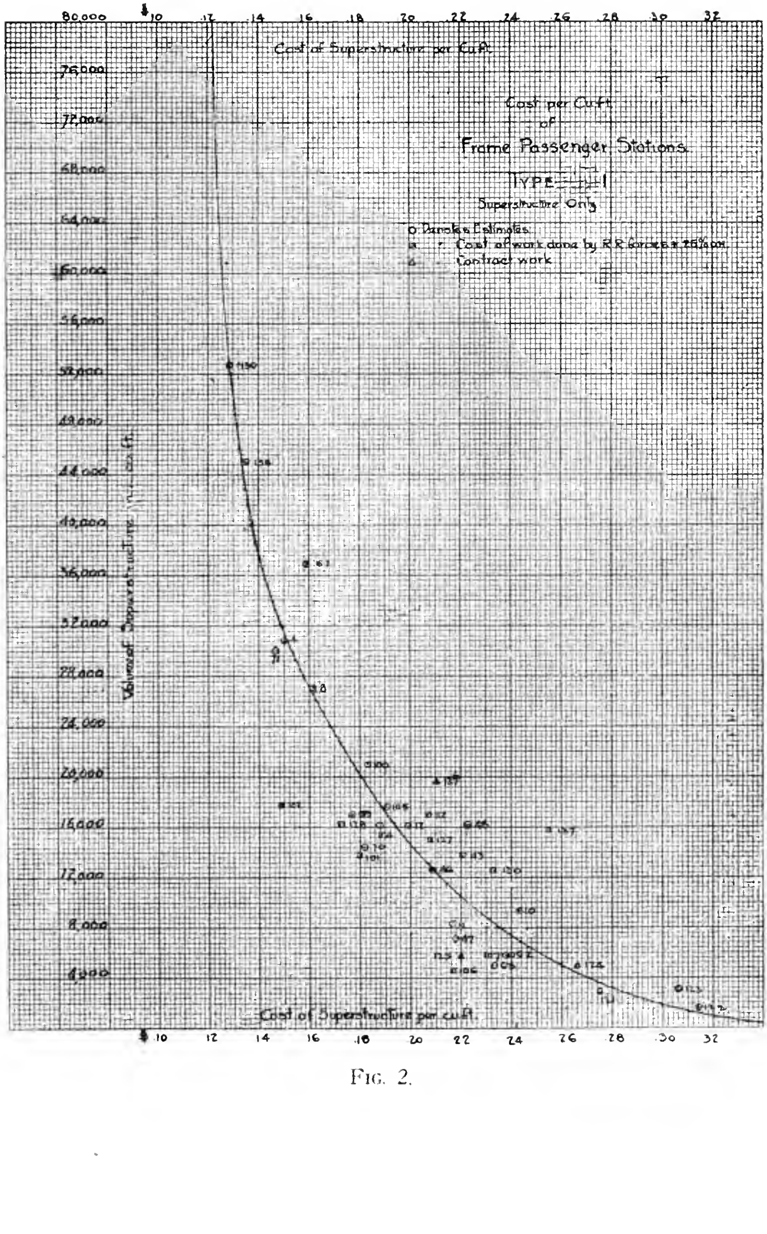

Cost of Superstructure per Cu.ft.
Cost per Cu.ft.
of
Frame Passenger Stations
TYPE
Superstructure Only
Volume of Superstructure
Cost of Superstructure per cu.ft.
80,000
76,000
72,000
68,000
64,000
60,000
56,000
52,000
48,000
44,000
40,000
36,000
32,000
28,000
24,000
20,000
16,000
12,000
8,000
4,000
$.10
.12
.14
.16
.18
.20
.22
.24
.26
.28
.30
.32

FIG. 2.

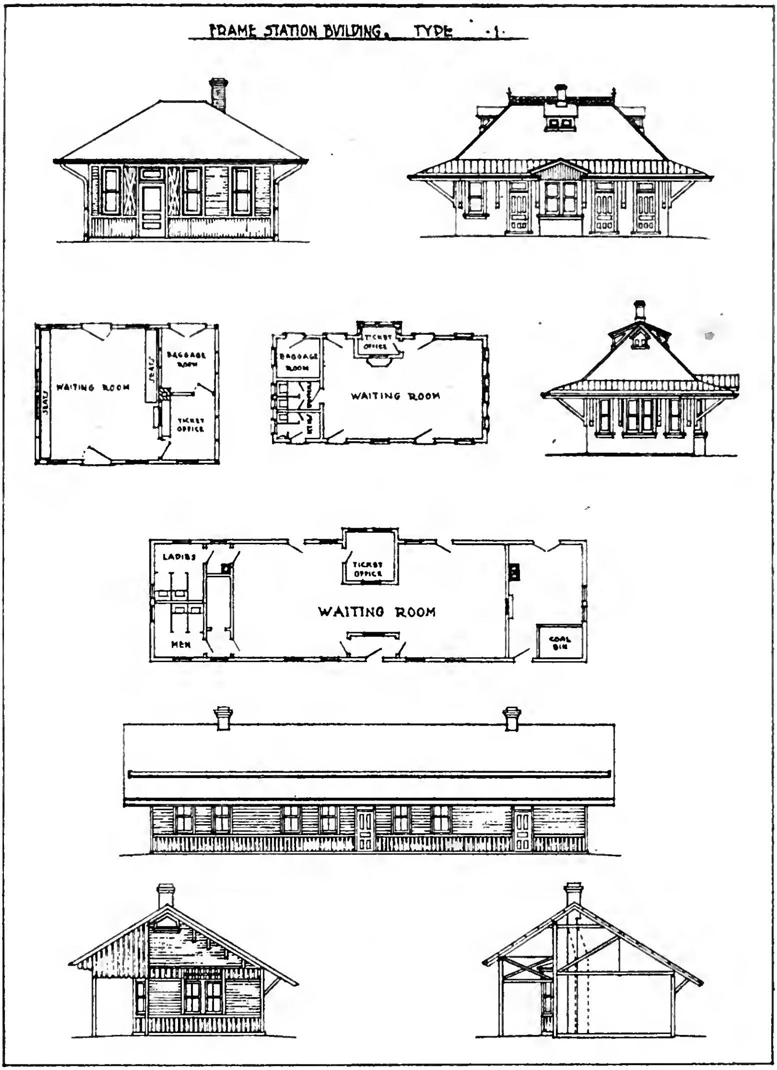

FRAME STATION BUILDING. TYPE ·1·
WAITING ROOM
BAGGAGE ROOM
TICKET OFFICE
SEATS
WAITING ROOM
LADIES
MEN
TICKET OFFICE
COAL BIN

FIG. 3.

Appendix B

(5) "SPECIFICATIONS" FOR BUILDINGS FOR RAILROAD PURPOSES

The Committee presents for discussion the following specifications:

SPECIFICATIONS FOR RAILWAY BUILDINGS

SECTION 1

General Conditions

1. General

These general conditions to be used with the A.R.E.A. Contract Form as published in the Manual, and shall apply to all specifications used in connection with the work.

2. Company, Engineer and Contractor Defined

The word Company shall designate the Railroad Company or Railway Company, and the word Engineer the Chief Engineer of the Company, or his authorized representative, and the word Contractor the Contracting Party.

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 may furnish proper scale details of such portions as in its judgment require it, in the preparation of which slight modifications will be made in minor details of design, if necessary. The Contractor shall not execute any work requiring such large size details until same have been furnished him and all work must be made in strict accordance with said details.

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 the same. Any work done after such discovery until authorized 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 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. The Contractor shall supply additional copies of erection diagrams or working drawings on request.

6. Laying Out Work

Lines will be staked out and elevations given, when necessary, by the Engineer.

7. Prosecution of the Work

When the work of this Contractor engages with the work of any other contractor, he must co-operate with the other contractor and exercise extraordinary care to prevent injury to any work or material. This Contractor shall do all necessary cutting and fitting of his work where same engages the work of another contractor or the Company.

8. Special Materials

Special brands of material or devices mentioned in specifications or on drawings are for the purpose of establishing a standard or criterion of quality and character desired. Other material of equal quality and adaptability to purposes 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 mentioned on the drawings or in the specifications, he must submit a statement with his proposal clearly and fully describing such substitutions as he desires to make.

Where specific make or kind of apparatus is called for and furnished by Contractor, the furnishing of the 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.

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

The Contractor shall give the proper authorities all requisite notices in connection with his work and shall procure at his own expense all permits, licenses, etc., of any 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 adequate temporary toilet facilities for accommodation of Contractor's employees, to be located where directed by the Engineer.

12. Temporary Heat

Wherever temporary heat or heat during construction of building is required for drying of plaster or paint, for prevention of damaging of materials by freezing, or for any other reason, such heat shall be provided for by the Contractor and the entire expense in connection therewith shall be borne by him unless otherwise specified hereinafter.

13. Force Account Work

Whenever any work is done or material furnished for a price based upon the actual cost and added percentage to cover general expense and superintendence, profits, 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. In such case the time of all employees shall be entered by the Contractor on forms supplied by him for the purpose and checked and signed daily in duplicate by the Contractor and the Engineer, and no labor not so entered and checked will be allowed.

14. 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 requirements.

SPECIFICATIONS FOR RAILROAD 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 or 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 or 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 concrete is 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. Piling

If foundation piles are required they will be excavated around and cut off by the Contractor.

12. Disposal of Excavated Material

Excavated material shall be used for backfilling around all underground work. After forms of such work have been removed and same 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.

13. Filling

Where sand or cinder filling is called for on the drawings, the same 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.

14. Frost

No filling or backfilling shall be done at a time when there is danger of frost entering the same, except at the discretion of the Engineer.

15. Grading

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.

16. General Conditions

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 site clean and graded to finished grades as shown by the drawings.

No part of the work shall 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.

SPECIFICATIONS FOR RAILROAD 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 assemble 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 eight (8) inches shall be used except for downspout connections.

The pipe shall be subject to inspection and approval or rejection by the Engineer.

8. **Mortar**

All mortar for cementing the pipe joints shall be made from neat Portland cement, of quality as specified without a mixture of sand, only enough water shall be added to give it the proper consistency and shall be mixed only as needed for use. The retempering of mortar that has already become partly set will not be allowed.

All mortar for brickwork shall be prepared from Portland cement of quality specified, thoroughly mixed with sand in the proportion of one (1) part by volume of loose cement to three (3) parts of sand.

9. **Cement, Sand, Stone**

Cement, sand and stone shall be of the quality as specified in the specifications for cement or concrete work.

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, 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.

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 RAILROAD 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.

Any work paid for or deducted 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 of 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 final 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 cement, 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. **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.

23. **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.

24. **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. No reinforcement shall extend across an expansion joint.

25. **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.

26. **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.

27. **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.

SPECIFICATIONS FOR RAILROAD 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") 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 twenty 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 specification 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

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. Proportions for Cast Concrete

Concrete for cast coping, 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 through a one and one-fourth inch (1¼″) ring. Exposed surfaces shall be troweled smooth and edges to be smooth and unbroken. All coping shall be carefully pointed up. All window and door sills shall be set true, level and plumb. All sills shall be carefully pointed up.

23. New Masonry Joining to Old

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.

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

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 from same. 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.

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 RAILROAD BUILDINGS

SECTION 6

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. All through partitions carried from the ground floor up shall have a joist run close up against the same on either side at each floor. All 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.

All flooring shall be tightly driven up before nailing so that joints are absolutely tight. Where wood floors are laid over concrete sub-floors, 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

All 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

All 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. All 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

All 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

All 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

All sash shall be accurately made to fill openings, dressed and sanded to a smooth finish, pinned and through tennoned with muntins, etc., as detailed. All shall be checked for glass and moulded and shall be properly hung, hinged or pivoted as required. All sash for exterior windows shall have small groove cut around sash to make a watertight fit. All 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 two thicknesses of tongued and grooved boards nailed together in opposite directions, 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 tennoned 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.

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 RAILROAD BUILDINGS

SECTION 7

Lathing and Plastering

1. General

Under this heading shall be included all wood and 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 wood and 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 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.

All 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.

All 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 weighed 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.

Sand Floated.—Finishing coat, after being brought to a smooth, even surface, shall be rubbed in a circular motion with a wood float. This floating shall be done when mortar has partially set.

Rough Cast or Spatter Dash.—After the finishing coat has been brought to an even surface and before attaining its final set, it shall be uniformly coated with a mixture of 1 part *white* cement to 2 parts *white* sand, thrown forcibly against the wall in such a manner as will produce a rough surface of uniform texture.

Pebble Dash.—After the finishing coat has been brought to an even surface and before attaining its initial set, clean pebbles shall be forcibly thrown against the mortar and embedded therein. Pebbles shall vary in size from ¼-in. to ⅜-in., shall be well wetted before being cast, and shall be uniformly distributed over the surface. They may be pressed into the mortar with a clean wooden paddle, but the surface shall not be otherwise disturbed.

NOTE.—The above surface finishes are alternatives. Under no circumstances should the stucco be worked after it has attained its initial set.

Samples of the surface finish shall be laid up well in advance of the work, and the approved sample shall be carefully preserved during the prosecution of the work and used as a standard.

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.

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 RAILROAD BUILDINGS

SECTION 8

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.

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.

REPORT OF COMMITTEE XIV—ON YARDS AND TERMINALS

B. H. MANN, *Chairman;*
J. E. ARMSTRONG,
HADLEY BALDWIN,
C. A. BRIGGS,
J. H. BRINKERHOFF,
MILES BRONSON,
A. E. CLIFT
L. G. CURTIS,
H. T. DOUGLAS, JR.,
A. W. EPRIGHT,
E. M. HASTINGS,
REUBEN HAYES,
L. J. F. HUGHES,
A. MONTZHEIMER, *Vice-Chairman;*
J. B. HUNLEY,
D. B. JOHNSTON,
H. A. LANE,
R. J. MIDDLETON,
O. MAXEY,
F. E. MORROW,
H. J. PFEIFER,
S. S. ROBERTS,
C. H. SPENCER,
E. B. TEMPLE,
E. E. R. TRATMAN,
J. G. WISHART,

Committee.

To the American Railway Engineering Association:

The following subjects were assigned the Committee on Yards and Terminals for study and report:

1. Make thorough examination of the subject-matter in the Manual and submit definite recommendations for changes.

2. Make final report, if practicable, on unit operation of railroad terminals in large cities, including a revision of the catechism on unit operation of terminals as a statement of principles.

3. Report on handling of freight on two-track level freight houses and team tracks. Also, multiple-storied freight houses and handling of freight by mechanical means.

4. Make final report, if practicable, on typical situation plans for passenger stations, and methods of their operation.

5. Report on classification yards, including methods of switching from classification yards to advance yards.

6. Report on advantages of small sorting yards with grade sufficient for gravity switching to be located between classification and advance pocket, for the purpose of switching trains into station order.

7. Report on passenger station, freight house, and grain weighing scales.

8. Study and report on methods of economic transfer of lading of bad-order cars in large terminals by the introduction of mechanical means or otherwise.

Committee Meetings

Meetings of the Committee were held in Chicago, May 20 and December 9; in Atlantic City, September 22, 23 and 24, and in Washington, November 30. The names of members in attendance have been given in the minutes of the meetings, which have been printed in the Bulletin.

(1) Revision of Manual

No changes in the Manual are recommended by the Committee.

(3) Two-Track Level and Multiple-Storied Freight Houses, Two-Track Level Team Tracks

In Appendix A the Committee submits the results of its study of the subject of handling of freight on two-track level freight houses and team tracks. Also multiple-storied freight houses and handling of freight by mechanical means.

(4) Passenger Stations

In Appendix B the Committee reports its continued study of the subject of typical and actual situation plans for passenger stations and methods of their operation.

(7) Scales

In Appendix C the Committee submits its outline of methods of work and enumerates some of the problems to be solved in its study of proposed specifications for the manufacture and installation of railroad, motor truck, built-in, self-contained and portable scales. The Committee reports progress in the result to be attained.

(8) Economic Transfer of Lading of Bad-Order Cars

In Appendix D the Committee reports on the subject of economic transfer of lading of bad-order cars in large terminals by the introduction of mechanical means or otherwise and its recommendations are given under the head of Conclusions.

Progress Report

The Committee reports progress this year in its continued study of subject (2) Unit operation of railroad terminals in large cities, on subject (5) Classification yards, including methods of switching, and subject (6) Advantages of small sorting yards and gravity switching for switching trains into station order.

CONCLUSIONS

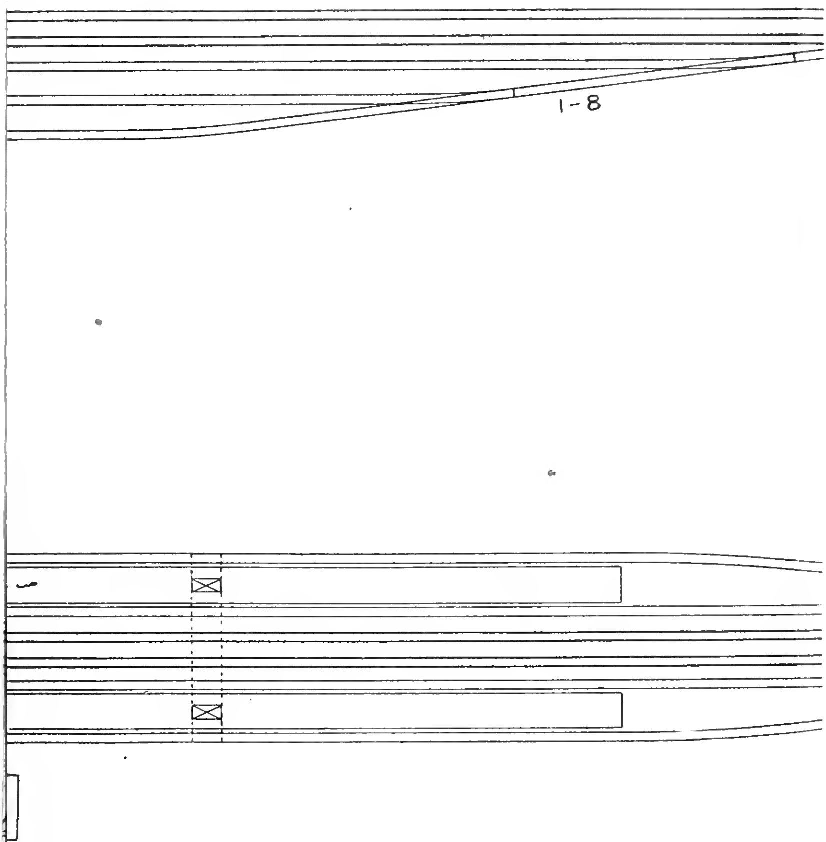
1. The Committee recommends that the following plans, taken from the Proceedings and revised, be approved for publication in the Manual:

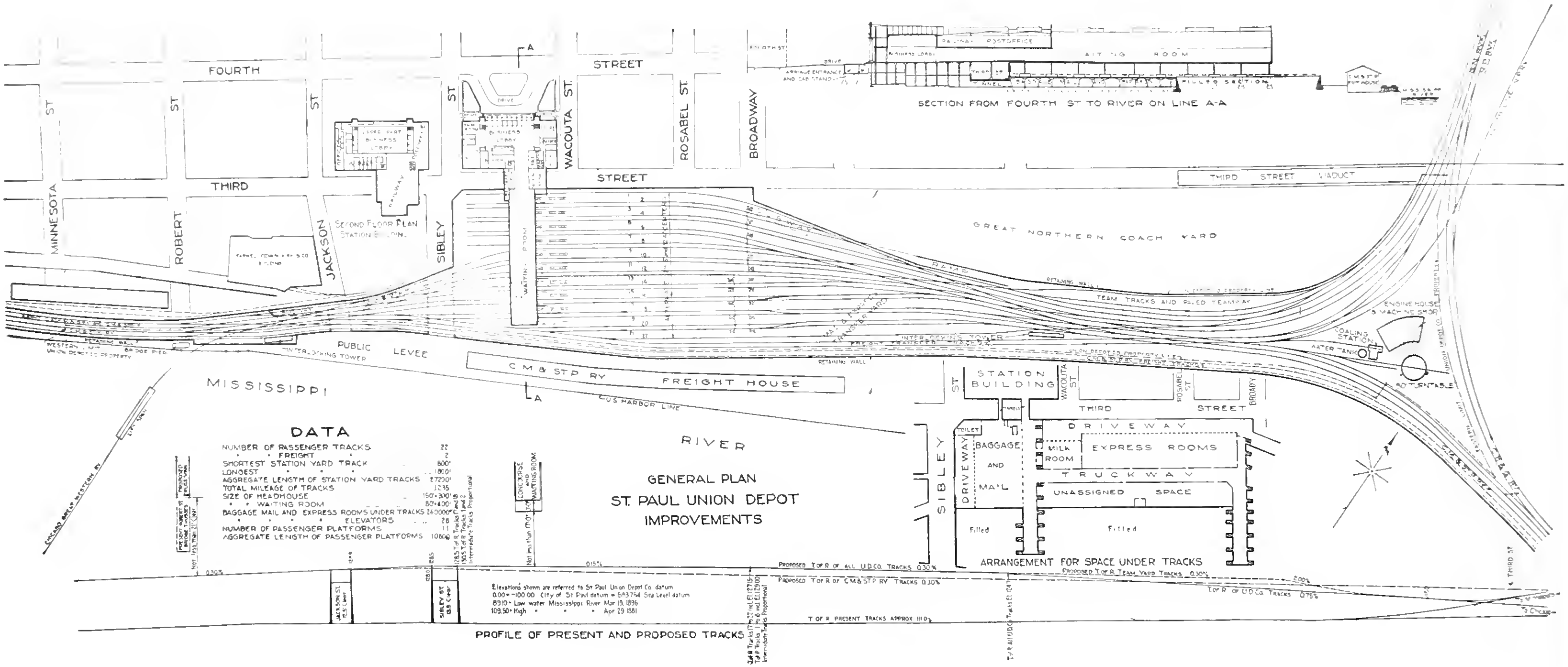
Typical and actual situation plans for passenger stations and methods of their operation:

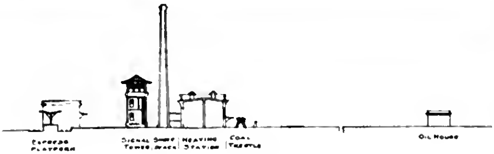
(a) Plan showing a typical track layout at a dead-end passenger terminal station.

(b) Plan showing a typical track layout at a through passenger terminal station.

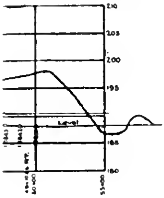
(c) Plans Nos. 20 to 26, showing types of ladders for passenger stations.

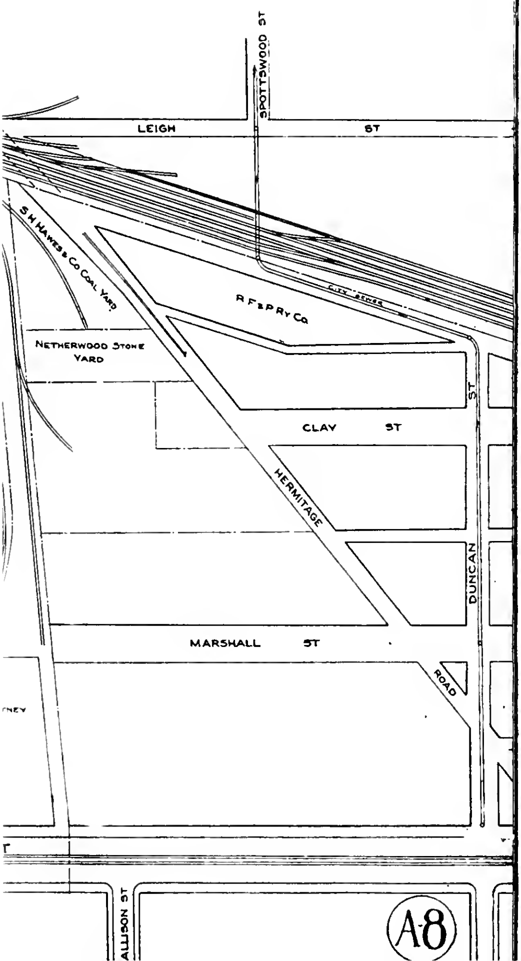

1-8


FOURTH
STREET
SECTION FROM FOURTH ST TO RIVER ON LINE A-A
MINNESOTA ST
ROBERT ST
JACKSON ST
SIBLEY ST
WACOUTA ST
ROSABEL ST
BROADWAY
THIRD
STREET
THIRD STREET VIADUCT
SECOND FLOOR PLAN STATION BUILDING
GREAT NORTHERN COACH YARD
TEAM TRACKS AND PAVED TEAMWAY
RETAINING WALL
PUBLIC LEVEE
INTERLOCKING TOWER
C M & ST P RY FREIGHT HOUSE
U S HARBOR LINE
MISSISSIPPI RIVER
ENGINE HOUSE & MACHINE SHOP
COALING STATION
WATER TANK
TURNTABLE
STATION BUILDING
DRIVEWAY
BAGGAGE AND MAIL
MILK ROOM
EXPRESS ROOMS
TRUCKWAY
UNASSIGNED SPACE
TOILET
Filled
ARRANGEMENT FOR SPACE UNDER TRACKS
DATA
NUMBER OF PASSENGER TRACKS 22
" " FREIGHT " 2
SHORTEST STATION YARD TRACK 800'
LONGEST " " " 1800'
AGGREGATE LENGTH OF STATION YARD TRACKS 27200'
TOTAL MILEAGE OF TRACKS 12.35
SIZE OF HEADHOUSE 150'×300'
" " WAITING ROOM 80'×400'
BAGGAGE MAIL AND EXPRESS ROOMS UNDER TRACKS 260000 □'
" " " ELEVATORS 28
NUMBER OF PASSENGER PLATFORMS 11
AGGREGATE LENGTH OF PASSENGER PLATFORMS 10800
CONCOURSE AND WAITING ROOM
GENERAL PLAN
ST. PAUL UNION DEPOT
IMPROVEMENTS
PROPOSED T of R OF ALL U.D.CO. TRACKS 0.30%
PROPOSED T of R OF C M & ST P RY TRACKS 0.30%
T of R PRESENT TRACKS APPROX 111.0
Elevations shown are referred to St Paul Union Depot Co. datum
0.00 = -100.00 City of St Paul datum = 583.754 Sea Level datum
89.10 = Low water Mississippi River Mar 19, 1896
109.50 = High " " " Apr 29 1881
PROFILE OF PRESENT AND PROPOSED TRACKS
THIRD ST

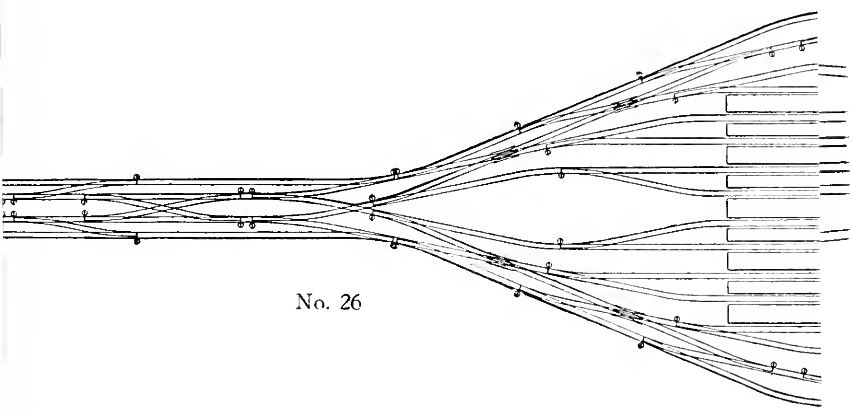

Signal Tower
Heating Station
Oil House


Canopy


210
205
200
195
Level
180

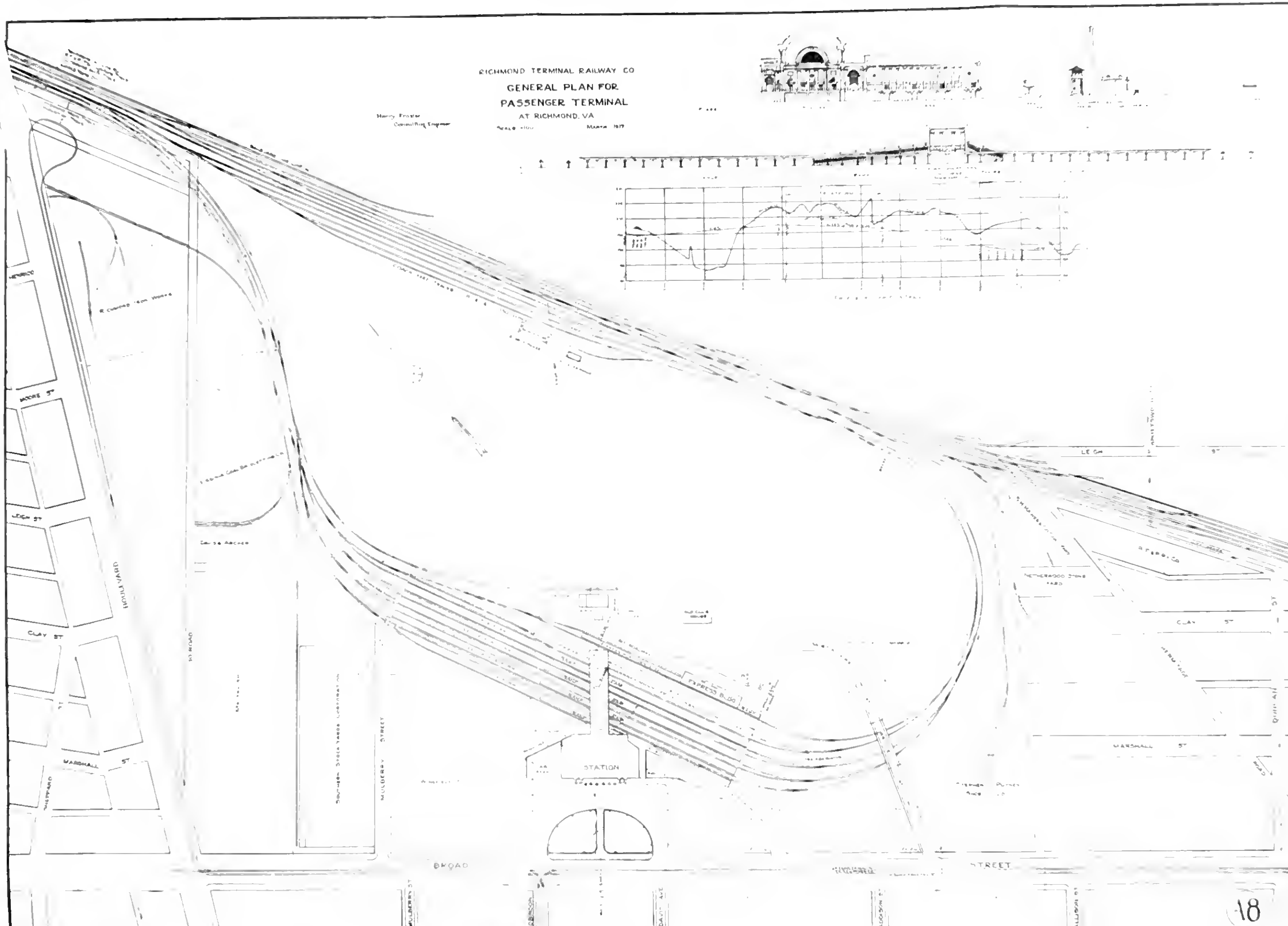

Spottswood St
Leigh St
S H Hawes & Co Coal Yard
R F & P Ry Co
City Sewer
Netherwood Stone Yard
Clay St
Hermitage
Duncan St
Marshall St
Road
Allison St
A-8

No. 25

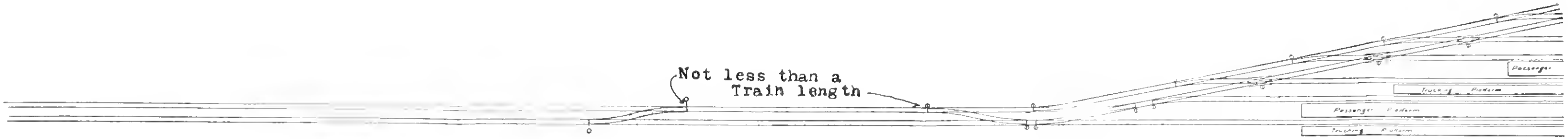


No. 26

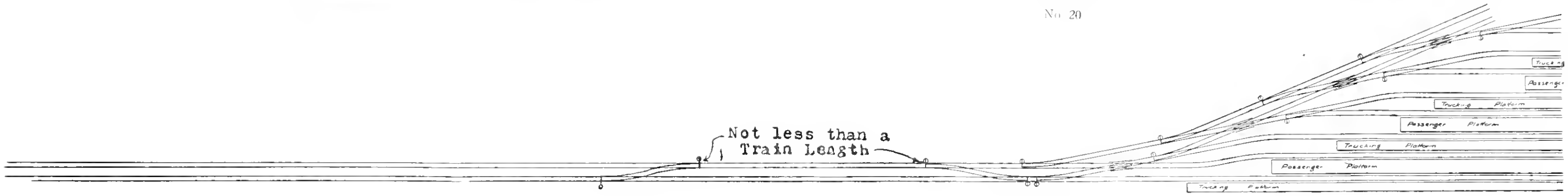
Types of Ladders.



RICHMOND TERMINAL RAILWAY CO
GENERAL PLAN FOR
PASSENGER TERMINAL
AT RICHMOND, VA
MOORE ST
LEIGH ST
CLAY ST
MARSHALL ST
BOULEVARD
MULBERRY STREET
STATION
EXPRESS BLDG
LEIGH ST
CLAY ST
MARSHALL ST
BROAD
STREET

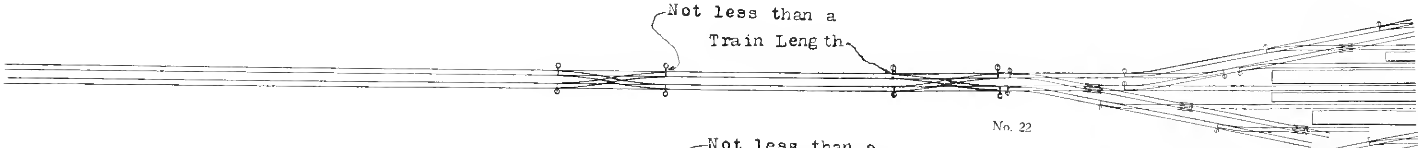


No. 20

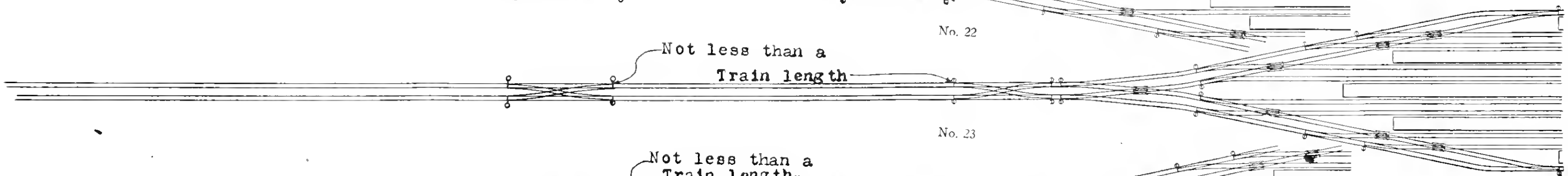


No. 21

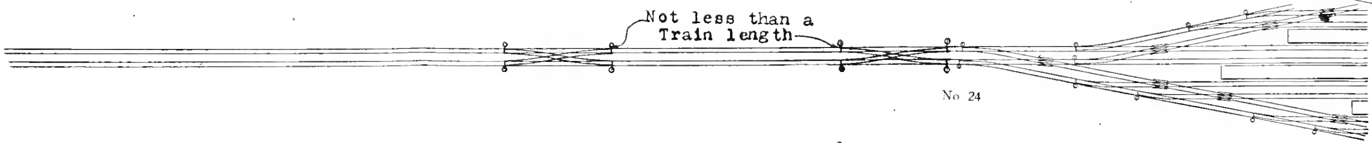
TYPES OF LADDERS



No. 22

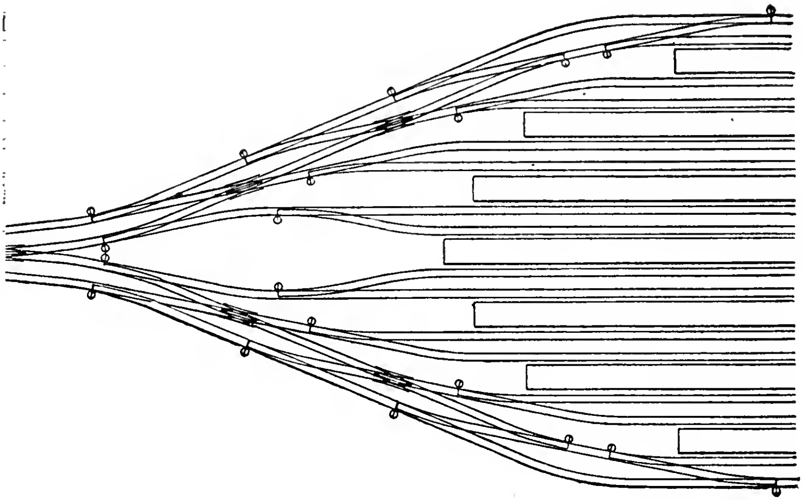


No. 23

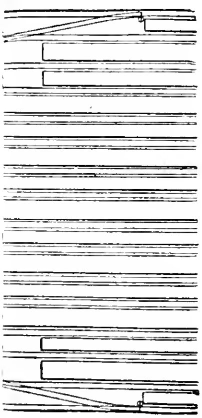


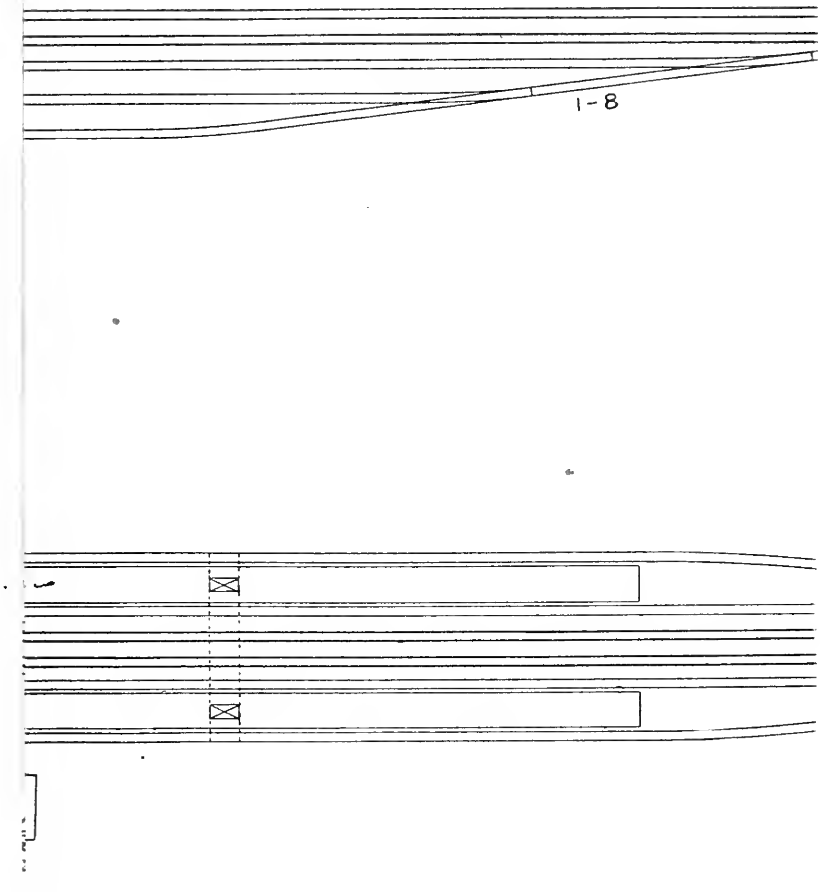
No. 24

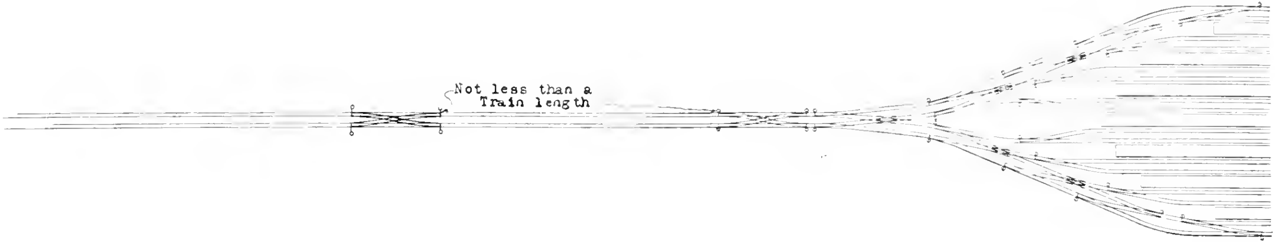
TYPES OF LADDERS.



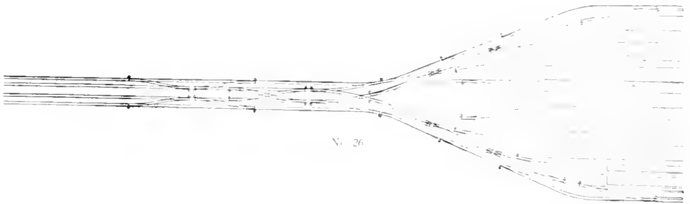
Types of Ladders.




1-8



Types of Ladders



Types of Ladders

NOTE.—Recommended minimum distances between the centers of tracks are shown, except in the coach and shop yards, where the spacing of tracks should be fixed to provide ample space for the work to be done. Generally the minimum distance center to center of coach yard tracks should be 15 ft., although such tracks may be arranged with alternating distances of 14 and 15 ft. center to center. Generally the minimum distance center to center of shop yard tracks should be 20 ft., although such tracks may be arranged with alternating distances of 15 and 25 ft. center to center.

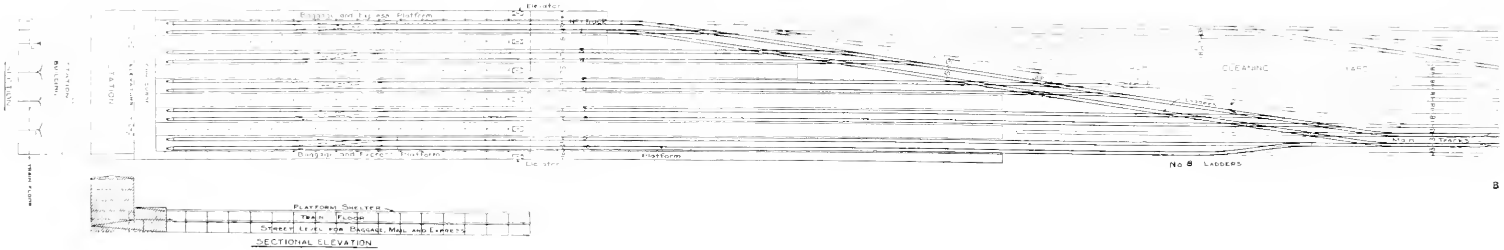


FIG. 1. TYPICAL TRACK LAYOUT AT DEAD-END PASSENGER TERMINAL STATION

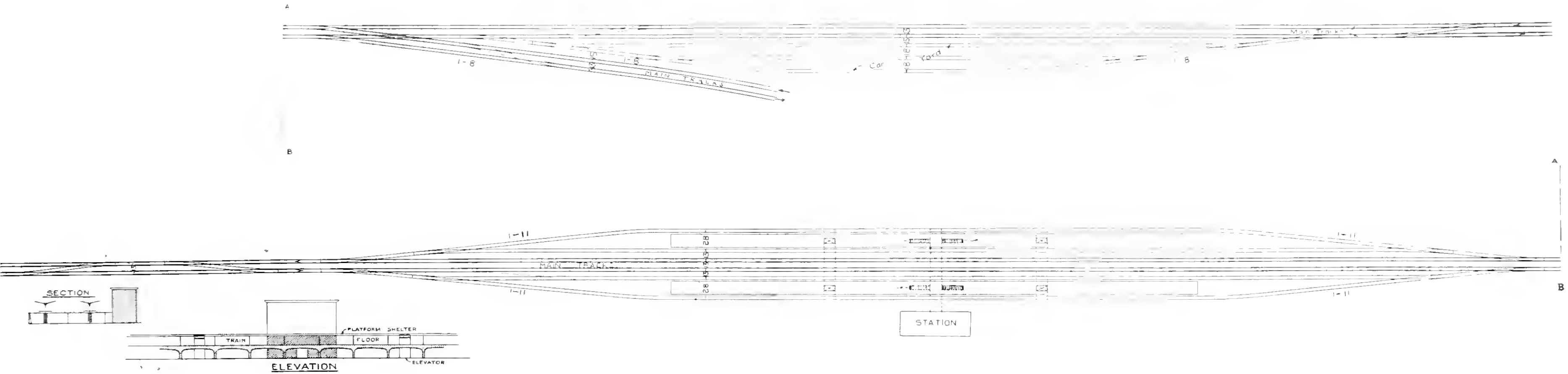


Fig. 2. Typical Track Layout at Through Passenger Terminal Station

2. The Committee recommends the following for approval and publication in the Manual:

Methods of economic transfer of lading of bad-order cars in large terminals by the introduction of mechanical means or otherwise:

(a) Hand labor for transferring freight from cars in most cases is slow and expensive and without real justification.

(b) The employment of a locomotive crane is generally justified in any case where the transfer of freight from open-top cars otherwise requires the equivalent of the constant daily service of six or more men, or the intermittent service of six men where the machine may be economically employed in the interim.

(c) A study of each situation may develop extensive means of economy out of all proportion to the cost and such study is justified in each case.

3. The Committee recommends that its report on the subject of handling freight in two-track level freight houses and team tracks be received as information and that the subject be reassigned.

4. The Committee has made progress in its study of the subject of passenger station, freight house and grain weighing scales and recommends that the subject be reassigned.

5. The Committee recommends that the subject of unit operation of railroad terminals in large cities be continued and reassigned.

6. The Committee recommends that the subject of classification yards be reassigned.

Recommendations for Future Work

The Committee recommends that the following new topic be assigned for future work:

Analyze the relative advantages and disadvantages of including storage warehouses in L. C. L. freight houses.

Respectfully submitted,

THE COMMITTEE ON YARDS AND TERMINALS,

B. H. MANN, *Chairman*

Appendix A

(3) MULTIPLE-STORIED FREIGHT HOUSES

H. T. Douglas, Jr., *Chairman;*
A. E. Clift,
L. G. Curtis,
L. J. F. Hughes,
F. E. Morrow,
H. J. Pfeifer,
E. E. R. Tratman,
J. G. Wishart,

Sub-Committee.

Your Committee has held three meetings in the offices of the Association at Chicago and one at Atlantic City, and submits the following as a preliminary or progress report. It is felt that labor and railway operating conditions have been so unsettled that statistical information now procurable as to present costs and service has little or no value and that the importance of the subject demands further study before a final report is made.

The subject divides itself into four parts:

(1) Two-track-level freight houses as compared with single-level freight houses.

(2) Two-track-level team tracks.

(3) Multiple-storied freight houses, or the operation of storage warehouses in connection with freight houses.

(4) Handling freight by mechanical means.

The Committee has been unable to find any installations of two-track-level freight stations. In its report of 1917 the Committee noted two-level stations at several points, but these—as well as later structures—have the tracks at one level and the team driveways at the other level. Of nine such stations, five have the tracks on the upper level and four have them on the lower level. Though in some cases the time or operating cost for handling freight may be greater in a two-level station than in a single-level station of equal capacity, the net cost may be favorable when the overhead and capital costs are included.

Assuming that a two-level design is adopted, one of the first considerations is adequate provision for handling freight between the two levels. Elevators are the principal means employed, handling both freight packages and freight trucks, although inclined conveyors or escalators have been proposed in some cases.

As to the general plan, the almost universal arrangement is to have both tracks and driveways run longitudinally with the building, with the platforms on the upper level directly above those on the lower level. In a design made in 1912 by the Pennsylvania Railroad for a large freight terminal at Chicago the freight house was to cover an entire block and to have transverse driveways connecting the two streets on the longer sides, thus increasing the length of frontage for teams. This project was abandoned, however, in favor of the present terminal with longitudinal driveways.

(1) Two-Track Level Freight Houses

Double-deck freight house design is attracting increased attention in connection with railway terminal facilities in large cities, especially where separation of grades of tracks and streets involve steep grade approaches for single story freight houses. The floor area of many single-level freight stations is inadequate for their business, but expansion is either impossible or is practicable only at great expense for additional land. In such cases the introduction of the two-level type of station may furnish a satisfactory solution of the problem, also being adapted to separation of grades, reducing congestion of vehicles, avoiding steep driveways and shortening trucking distance, the latter being one of the principal factors in the expense of freight house operation.

Two-level stations have been and are being built under governing conditions such as are imposed by topography, grade separation or the necessity of intensified use resulting from restricted area or high value of land. Where conditions permit of choice between single or multiple level designs, selection should be based upon these considerations:

(1) Value of land.
(2) Construction costs.
(3) Present and future business.
(4) Operating costs.
(5) Operating capacity.

(2) Two-Track Level Team Tracks

The Committee has been unable to find any installations of two-track level team tracks but is advised that plans for such installations are being considered by some railroads to secure intensified use of the property.

(3) Multiple-Storied Freight Houses

This subject relates to the provision of upper stories for holding of inbound freight until delivered or for warehouse purposes. Some railway officers do not favor going into the warehouse business; the Committee holds, however, that where the freight house occupies land of high value it is desirable to develop revenue from the area occupied, increase traffic, and offer economy to shipper, providing that this can be done without interfering with the normal business of the railway.

One objection that has been made is the possible confusion between teams for freight house and warehouse business, and confusion in the elevator service handling both kinds of business. In this connection reference may be made to the combined freight station and warehouse of the Central Manufacturing Company at Thirty-ninth and Robey Streets, Chicago. The tracks are at the first-floor level, and two outside tracks along one side are for the carload business of the warehouse. Along the other side is a double deck driveway, the lower deck serving the freight house platform and the upper deck serving the warehouse. Access to the upper deck is by two large elevators for wagons and motor trucks. Some of the interior elevators serve the warehouse floors only, and others serve both the warehouse and the freight station.

The new five-story freight terminal of the Pennsylvania Railroad at Chicago has tracks at the basement level and team driveways on the first floor, with the three upper stories designed for warehouse purposes. The new Chicago freight stations of the Chicago & Alton Railroad and Chicago, Burlington & Quincy Railroad will have a similar arrangement, the Chicago & Alton Railroad having one warehouse floor, the Chicago, Burlington & Quincy four. The Orange Street freight station of the New York Central Lines at Cleveland, Ohio, is of the single-floor type with provision for future upper floors for warehouse purposes.

(4) Mechanical Handling of Freight

Two difficult conditions are involved in attempts to simplify the operation and to introduce mechanical methods of handling. In the first place, there is the network of movements. Outbound freight from each doorway must go to a scale and checker's desk and then to any one of the cars which stand alongside the house. In the second place, the freight to be handled is of bewildering variety in material, size and weight.

Hand trucking has met the requirement of flexibility of movement fairly well, but it is slow and expensive, and involves considerable confusion, with liability of numerous errors. Overhead cranes, trolley hoists and conveyor equipment has been used very little in freight house work. In fact, it has been difficult to adapt such appliances to this work, since their operations are limited to fixed routes and directions and cannot generally be adapted to the irregular and changing directions of movements on a freight house floor. In warehouse work, however, such mechanical equipment finds numerous applications.

For the mechanical handling of freight in freight house work the most extensive and successful development has been the introduction of small tractors to haul trucks or trailers in trains. The tractor taking a train of loaded trucks drops them at their destined cars and collects empty trucks for delivery to loading points.

This system is in operation at a number of freight houses and also at warehouses. To enable the truck trains to cross the tracks between station platforms, light bascule bridges are employed in the Orange Street freight house of the New York Central Lines at Cleveland, Ohio. In setting cars on the house tracks they are spotted to clear these bridges. In the U. S. Army warehouse at Brooklyn, N. Y., the truck and tractor system is operated in combination with an automatic elevator service. Detailed description of the methods of operation at above stations as well as several others are described in articles listed in an appendix to this report.

Your Committee in 1917 also described this system as used at the 43rd Street house of the Chicago Junction Railway at Chicago.

Automatic elevator service is a remarkable development of elevator equipment which has been applied with marked success in some of the busiest railway, commercial and army warehouses. It requires no operators on the elevator cars, thus eliminating a large wage item and eliminating also the innumerable slight delays due to the personal equations of a number of employees. In ordinary railway installations the elevators are operated by the freight handlers by means of push buttons at the elevator doors. As applied at the Brooklyn Army warehouse, however, one dispatcher at a desk equipped with a battery of signal lights controls all movements and has before him the record of movements and location of all elevator cars.

At the Brooklyn Army warehouse he controls thirty elevators in the inbound warehouse and forty-two in the outbound warehouse. In any case the operation of the doors and the leveling of the cars at the landings are effected automatically. The system is applicable to terminals of moderate size as well as to the immense warehouses provided for war emergencies. The Pennsylvania freight station at Chicago has sixteen of these automatic elevators of three to five tons capacity, and the new Chicago & Alton Station at Chicago will have seventeen five-ton and two ten-ton automatic elevators. These Chicago elevators do not require dispatchers, but are operated by the freight truckers by means of push-buttons adjacent to the doors of the elevators.

In conclusion, it may be pointed out that any study as to the application of mechanical methods of handling freight in a specific freight house should include study of methods of improving the efficiency of operation as a whole.

REFERENCE LIST TO ARTICLES ON FREIGHT TERMINALS AND FREIGHT HANDLING

Engineering News-Record

1. Ocean Freight Terminal on Staten Island, New York. Private plant. Covered piers and seven-story concrete building, with no walls around first floor. January 17 and February 28, 1918, pages 120 and 426.

2. Produce Market and Warehouses at Los Angeles. Two-story and six-story buildings. January 24, 1918, page 167.

3. Freight Station of Central Manufacturing District, Chicago; L. C. L. freight handled by tractors and trucks; tunnels for trucking to industries. February 28, 1918, page 405.

4. Warehouse at Buffalo, N. Y. Conveyor systems used and upper floors cantilevered over tracks. February 28, 1918, page 411.

5. Freight Terminal at Cleveland; New York Central R. R. Electric elevators and inclined conveyors. Bascule bridges for trucking across tracks instead of through the cars. Details of operation. March 14, 1918, page 495; March 13, 1919, page 509.

6. Freight Piers at Norfolk, Va.; Norfolk & Western Ry. Hinged ramps with conveyor chains for loading and unloading vessels. May 16, 1918, page 940.

7. Freight Handling by Tractors; Chicago Junction Railway L. C. L. business at 43rd Street Station; cost figures. October 17, 1918, page 720.

8. Ocean Pier and Warehouse at Houston, Texas. Ramps at wharf; elevators and overhead traveling crane into warehouse. July 24, 1919, page 156.

9. Freight Terminal Design as Work of Engineers. September 18, 1919, page 540.

10. Freight Handling at the Brooklyn Army Base, U. S. A. Double-deck piers, nine-story warehouses, electric tractors hauling trains of trucks under control of dispatcher system. September 18, 1919, page 555.

11. Ocean Pier and Terminal at Seattle. Freight-handling methods. November 13, 1919, page 855; January 1 and June 3, 1920, pages 37 and 1107.

12. Transfer of L. C. L. Freight at Cincinnati. Motor truck service between all freight stations. Freight loaded into large wagon bodies, which are sealed; bodies placed on and taken off trucks by overhead cranes. March 11, 1920, page 508.

13. Railway Terminals in Relation to City Planning. May 6, 1920, page 901.

14. Ocean Terminal at New York, Lehigh Valley R. R. Long piers; warehouses. May 13, 1920, page 970.

15. Municipal Ocean Terminal on Staten Island, New York. Long, narrow piers. May 27, 1920, page 1047.

16. Width of Steamship Piers. Provision for cargo storage, railway tracks and mechanical handling. July 22, 1920, page 160.

17. Freight Yard of Denver & Rio Grande R. R. at Soldier Summit. Operating conditions; flat switching. May 27 and June 10, 1920, pages 1069 and 1159.

18. Freight Yard of Michigan Central R. R. at Niles, Michigan. Hump switching. January 8, 1920, page 81.

19. Freight Yard of Illinois Central R. R. at Chicago. Main line and local transfer business. Hump switching. August 5, 1918, page 313.

20. Trainshed of Indianapolis Union Station. August 19, 1920, page 350.

21. Development of Grand Central Station, New York. Lofty buildings erected over track space of electrically operated terminal. September 9, 1920, page 496.

22. Chicago Freight Terminal of Chicago & Alton R. R. Double-deck station with upper floors for warehouse and company's main offices. October 14, 1920, page 728.

23. Improved Freight Yard at Lincoln, Nebraska, for Chicago, Burlington & Quincy R. R. November 18, 1920, page 996.

24. Operation of Car-Float Transfer Yards. December 16, 1920, page 1186.

Railway Age

1. Terminal Ten-Story Warehouse at Cleveland; Big Four. June 29, 1917.

2. Freight House at Indianapolis; Pennsylvania System. Single deck. July 13, 1917.

3. Freight Station at Chicago: Pere Marquette Railroad. Three-story. August 10, 1917.

4. Freight Terminal at Vancouver; Canadian Northern Railway. Herringbone tracks in team yard. November 23, 1917.

5. Freight Terminal at Orange Avenue, Cleveland; New York Central R. R. July 19, 1918.

6. Freight Station and Warehouse at Chicago; Pennsylvania System. August 2, 1918.

7. Freight Station at Salt Lake City; Denver & Rio Grande R. R. Bascule bridges for trucking across tracks. May 2, 1919.

8. Electric Tractors at Pier 4, New York. August 3, 1917, page 199.

9. Pere Marquette Freight Station at Chicago. A description of a new local freight station. August 10, 1917, page 225.

10. Pennsylvania Hump Yard at Indianapolis. October 26, 1917, page 735.

11. Electric Trucks for Handling Freight. December 7, 1917, p. 1039.

12. Union Package Terminal. A proposed new package freight terminal at Jersey City. March 1, 1918, page 445.

13. Illinois Central Markham Yard and N. Y. N. H. & H. New Haven Freight Terminals Compared. May 10, 1918, page 1164.

14. New Passenger Station of R. F. & P. at Richmond, Va. February 14, 1919, page 401.

15. An Analysis of the Locomotive Terminal Problem. March 7, 1919, page 538.

16. Modern Tendencies in the Design of Roundhouses. March 14, 1919, page 587.

17. British Railway Improvements at Glasgow. March 28, 1919, page 843.

18. Reinforced Concrete Roundhouse Layout for T. & O. C. at Columbus. April 18, 1919, page 994.

19. Some Modern Tendencies in Roundhouse Design. May 16, 1919, page 1199.

20. Illinois Central Projected Terminal at Chicago. July 11, 1919, page 51.

21. Michigan Central Classification Yard at Niles, Mich. January 23, 1920, page 287.

22. Modernizing Freight Car Repair Facilities. February 27, 1920, page 608.

23. Handling l. c. l. freight in Interchange by Motor Trucks at Cincinnati. March 5, 1920, page 681, and August 6, 1920, page 219.

24. D. & R. G. Freight Terminal at Soldier Summit, Utah. March 26, 1920, page 1025.

25. Relation of Railroad Terminals to City Plan. April 30, 1920, page 1285.

26. First Unit of St. Paul Union Station Completed. May 21, 1920, page 1442.

27. Unit Construction Enginehouse. A standard design of unit construction for engine houses on the Pennsylvania. June 11, 1920, page 1663.

28. Report of Committee of American Railway Association, Section III—Mechanical (Master Car Builders) on Repair Shop Layouts. June 20, 1920, page 1801.

29. A. C. & O. Enginehouse for Mallet Compound Locomotives. June 25, 1920, page 1975.

30. N. Y. N. H. & H. Freight Terminal at Cedar Hill (New Haven), Conn. July 30, 1920, page 179.

31. The Claremont Terminal of the Lehigh Valley in Lower New York Harbor. October 8, 1920, page 599.

RAILWAY REVIEW

1. Freight Station and Warehouse at Pittsburgh (Federal Street); Pennsylvania System. December 15, 1917.

Appendix B

(4) PASSENGER STATIONS

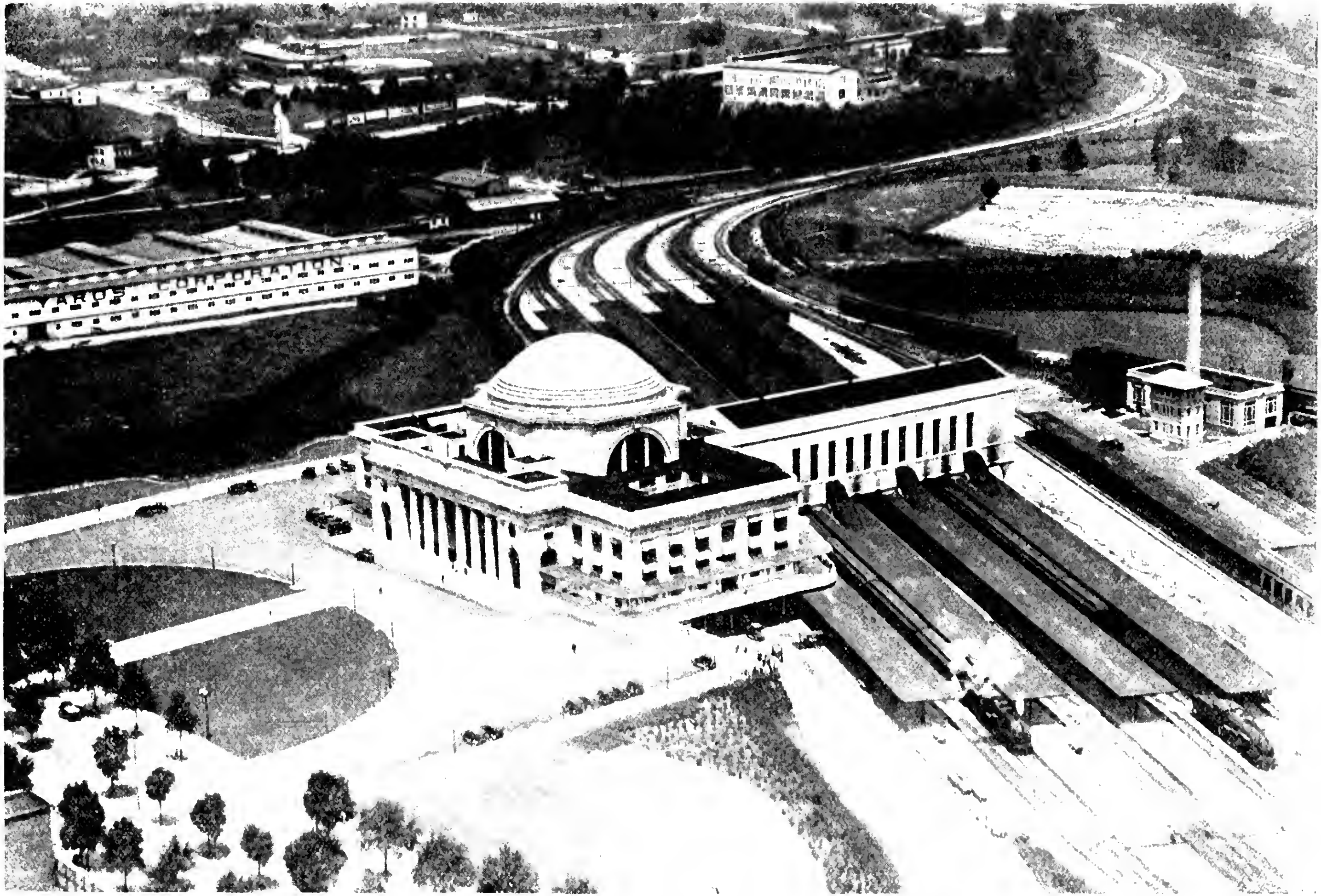
E. M. HASTINGS, *Chairman;*
J. E. ARMSTRONG,
MILES BRONSON,
H. A. LANE,
S. S. ROBERTS,
C. H. SPENCER,
E. B. TEMPLE,
Sub-Committee.

It is the view of the Committee that the subject of Passenger Terminals covers work which is constantly in the process of development and it is not thought wise to make a final report on the subject, but that the work should be continued open from year to year, so that progress and development in the design and operation of passenger terminals may from time to time be reported.

Following out this idea, the Committee presents for information and publication in the Proceedings the plan of the new passenger terminal now being constructed at St. Paul, Minn., by the St. Paul Union Depot Company, and for a description of this terminal refers to "Railway Age" of May 21, 1920, page 1442, and "Engineering News-Record" of June 20, 1918; also the plans and photograph of the new passenger terminal constructed at Richmond, Va., for the Richmond Terminal Railway Company and used by the Atlantic Coast Line Railroad and the Richmond, Fredericksburg & Potomac Railroad. For a description of this terminal refer to "Railway Age" of February 14, 1919, page 401, the "Architectural Review" of June, 1919, and the "Railway Review," December 15, 1919.

The Committee recommends that the plans submitted to the Association and printed in the Proceedings as information in 1911, Volume 12, page 240, Fig. 1, showing a typical track layout at a dead-end passenger terminal station, and Fig. 2, showing a typical track layout at a through passenger terminal station, as revised, be included in the Manual as recommended practice.

The Committee recommends that types of ladders originally prepared by Mr. S. S. Roberts, a member of this Committee, and printed in the Proceedings of 1917, Volume 18, pages 746 to 749, types Nos. 20 to 26, both inclusive, as revised, be printed in the Manual as recommended practice.



RICHMOND (VA.) PASSENGER TERMINAL.

Appendix C

(7) SCALES

Hadley Baldwin, *Chairman;*
J. E. Armstrong,
C. A. Briggs,
A. E. Clift,
A. W. Epright,
R. Hayes,
J. B. Hunley,
O. Maxey,
Sub-Committee.

The Sub-Committee was instructed to make report on passenger station, freight house, and grain weighing scales, conferring with Committee on Buildings.

The Sub-Committee has gathered statistics, a digest of which indicates that the practice of the railroads and of the scale manufacturers also is far removed from anything approaching rational standardization—a situation that in the Committee's opinion deserves remedy, such as can be attained only by the preparation of specifications that will meet the proper requirements and reduce the multiplicity of types, now in use or recommended, to the minimum number consistent with satisfying the common demands of railroad service weighing.

The Sub-Committee has begun the work of preparing such specifications. This work has been prosecuted energetically during the year, but because of the large amount of time required to accumulate and digest statistics and recommendations submitted by the individual railroads and for an exhaustive analysis thereof and for the adjustment of more or less widely varying opinions, on questions of basic importance, among members of the Committee itself and between the Committee and the Scale Manufacturers' Association, it has been found impossible so to advance the work as to have ready at this time even a tentative draft of the specifications later to be submitted.

Appendix D

8. METHODS OF ECONOMIC TRANSFER OF LADNIG OF BAD-ORDER CARS IN LARGE TERMINALS BY THE INTRODUCTION OF MECHANICAL MEANS OR OTHERWISE

D. B. JOHNSTON, *Chairman;*
J. H. BRINKERHOFF,
H. T. DOUGLAS, JR.,
A. MONTZHEIMER,
R. J. MIDDLETON,
H. J. PFEIFER.

In every large railroad terminal and many small terminals there accumulates loaded cars, which, through defects of equipment or loading, are not ready to move forward, but must undergo heavy repairs. In the majority of cases such attention requires entire transfer of, reduction in, or shifting of lading.

The routine of yard operation collects bad-order cars as they appear and moves them from the current of traffic into the car repair yard or other yard where transferring is done by forces assigned for that purpose. The variation in the nature of the transfer work required is very wide, covering the whole range of rolling stock and commodities. In certain districts, such as those devoted to mining, quarrying, or steel manufacturing, the major portion of the lading to be transferred may be similar from day to day, but in most terminals all varieties are handled in transfer.

A canvass of the principal terminals of the country made by your Committee indicates that the great bulk of transferring is done by hand labor, either entirely or supplemented by such machinery as can be diverted from its primary use. The objection to hand labor lies in its heavy cost of wages, the delay to cars while undergoing the process, the delay to the lading, to the disadvantage to the owner thereof, and the investment in tracks and other plant for holding cars awaiting transfer.

The selection of proper machinery for work of such varied nature brings out its own problems, for instance: As only freight in open top cars can be transferred by machinery, if box cars comprise the prevailing equipment, the cost of machinery may not be justified. If the bulk of the transferring is applied to self-clearing cars, elevated trestles may be superior to the use of machines.

For situations requiring the transfer of miscellaneous freight the locomotive crane is the most useful machine that has been employed. Its range of efficiency is very wide, its operation is simple and low in cost, and its portability makes it preferable to stationary machines.

The question of the possible economies to be effected in each location and by each railroad can be determined only locally, and should be based upon the amount and nature of transferring normally made, the cost and efficiency of hand labor, the cost of machinery serving the same purpose including investment, and the demand for expediting the forward movement of cars and lading.

The cost of transferring a carload of freight by hand varies from $15.00 to $60.00, the narrow range being from $20.00 to $40.00. The cost when machinery is available varies from $5.00 to $25.00, the narrow range being from $5.00 to 15.00, and as a general rule the use of machinery effects a saving ranging from 25 to 75 per cent, with an average of 50 per cent, or $12.00 to $15.00 per car.

While analysis may well be made of the efficiency of any proposed machine, the locomotive crane, being of wide application, is here taken as an example: A modern 8-wheel crane of 15 to 25 tons capacity costs. .$15,000

Interest at 6%	$ 900		
Depreciation, maintenance and repairs at 10%	1,500		
		$2,400	
Operation, wages, fuel and stores		2,400	
Making cost per annum			4,800
or per month			400

This cost is the equivalent of about three laborers with their necessary supervision, but as at least three laborers, not included in the above cost of operation, must accompany the crane, the machine is equivalent in cost to six men. This force of six men is about the minimum usually applied to car transfer work and its performance will average no more than two cars per day. Therefore, it may be said that where more than two cars per day are set out for transfer or more than six laborers are employed in transferring, the use of machinery should be seriously considered.

A few suggestions bearing on the general subject are offered:

For transferring self-clearing cars, a dumping trestle with track layout to serve it is low in cost of operation. The justification for building it is dependent upon first cost.

The overhead crane is efficient for transferring lading from open top cars, but it has the disadvantage of involving high first cost and expenses of car switching due to fixed location of the crane.

Service similar to that suited to the locomotive crane may be had by the use of industrial and home-made derrick cars costing much less than cranes.

For transferring heavy units, over 25 tons, such not being common, the steam wrecking crane should be used, but the constant use of such an expensive and important machine for light work may easily become an abuse.

When it appears probable that the purchase of a locomotive crane would result in economies, investigation should be made to determine whether it may also be used in shop, yard or road service, to determine the maximum saving which may be made by using the crane during as many hours per day and in as many localities as may be scheduled.

Portable scoop conveyors operated by steam and gasoline have recently come on the market and give promise of large savings in labor.

The end shifting of lumber by bumping in place is rapid and cheap. It should be performed only by crews experienced in the practice as otherwise damage to equipment may be expected.

When a machine is inaugurated to supplant hand labor, there is at once opened a field for the foreman in charge to study, observe and apply new means of making hitches and movements, and thereby increase his economy, speed and safety. It can not be expected that any machine will develop its maximum service without constant watchfulness and study to improve its operation and broaden its field of usefulness.

Conclusions:

(a) Hand labor for transferring freight from cars in most cases is slow and expensive and without real justification.

(b) The employment of a locomotive crane is generally justified in any case where the transfer of freight from open top cars otherwise requires the equivalent of the constant daily service of six or more men, or the intermittent service of six men where the machine may be economically employed in the interim.

(c) A study of each situation may develop extensive means of economy out of all proportion to the cost and such study is justified in each case.

REPORT OF COMMITTEE XI—RECORDS AND ACCOUNTS

H. M. STOUT, *Chairman;*
A. M. BLANCHARD,
H. BORTIN,
W. A. CHRISTIAN,
R. A. COOK,
W. P. CRONICAN,
E. B. FITHIAN,
L. B. LINCOLN,
J. H. MILBURN,
HENRY LEHN, *Vice-Chairman;*
A. W. NEEL,
H. J. SARGENT,
*R. C. SATTLEY,
C. W. SIMPSON,
T. H. STRATE,
V. R. WALLING,
W. D. WIGGINS,
Committee.

To the American Railway Engineering Association:

The following subjects were assigned the Committee on Records and Accounts:

1. Make thorough examination of the subject-matter in the Manual, and submit definite recommendations for changes.
2. Make final report, if practicable, on cost-keeping methods and statistical records.
3. Recommend forms for recording data for keeping up-to-date valuation of property of railroads as required by Valuation Order No. 3, Second Revised Issue.
4. Study and report on feasibility of reducing the number of forms used in the Engineering and Maintenance-of-Way Department, combining forms, and simplifying those retained.
5. Study and report on the feasibility of reporting engineering data in diagrammatic or graphic form, and submit recommended diagrams.

Committee Meetings

Meetings of the General Committee were held as follows:

Chicago, Ill., May 26.
Chicago, Ill., June 24.
Pittsburgh, Pa., August 5.
Buffalo, N. Y., September 16.
Detroit, Mich., October 21.
Chicago, Ill., November 18.

The names of the members in attendance have been given in the Minutes of the Meetings, abstracts of which have been printed in the Bulletin.

*Died December 31, 1920.

(1) Revision of Manual

In Appendix A proposed changes in the Manual are given.

(2) Cost-Keeping Methods and Statistical Records

The Sub-Committee handling this subject has continued its study with the idea of embodying in its final report practical applications of the principles which were embraced in its preliminary report last year.

But, owing to the changes resulting from the return of the roads to their owners and the unsettled conditions, it was deemed advisable to report progress only so as to permit a more thorough report next year which will reflect more stabilized conditions.

(3) Forms for Recording Data for Keeping Up-to-Date Valuation of Property of Railways as Required by Valuation Order No. 3, Second Revised Issue

In Appendix B the Committee submits three additional forms as results of their work on this subject.

(4) Feasibility of Reducing the Number of Forms Used in the Engineering and Maintenance-of-Way Department, Combining Forms, and Simplifying Those Retained

This subject is being studied and data collected by a Sub-Committee, but it has not progressed sufficiently to present recommendations or conclusions to the Association this year.

(5) Feasibility of Reporting Engineering Data in Diagrammatic or Graphic Form, and Submit Recommended Diagrams

The Sub-Committee engaged in the study of this subject presents in Appendix C a bibliography of this subject and the progress of its work.

Progress Report

The Committee reports progress on subjects (2) Cost-keeping Methods and Statistical Records; (4) Reducing the number of Forms used in the Engineering and Maintenance-of-Way Department, and (5) Reporting Engineering Data in Diagrammatic or Graphic form.

Death of Robert Carlos Sattley

During the past year the Committee sustained the loss, by death on December 31, 1920, of one of its most active and valued members, Robert Carlos Sattley.

Mr. Sattley's contribution to the work of the Committee, on which he has served the past six years, was of high order and his death is keenly felt by members of this Committee and by his associates in the Association.

CONCLUSIONS

1. The Committee recommends that the changes in the Manual as given in Appendix A be approved and the revised matter be substituted for the present recommendations in the Manual.

2. The Committee recommends that the three additional forms shown in Appendix B, for keeping up records under Valuation Order No. 3, Second Revised Issue, be approved and published in the Manual.

3. The Committee recommends that subject (3) be continued as a part of next year's work.

4. The Committee recommends that the reports relating to (2) Cost-keeping methods and statistical records; (4) Reducing the number of forms, and (5) Reporting engineering data in diagrammatic or graphic form, be received as information and the subjects continued.

Recommendations for Future Work

The Committee recommends that the following new subject be added to those continued for future work:

Submit proposed Conventional Signs for Practical Architectural Details.

Respectfully submitted,

THE COMMITTEE ON RECORDS AND ACCOUNTS,

H. M. STOUT, *Chairman.*

Appendix A

(1) REVISION OF MANUAL

The Committee recommends the changes in the Manual shown below. Under DEFINITIONS the new or added letters and words are underscored and the old or omitted letters and words are enclosed in parentheses.

Definitions, Page 339

ACCOUNT(S).—A statement(s) required to enable payment(s) to be made for labor performed and material furnished, or to establish the detail, total and comparative cost of work and various classes of expenses.

CONVENTIONAL SIGN(S).—A symbol(s), such as a mark, character, abbreviation or letter, selected or sanctioned by general agreement or common use (and) to indicate upon a map or plan certain forms, conditions (and) or objects, both natural and structural.

LEDGER ACCOUNTS (FOR INDIVIDUAL PIECES OF WORK).—Statements kept in ledger form in order to establish the detail, total and comparative cost of (any particular) individual pieces of work or classes of expenses.

PROGRESS PROFILE.—A graphical record (of the progress) showing status of work (prepared) at stated periods.

RECORD(S).—Authenticated information or data in graphical, tabular or statement form relating to physical characteristics, conditions, cost and such other information as may seem desirable for (record) preservation.

REPORT(S).—The medium through which information is transmitted (from one to another official) and from which records and accounts are prepared or compiled (in the filing office).

RIGHT-OF-WAY MAP.—A plat representing the actual location and dimensions of the property, (right or) franchises or other rights (that are) owned or controlled by a railway company.

TRACK CHART.—A diagram showing the physical characteristics of (track and roadbed) roadway and track.

TRACK MAP.—A (map used primarily for) plat showing existing physical (conditions) plant, including tracks, bridges, buildings, water service and mains, leases, station facilities and all (of the) other physical and operating (features) property.

Form 501, Monthly Track Material Report, opposite page 384

At a meeting of the Committee, October 23, 1919, it was decided to collect copies of material report blanks in use by various railroads. The Secretary of the Association collected the forms in use on the 23 railroads shown in the attached list and these have been examined to determine what, if any, changes should be made in the form as published in the Manual. Eleven of these reports are bound in book form, in some cases being combined with time books and tool reports. The principal features in which these forms differ from the form in the Manual are as follows:

Four roads use separate forms for recording ties, rail, and miscellaneous track material; three roads divide the columns showing materia received from track into fit and scrap; the Norfolk Southern anc B. & L. E. have a simplified form using only five columns. Some roads use an alphabetical arrangement of the material in the left-hand column, and one road prints the material in columns reversing the use of the lines and columns. P. & L. E. prints a list of 232 items on four sheets, and furnishes a blank sheet for additional items; the Pennsylvania Lines has a form with 40 columns. The form in the Manual is followed closely by the C. & W. I., C. R. I. & P., M. O. & G., and M. D. & W. railroads.

The list of materials shown in the left-hand column will vary on different railroads and should be omitted entirely, and left to be filled in by printing or in pencil, according to requirements of individual railroads. It might be advisable to print a list of materials as now shown on Form 501, as a suggestion of the items to be included.

The headings of the columns on Form 501 in the Manual seem to meet the requirements of a form of this kind, except that we suggest dividing column five (5), showing material received from track, into two columns, showing main tracks and side tracks; changing columns 10 and 11 to three columns, in order to itemize material used on different construction jobs, and divide column 12 into three columns in order to report material shipped to various divisions or destinations.

On the back of Form 501 are instructions, daily record of material received and shipped, and switch tie data. The instructions should be printed on the face of the form. The daily record of material received and shipped does not seem to be necessarily a part of this blank. The switch ties might be included in the items on the face of the sheet, with details in a separate table, if desired.

We recommend that the form be revised as here shown (Exhibit A), to be made 11x16 inches, so as to fold once to lettersize with one-inch margin for binding. The form to be printed in black with horizontal lines, 6 per inch. Instructions to be printed at the bottom of the sheet as shown.

In making up the report one or more sheets may be used as required.

Exhibit A

North & South Railroad ....

Sheet No ...... of ... Sheets

MONTHLY TRACK MATERIAL REPORT

.... DIVISION SEC NO .... MONTH OF .... 19 ....

				RECEIVED DURING THE MONTH							USED AND SHIPPED DURING THE MONTH										
					OUT OF TRACK BY RENEWALS		FROM TRACK TAKEN UP				RENEWALS OR REPAIRS		CONSTRUCTION OR NEW WORK			SHIPPED AWAY					
LINE NO	DESCRIPTION OF MATERIAL	UNIT	ON HAND AT DATE OF LAST REPORT	BY SHIPMENT	MAIN TRACK	SIDE TRACK	MAIN TRACK	SIDE TRACK		TOTAL TO ACCOUNT FOR	MAIN TRACK	SIDE TRACK							TOTAL DISPOSED OF	ON HAND AT DATE OF THIS REPORT	LINE NO
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
	This column blank "New" "fit" or "scrap" to be shown in this column																				

INSTRUCTIONS

1.– The Section Foreman must keep a daily record of all materials used, received and shipped

2 – He must close his accounts on the ...... th. of each month, and forward the report so as to reach the Supervisor not later than the morning of the ...... th of each month

3 – Column No 21 must show the material actually on hand on the day the report is made.

4 – The Supervisor must check the report, sign it and send it to the Division Engineer so as to reach him on the morning of the ...... th.

Checked and found correct :

.... Supervisor of Track

The above account is correct

.... Section Foreman

List of Railroads Submitting Material Report Blanks in Use

Pittsburgh & Lake Erie,
Pennsylvania,
Pennsylvania Lines,
Chicago & Western Indiana,
Chicago, Rock Island & Pacific,
Missouri, Oklahoma & Gulf,
Bessemer & Lake Erie,
Central Railroad of New Jersey,
United States Railroad Administration,
Port Arthur Route,
Pere Marquette,
Temiskaming & Northern Ontario,
Southern,
Seaboard Air Line,
Minnesota, Dakota & Western,
Grand Trunk,
Elgin, Joliet & Eastern,
Colorado & Southern,
Louisville & Nashville,
Norfolk Southern,
Georgia & Florida,
Duluth & Iron Range,
Bangor & Aroostook.

Appendix B

(3) RECOMMEND FORMS FOR RECORDING DATA FOR KEEPING UP-TO-DATE VALUATION OF PROPERTY OF RAILWAYS AS REQUIRED BY VALUATION ORDER NO. 3, SECOND REVISED ISSUE

The Interstate Commerce Commission, Bureau of Valuation, in issuing Order No. 3, Second Revised, made clear to the carriers that the purpose of the order is to keep up to date the valuation of the railway properties. To accomplish this the order provides:

I. A Uniform System of Records to be kept by the Carriers.
   1. Authority for Expenditures.
   2. Detailed Estimate Sheet to accompany the A. F. E.
   3. Register of Authorities for Expenditures.
   4. Roadway Completion Report.
   5. Equipment Completion Report.
   6. Record of Property Changes.

II. Prescribed Reports to be made to the Interstate Commerce Commission.
   1. Semi-annual Statement of Roadway Completion Reports. (B. V. Form 586)
   2. Semi-annual Statement of Equipment Completion Reports. (B. V. Form 587)
   3. Statement of Property Units Added and Retired and their Costs. (B. V. Form 588)
   4. Annual Statement of Charges and Credits to the Investment Account for Property Brought into or Retired from Operation. (B. V. Form 589)

Since the four reports listed above (II. Prescribed Reports) are prescribed by the Order as to form, size, and contents, no modifications are proposed.

Of the six forms "I. Uniform System of Records," the minimum amount of information required by the Commission is stipulated for each of the first five; the size, arrangement and total amount of information is optional with the carrier. The sixth form, "Record of Property Changes," is prescribed, except as to size, which is optional.

Last year your Committee submitted an A. F. E. form on a Roadway Completion Report form which was approved and ordered published in the Manual. Your Committee now offers the following three additional forms which have been drawn primarily to fit the needs of the carriers but the minimum requirements of the Interstate Commerce Commission as prescribed by its B. V. Order No. 3, Second Revised, have also been kept in mind:

1. Detailed Estimate Sheet. (See Exhibit B)
   This form to be the same size as the A. F. E. form; size, 8½x11 inches, printed in black on one side only.
2. Register of Authority for Expenditure. (See Exhibit C)
   This form to be 14x17 inches, printed in black on both sides and is designed as a leaf of a loose-leaf book.
3. Equipment Completion Report. (See Exhibit D)
   This form to be 8½x14 inches, printed in black on one side only. A margin is provided on the left for binding.

Your Committee recommends the adoption of these three forms and their publication in the Manual.

In addition to these forms for receiving the records in the final form there is room for a great deal of good work in planning for the collection of and assemblying the elemental and supporting data.

Exhibit B

North & South Railroad

DETAILED ESTIMATE

A.F.E. No.________________

Sheet No.___of____Sheets

Plan No. ___________

Reference _________________

Office of____ Date _________________192___

Location and description of project ____

____

____

Quantity	Unit	Price	Description of Unit	Total Cost	Distribution of Estimated Cost			
					Road and Equipment		Operating Expenses	•
					Railroad	Railroad		
			TOTALS					

Estimated by ______________________ Approved ______________________

Checked by ______________________ Approved ______________________

• Fill in Individuals & Companies, Profit and Loss, Misc. Physical Property or other account titles as circumstances require.

North & South Railroad

REGISTER OF AUTHORITIES FOR EXPENDITURE.

Valuation Engineer's File No.	AUTHORITY				LOCATION		DESCRIPTIVE TITLE	DATE OF WORK		Completion Report Received	TOTAL COSTS		REMARKS
	A. F. E.		D.C.E.										
	No.	Date	Form	No.	State	Val Sec.		Beginning	Completion		Estimated	Actual	
											$	$	

Exhibit D

North & South Railroad

Sheet No .... of .... Sheets.

COMPLETION REPORT
OF
CHANGES MADE IN EQUIPMENT DURING THE SIX MONTHS ENDED ....19....
General Account 11. Equipment.

Authority	Equipment, unit numbers, names or series affected by the change.	Owner	Lessee	Description of Equipment to which the change is applicable.	Total number of units affected	Description of the change effected and of the other items contributing to the costs incurred.	Date of Change	COSTS INCURRED		COSTS RETIRED	
A. F. E. No.								Dr. Acct. No.	Amount	Cr. Acct. No.	Amount

I, ... (Name) .... (Title) .... of the above named company do swear that the foregoing report of property changes which were made under my supervision is true to the best of my knowledge and belief.

Subscribed and sworn to before me this .... day of .... 19....

.... (Signature)

.... (Title) ....My Commission Expires..............................

.... (Signature)

.... (Title)

Appendix C

(5) STUDY AND REPORT ON THE FEASIBILITY OF REPORTING ENGINEERING DATA IN DIAGRAMMATIC OR GRAPHIC FORM, AND SUBMIT RECOMMENDED DIAGRAMS

As a preliminary study of this subject the Committee has prepared a short bibliography comprising a list of nineteen books, pamphlets, and papers. Also, a very complete bibliography has been prepared for the Committee under the direction of Mr. R. H. Johnston, Librarian, Bureau of Railway Economics, Washington, D. C.

These lists follow and are offered as information and a report of progress.

Bibliography Relating to the Graphical Presentation of Engineering Data

1. Elements of Statistical Methods.—Wm. I. King, Univ. of Wisconsin.
2. Elements of Statistics.—Arthur I. Bowley, London.
3. An Introduction to the Theory of Statistics.—G. Udny Yule, London.
4. Statistical Averages.—Dr. Franz Zizek, Univ. of Vienna. Translated by W. M. Persons of Colorado College.
5. Primer of Statistics.—W. P. and E. M. Elderton, London, 1912.
6. School Statistics and Publicity.—Carter Alexander.
7. Graphic Algebra.—Arthur Schultze, N. Y. University.
8. Graphic Presentation of Statistics.—L. M. Haupt. Jour., Franklin Inst. Vol. 147, No. 5, 1889.
9. Graphical and Mechanical Computations.—J. Lipka, Wiley, N. Y. 1918.
10. Graphics applied to Arithmetic, Mensuration and Statistics.—G. C. Turner.
11. Graphical Methods.—C. Runge, Columbia Univ. Press, N. Y. 1912.
12. The Logarithmic Plotting of Alinement Charts for Additive Expressions.—C. E. P. Sankey, Inst. C. E. Paper No. 4154, London, 1916.
13. Book of Charts.—Warne, London, 1918.
14. Developing Executive Ability.—E. B. Gown, The Ronald Press Co., N. Y.
15. Nutshell Reports for the Boss.—J. H. McCullough, "System," May, 1918.
16. How I get my ideas across.—J. H. Patterson, "System," June, 1918.
17. Graphs and Statistics in Business.—(In Library of Business Practice, Vol. 10) Shaw, 1914.
18. Graphic Presentation of Data.—American Railway Engineering Association, Bulletin 206, June, 1918.
19. Illustrations of Graphical Analysis.—J. Harrison, Engineering, Sept. 18, 1903.

List of References on the Graphic Representation of Engineering Data

This list has been prepared by Miss Mary B. Ladd, Cataloguer of the Bureau of Railway Economics Library. It is based primarily on the contents of the Bureau Library, but other material has been added as found in certain other libraries indicated by the abbreviations below. The use of these abbreviations at the end of titles must not be understood, however, as meaning that other titles in the list may not also be found in these libraries.

The figures which follow titles, such as 18-1492, represent the Library of Congress printed card numbers by which the card may be ordered for use in cataloguing.

Agr —Library U. S. Dept. of Agriculture.
B —Bureau of Railway Economics.
BA —Boston Athenaeum.
BPL—Boston Public Library.
HU —Harvard University Library.
LC —Library of Congress.
MIT—Massachusetts Institute of Technology Library.
NY —New York Public Library.
UES—United Engineering Societies Library, New York.

Library Bureau of Railway Economics.

November 23, 1920.

List of References on the Graphic Representation of Engineering Data

American society of mechanical engineers. Joint committee on standards for graphic presentation.
Preliminary report published for the purpose of inviting suggestions for the benefit of the committee. New York [1915] 2 p. 8° B, HU, NY, UES.
Reprinted in Quarterly publications of the American statistical association, v. 14:790-97; Dec., 1915; in Engineering record, v. 72:633; Nov. 20, 1915; in Bulletin of the American institute of mining engineers, v. 106:ix-xii; Oct., 1915; in Journal of industrial and engineering chemistry, v. 7:894-95; Oct., 1915; in Society for the promotion of engineering education, Bulletin, v. 6:141-46; 1915.

Anderson, A. H.
Plotting blower-test curves.
(Journal of the American society of mechanical engineers, v. 39: 902-04; Nov., 1917) B, HU, MIT.

Appel, R.
Reducing time out through graphic charts.
(Factory, v. 19:349; Sept., 1917) HU.

Arthur, William.
Graphics as applied to car maintenance.
(Electric railway journal, v. 32:30-31; June 6, 1908) HU, LC.

Auerbach, Felix.
Die graphische darstellung; eine allgemeinverständliche, durch zahlreiche beispiele aus allen gebieten der wissenschaft und praxis erläuterte einführung in den sinn und den gebrauch der methode. Leipzig und Berlin, B. G. Teubner, 1914. 97 p. 12° (Aus natur und geisteswelt, 437. bdchen) MIT, NY.

Bailey, William Bacon, and Cummings, John.
Statistics...Chicago, A. C. McClurg & co., 1917, 5 p. l., 153 p. diagrs. 12° (The national social science series, ed. by F. L. McVey) B, BPL, HU, LC, MIT, NY, UES. 18-1492
Bibliography: p. 149.
Graphic representation: p. 109-30.

Bertillon, Jacques.
Propositions relative à l'uniformité à apporter dans l'établissement des graphiques.

(Bulletin de l'Institut international de statistique, v. 13, 1:313-18; 1903) Agr, HU, MIT, NY.
Discussion: p. 132-37.

Blake, A. F.
An alinement chart for the evaluation of coal.
(Journal of industrial and engineering chemistry, v. 10:627-28; Aug., 1918) HU, LC, MIT, UES.

Blake, A. F.
A graphic chart for the evaluation of coal.
(Journal of industrial and engineering chemistry, v. 8:1140-42; Dec., 1916) HU, LC, MIT, UES.

Bolam, Austen.
Chart for determining economy of insulation.
(Electrical world, v. 71:1275; June 15, 1918) HU, LC.

Brinton, Willard Cope.
...Graphic methods for presenting facts. New York, Engineering magazine company, 1914. 371 p. 4° (Works management library) B, BPL, HU, LC, MIT, NY, UES. 14-18712
Published in part in the Engineering magazine, v. 47:651-66; 817-29; v. 48:73-85, 229-41, 396-406, 551-68; Aug., 1914-Jan., 1915.

———New York Ronald press co., 1918, xii, 371 p. 12° [Industrial management library] BPL.

Brown, Reginald.
Diagrammatic statistics for municipal engineers.
(Canadian engineer, v. 31:317-19; Oct. 19, 1916) LC, MIT, NY, UES.
Read before the Institution of municipal and county engineers. Also in Surveyor and municipal and county engineer, v. 50:138-45; Aug. 18, 1916.

Buck, Alonzo Morris.
...Some graphical solutions of electric railway problems. Urbana, University of Illinois, 1916. 36 p. 8° (Bulletin no. 90, Engineering experiment station) B, BPL, LC, MIT, NY. A 16-1176
Abstract in Electric railway journal, v. 48:281; Aug. 12, 1916.

Buford, C. H.
Program of construction work shown graphically.
(Engineering record, v. 74:89; July 15, 1916) HU, LC.

Burkhardt, Otto M.
Determining of piecework rates from charts.
(American machinist, v. 49:383-87; Aug. 29, 1918) HU, LC, MIT.

Carpenter, Sidney C.
Graphic presentation of train resistance formulas.
(Railroad age gazette, v. 46:944-45; Apr. 30, 1909) B, HU, LC, NY.

Charlton, D. E.
Utilization of mine-accident reports.
(Engineering and mining journal, v. 106:945-48; Nov. 30, 1918) LC, NY, UES.
Graphic methods of presenting data.

Conway, J. B.
An accumulative graphic record.
(American machinist, v. 50:242; Feb. 6, 1919) HU, LC, MIT.

Copeland, Melvin T., *ed.*
Business statistics. Cambridge, Harvard university press, 1917. 696 p. 8° HU, LC, NY, UES. 17-18599
With numerous applications of the graphic method to the presentation of business statistics.

Cunningham, William J.
The logarithmic scale in graphic charts.
(Railroad age gazette, v. 46:1517-19; June 25, 1909) B, HU, LC, NY.

Cunningham, William J.
Statistics of railroad operation.
(New England railroad club. Proceedings, Oct. 12, 1909, p. 4-61) B, HU, MIT, UES.
Illustrated by graphic charts.

Curves reveal significant facts; valuable data which indicate performance of personnel, machine equipment, and administration policies in manufacturing plants are obtained from graphic records.
(Iron trade review, v. 65:1116-17; Oct. 23, 1919) HU, LC, UES.

Davies, John P.
Engineering office systems and methods. New York, McGraw-Hill book co., 1915. XVI, 544 p. 8° BPL, HU, LC, MIT, UES.
15-5340
"Progress charts, scheduling systems, etc.": p. 392-406.

Davis, Francis W.
Truck efficiency graphically shown.
(Automotive industries, v. 38:33-36; Jan. 3, 1918) HU, LC, MIT, NY, UES.

Deesen, F. J.
The logarithmic chart in the analysis of railroad operations.
(Railway age, v. 67:570-71; Sept. 19, 1919) B, HU, LC, NY.

Dreyfus, Edwin D.
Graphic analyses of managerial problems.
(Electrical world, v. 68:710-12; Oct. 7, 1916) HU, LC, NY.

Durand, W. F.
Graphical methods for reduction of experimental observations.
(Sibley journal of engineering, v. 13:57-62; Nov., 1898) HU, LC, UES.

Durand, W. F.
The uses of logarithmic cross-section paper.
(Engineering news, v. 30:248-50; Sept. 28, 1893) HU, LC, MIT.

Engineers' study course. Curve plotting.
(Power, v. 39:315-16, 346-48, 385-86; Mar. 3, 10, 17, 1914) HU, LC, MIT, UES.

Estes, L. V.
Visualizing facts for control.
(Industrial management, v. 59:57-63, 127-33, 209-14; Jan.-Mar., 1920) HU, LC, UES.

Ewing, D. D.
Dissecting passenger interchange time graphs; in this article the author shows how an interchange time graph can be built up from simple elements and separates some actual graphs into their component parts.
(Electric railway journal, v. 52:610-12; Oct. 5, 1918) B, HU, NY.

Farnham, Dwight T.
How graphic control facilitates the fixing of profits.
(Engineering magazine, v. 52:16-22; Oct., 1916) HU, LC, MIT, UES.

Farnham, Dwight T.
Scientific versus intuitive administration.
(Engineering magazine, v. 51:849-54; Sept., 1916) HU, LC, MIT, UES.

Farnham, Dwight T.
Visualizing the essential facts of a business.
(Engineering magazine, v. 51:651-56; Aug., 1916) HU, LC, MIT, UES.

Farnham, Dwight T.
Visualizing the essential facts of a business.
(Cassier's engineering monthly, v. 50:331-46; Nov., 1916) LC, UES.

Field, James A.
Some advantages of the logarithmic scale in statistical diagrams... [n. p., 1917] cover-title, p. 805-41. diagrs. 8° B, HU.
Reprinted from the Journal of political economy, v. 25, no. 8, Oct., 1917.

Fisher, Irving.
The "ratio" chart for plotting statistics.
(Quarterly publications of the American statistical association, v. 15:577-601; June, 1917) B, BA, HU, MIT. HU and NY have separate.

Gehring, H. A.
Logarithmic diagrams based on isoplethe points.
(Engineering record, v. 61:77-79; Jan. 15, 1910) HU, LC, MIT, UES.

Gilbreth, Frank B.
Graphical control on the exception principle for executives.
(Journal of the American society of mechanical engineers, v. 39: 311-12; Apr., 1917) B, HU, MIT, NY, UES.
Presented at the annual meeting of the American society of mechanical engineers, Dec. 6, 1916.
Also in Scienitfic American supplement, v. 83:1888-89; Mar. 24, 1917.
Abstract in Iron age, v. 99:426-27; Feb. 15, 1917.

Gilbreth, Frank B.
Graphical control on the exception principle.
(Engineering and industrial management, v. 1:433-34; May 15, 1919) LC, NY, UES.

Gilman, Stephen.
Basis principles of graphic illustration.
(Personal efficiency, v. 6:12-13; Oct., 1916) B, NY.

Gilman, Stephen.
Graphic charts for the business man. Chicago, La Salle extension university [c1917] 62 p. 8° HU, LC, UES. 17-23819
———Another ed. 1918. NY.

Goldenweiser, E. A.
Classification and limitations of statistical graphics.
(Quarterly publications of the American statistical association, v. 15:205-09; June, 1916) B, BA, BPL, HU, MIT.

Goodwin, H. M.
Notes on graphical methods. Boston, 1904, 22 p. 8° MIT.
Printed for the use of students of the Massachusetts institute of technology.

A graphical method of recording data of boiler trials.
(*In* Cyclopedia of applied electricity, Chicago, 1905, v. 3, p. 391-96) BPL, MIT.

Graphics in maintenance work. Examples of graphical records of various kinds in modern electric railway practice, together with some generalizations based thereon.
(Electric railway journal, v. 46:947-51; Nov. 6, 1915) B, HU, LC.

Gray, F. W.
A graphical note-book.
(Mines and minerals, v. 31:332-34; Jan., 1911) LC, UES.
Explains a graphic method of recording data in connection with mining work.

Hall, Leo G.
Another method of constructing logarithmic charts for hydraulic formulas.
(Engineering and contracting, v. 44:31-32; July 14, 1915) HU, LC, NY, UES

Haskell, Allan Cecil.
How to make and use graphic charts . . . with an introduction by Richard T. Dana . . . 1st ed. New York, Codex book company, 1919. 539 p. 8° Agr., B. BPL, HU, LC, MIT, UES, 20-99.
Contains bibliographies.

Hele-Shaw, H. S.
The graphical method of solving engineering problems.
(Liverpool engineering society, Transactions, v. 14:173-88; 1893) LC, MIT, UES.

Hele-Shaw, H. S.
Second report on the development of graphic methods in mechanical science.
(British association for the advancement of science. Report of the 62d meeting, 1892, p. 373-531) BPL, HU, LC, MIT, NY, UES.
Appendix: Classified list of references to graphical methods: p. 433-531.

Hess, Henry.
A new development in cross-section paper.
(Proceedings of the Engineers club of Philadelphia, v. 25:153-80; Apr., 1908) HU, LC, MIT, NY, UES.
Discussion: p. 180-95.

Hess, Henry.
A useful industrial diagram.
(Mechanical engineering: the journal of the American society of mechanical engineers, v. 41:165-6; Feb., 1919) HU, LC, MIT, NY.
For showing output, etc.

Hibbard, H. Wade.
Graphical study of information.
(Western railway club, Proceedings, v. 22:300-19; Mar. 15, 1910) B.

Hildebrandt, R.
Graphische Darstellung der rentabilitäts verhältnisse von fabrikbetrieben.
(Technik und wirtschaft, v. 5:366-67; May, 1912) NY.

Holcroft, H.
The graphical representation of locomotive performance.
(Engineer (London), v. 125:353-55, 376-79; Apr. 26, May 3, 1918) HU, LC, MIT, UES.

Howe, Henry M.
Note on the use of the tri-axial diagram and triangular pyramid for graphical illustration.
(American institute of mining engineers, Transactions, v. 28:346-55; Oct., 1898) HU, LC, MIT, NY, UES.
Calls attention to the tri-axial diagram as a convenient means of illustrating the properties of slags, and commends it to those inclined to graphical studies, having other possible applications.
Discussion: p. 894-901.

Huhn, R. von.
Graphic analysis of an overtime problem.
(Industrial management, v. 57:86-88; Feb., 1919) HU, LC, NY, UES.

Huhn, R. von.
New graphical method for comparing performance with program or expectation.
(Science, n. s., v. 47:642-45; June 28, 1918) HU, LC, MIT, NY, UES.

Hummel, F. H.
Graphical solutions of certain problems in engineering.
(Practical engineer, v. 21:371-73; Apr. 20, 1900) HU, LC, MIT, NY, UES.
Abstract of a paper read at the meeting of the Society of civil and mechanical engineers.

Knoeppel, C. E.
Graphic production control. New York, Engineering magazine co., 1920. xxiii, 477 p., 8°. BPL, HU, LC, NY, UES. 20-3564
Reprinted in part from Industrial management, v. 56:177-80; v. 57:56-62, 113-18; Sept., 1918-Feb., 1919.

———Another edition [n. p., 1919?], various paging. HU.

Krulla, Rudolf.
Die graphische darstellung von mehr als drei komponenten und über logarithmische darstellung.
(Zeitschrift für metallkunde, v. 12:81-84; Mar. 1, 1920) NY.

Land, Frank.
A production chart for turned pieces.
(American machinist, v. 37:171-72; Aug. 1, 1912) HU, LC, MIT.

Lane, E. W.
System makes easy determination of empirical formulas; procedure laid down for use of logarithmic paper in finding equations for simpler experimental graphs.
(Engineering news-record, v. 79:554-56; Sept. 20, 1917) HU, LC, NY, UES.

Layng, J. F.
Keep graphic records of railway statictics; how the expenditures of each department can be checked against preceding years and their corresponding gross earnings.
(Electric railway journal, v. 51:9-10; Jan. 5, 1918) B, HU, LC.

Levasseur, E.
La statistique graphique.
(In Royal statistical society, London, Jubilee volume, June 22-24, 1885, p. 218-50) BPL, HU, LC. NY has separate.

Lewin, C. M.
Graphische statistik im dienste der fabrikorganisation.
(Zeitschrift fur werkzeugmaschinen und werkzeuge, v. 15:63-66; Nov. 15, 1910) NY.
Graphical charts in factory management.

Lindsay, C. E.
Efficiency in track maintenance.
(Railway age gazette, v. 52:1112-14; May 17, 1912) B, HU, LC, NY.
Graphical method for showing costs in maintenance work.

Lyon, Tracy.
Graphic methods as applied to railway records.
(North-west railway club, Official proceedings, v. 3, Jan., 1898, p. 8-17) B, MIT, NY.

Lyon, Warren A.
Procedure in logarithmic diagram plotting of hydraulic formulas.
(Engineering and contracting, v. 43:239; Mar. 17, 1915) HU, LC, MIT, NY, UES.

McCauley, W. J.
Solution of pulp problems by graphic methods.
(Engineering and mining journal, v. 100:98-100; July 17, 1915) LC, NY, UES.

Mailloux, C. O.
Notes on the plotting of speed-time curves. Followed by a general discussion of railway papers and topics, at the 19th convention of the American institute of electrical engineers, Great Barrington, Mass., June 19th, 1902. [n. p., 1902] p. 1035-1146. diagrs. 8° B, UES.
Also in Transactions of the American institute of electrical engineers, v. 19:901-1001; June 19, 1902; in Street railway journal, v. 20:51-54, 121-28, 199-203, 231-34, 254-57, 275-79; July 15, 26, Aug. 9, 16, 23, 30, 1902.

March, Lucien.
Les représentations graphiques et la statistique comparative.
(Journal de la Société de statistique de Paris, 43d year. 407-20; Dec., 1904) NY.

Marey, E. J.
La méthode graphique dans les sciences expérimentales et principalement en physiologie et en médecine. Paris, G. Masson [1878] 673 p. 8° HU, MIT.

Marshall, Alfred.
The graphic method of statistics. London, 1885. 10 p. 8° NY.
Read at the International statistical congress, 1885. Also in Royal statistical society, London, Jubilee volume, June 22-24, 1885, p. 251-60. BPL, HU, LC.

Martin, F. H.
The practical value of curves; the application of curves, charts and graphs to facilitate the analyses of engineering problems and statistical information.
(Electrical news, v. 25:28-31; Mar. 1, 1916) NY.

Marx, Guido H.
Isometric plotting of graphical charts.
(American machinist, v. 31:701-03; Nov. 12, 1908) HU, LC, MIT, NY, UES.

Merry, H. M.
Graphic metallurgical control.
(Bulletin of the American institute of mining and metallurgical engineers, No. 153:2313-21; supplement to Sept., 1919) LC, NY, UES.
Methods and records developed for use of executives of the Chino Copper Company in New Mexico
Abstract in Engineering and Mining Journal, v. 108:512; Sept. 20, 1919.

Moore, Joseph K.
Presenting facts graphically.
(Brick and clay record, v. 53:39-43; July 2, 1918) NY.

Morrisson, James W.
Making pictures of facts.
(System, v. 33:382-83; Mar., 1918) HU, LC, MIT, NY.

Müller, O.
Graphisches rechnen und die graphische darstellung; ein hilfs und lehrbuch für den unterricht an höheren schulen und gewerblichen lehranstalten, sowie zum selbstunterricht. Glauchau i. Sa., O. Streit [1913] 64 p. 8° HU.
"Die anwendung der graphischen darstellung": p. 51-64.

Munger, William P.
Keeping progress records.
(Railway age, v. 64:1075-76; Apr. 26, 1918) B, HU, LC, NY.
Records of engineering work.
Murphy, Carroll Dean.
Graphs that short-cut your work.
(System, v. 30:247-56; Sept., 1916) HU, LC, MIT, NY, UES.
Musyck, J.
Note on the drawing of the speed-time curves of electric trains.
(Bulletin of the International Railway Association, English ed., v. 2:581-90; Sept., 1920) B.
Parker, F. A.
Graphic comparisons of tonnage.
(Railway age gazette, v. 49:971; Nov. 18, 1910) B, HU, LC, NY.
Parker, R. W.
Graphic aid in figuring power bills.
(Electrical world, v. 67:1422; June 17, 1916) HU, LC, MIT, UES.
Patch, Dan.
Diagrams for cost of placing steel reinforcement.
(Engineering record, v. 74:264; Aug. 26, 1916) HU, LC, NY, UES.
Patch, Dan.
Predict labor demand before job is started. New use of progress charts combined with "bogey scores" makes it possible to tell where and why actual work varies from estimate.
(Engineering news-record, v. 79:684-87; Oct. 11, 1917) HU, LC, NY, UES.
Peddle, John Bailey.
The construction of graphical charts. New York, McGraw-Hill book co., 1910. 109 p. 8° Agr, HU, LC, MIT, NY, UES, 10-20827.
Originally published in the American machinist.
———1st ed., 2d impression, cor. New York, McGraw-Hill book co., 1910 109 p. 8° HU, LC. 15-15597
———2d ed., New York, McGraw-Hill book co., 1919. 158 p. 8° LC, MIT, NY, UES. 19-10098
The Pennsylvania railroad company's educational course conducted by correspondence.
Curve reading.
(Mutual magazine, v. 4:37-39; July, 1918) B.
Pigott, R. J. S.
Graphic methods of analysis in the design and operation of steam power plants.
(Journal of the American society of mechanical engineers, v. 38:947-53; Dec., 1916) B, HU, LC, MIT, NY.
Discussion: v. 39:16-17, 128-29; Jan., Feb., 1917.
Abstract in Power, v. 45:62-5; Jan. 9, 1917.
Polakov, Walter N.
Chart with which to make various records of coal.
(Electrical world, v. 70:911-12; Nov. 10, 1917) HU, LC, NY.
Rizer, F. W.
A graphic train sheet.
(Railway age gazette, v. 60:1549-50; June 23, 1916) B, HU, LC, NY.
Roberts, E. P.
The use and abuse of statistics, and pictures with punch.
(Journal of the Cleveland engineering society, v. 9:211-39; Jan., 1917) LC, MIT, NY, UES.
Robinson, E. W.
An office system for construction work, covering records of plans, progress and cost and bookkeeping methods.
(Engineering and contracting, v. 40:683-86; Dec. 17, 1913) HU, LC, MIT, NY.

Ruffner, Charles S.
Some practical applications of the principles of statistics.
(Journal of the Association of engineering societies, v. 53:264-80; Dec., 1914) HU, LC, MIT, NY, UES.
Read before the Engineers' club of St. Louis, Nov. 11, 1914.

Schlink, F. J.
Expenditure chart for executives.
(Industrial management, v. 55:192; Mar., 1918) HU, LC, NY, UES.

Schlink, F. J.
An improved progress-of-work chart.
(Journal of the Franklin institute, v. 185:697-701; May, 1918) HU, LC, MIT, NY, UES.

Schuyler, Mont.
War industries being brought under modern engineering control; use of progress chart by Ordnance department. . . .
(Engineering news, v. 80:323-25; Feb. 14, 1918) HU, LC, MIT, NY, UES.
Also in American machinist, v. 48:341-43; Feb. 21, 1918.

Seager, J. A.
Curves and their uses.
(National engineer, v. 19:137-39, 275-78; Mar., May, 1915) LC, NY.

Secrist, Horace.
An introduction to statistical methods. New York, Macmillan, 1917. 482 p. 12° BPL, HU, LC, MIT, NY, UES.
Graphic presentation: p. 193-233.

Secrist, Horace.
Statistics in business; their analysis, charting and use. New York, McGraw-Hill book co., 1920. IX, 137 p. 8° Agr, HU, LC, NY, UES. 20-4489
"Presenting the facts—Graphics": p. 55-96.

Simpson, Tracy W.
Notes on speed time curves.
(Street railway journal, v. 29:244-48; Feb. 9, 1910) B, NY.

Slifer, Hiram J.
Graphical daily records of performances of enginemen and locomotives.
(In International railway fuel association. Proceedings of the 9th annual meeting, 1917, p. 278-94) B, HU, UES.

Spidy, E. T.
Graphic production control.
(Canadian railway club. Official proceedings, v. 19:15-30; Jan., 1920) B, HU, MIT, UES.
Abstract in Canadian railway and marine world, No. 264:55-58; Feb., 1920; in Railway mechanical engineer, v. 94:227-30; Apr., 1920; in Railway review, v. 66:364-68· Mar. 6, 1920, with editorial comment, p. 383-84.

Squier, C. W.
Current and power curves show results to be expected of motors; the writer describes how current and power input graphs are derived from the speed-time and motor characteristic curves.
(Electric railway journal, v. 51:1134-36; June 15, 1918) B, HU, LC, NY.

Squier, C. W.
Effect of grades and curves in plotting speed-time graphs.
(Electric railway journal, v. 52:96-98; July 20, 1918) B, HU, LC, NY.

Starker, C. W.
Graphic control of production and cost.
(Industrial management, v. 55:306-10; Apr., 1918) HU, LC, NY, UES.

Stevenson, G. G.
Graphic use of logarithms.
(Machinery, v. 24:966; June, 1918) LC, NY, UES.

Stothart, E. C.
Graphs, charts and statistics as aids to administration.
(Electric railway journal, v. 46:665-67; Oct. 2, 1915) HU, MIT, NY, UES.

Strohm, R. T.
Curves of engineering data.
(National engineer, v. 18:749-51; v. 19:28-29; Dec., 1914, Jan., 1915) LC, UES.

Stronck, H. N.
The exception principle applied to graphic charts.
(Colorado school of mines magazine, v. 5:91-93; May, 1915) NY.

Swarts, Gardner T.
Drawing a picture of municipal business.
(American city, v. 21:39-44; July, 1919) HU, LC, NY.

Tarrant, Stanley C.
The graphic presentation of gas company statistics.
(Gas age, v. 39:13-18; Jan. 1, 1917) HU, LC, UES.

Tarrant, Stanley C.
Graphs that watch for danger points.
(System, v. 29:308-12; Mar., 1916) HU, LC, MIT, NY.

Tarrant, Stanley C.
6 simple ways to picture facts.
(System, v. 33:564; Apr., 1918) HU, LC, MIT, NY.

Tarrant, Stanley C.
Visualizing the vital facts.
(System, v. 26:665-67; Dec., 1914) HU, LC, MIT, NY.

Thorn, C. C.
Locating signals from braking distances. The effect of grades and curves complicates the problem, but a graphical chart reduces calculation.
(Railway signal engineer, v. 13:7-10; Jan., 1920) B.

Thurston, R. H.
Graphic diagrams and glyptic models.
(American society of mechanical engineers, Transactions, v. 19:514-50; June, 1898) HU, LC, MIT, NY, UES.

Twyford, H. B.
Picturing prices by charts.
(Factory, v. 16:573-74; June, 1916) HU, MIT, UES.

U. S. Central bureau of planning and statistics.
. . . Graphic presentation of statistical data. [Washington, Oct. 10, 1918] 20 p. 8° (Weekly statistical news, issued for information of government statistical agencies by the Statistical clearing house of the Central bureau of planning and statistics, No. 5.)
Report of Edmund E. Day, L. J. Reed and Horace Secrist, committee on graphic forms.
Originally mimeographed. NY has photostat copy.

Upton, S. B.
A system for plotting and cross-fairing results in lubrication testing.
(Sibley journal of engineering, v. 30:194-96; Mar., 1916) HU, LC, NY, UES.

Using graphs and statistics in business.
(In The library of business practice. Chicago, New York [etc.] A. W. Shaw co., c1914, v. 10, p. 151-200) HU, NY.

Van Zandt, J. G.
The interpretation of experimental data.
(Railway engineering and maintenance of way, v. 29:116-18; 254-56; Mar., June, 1914) B.

Waldo, Russell.
Use of charts in the employment department.
Machinery, v. 25:500; Feb., 1919) LC, MIT, NY, UES.

Warne, Frank Julian.
Chartography in ten lessons. Washington, D. C., c1919. 11 pts. 12° Agr, HU, LC, NY. 19-16604.

Warne, Frank Julian.
Elementary course in chartography; twenty lessons—seventy charts. Washington, D. C., c1917. 6 p. l., 70 numb.col. diagrs. f° LC. 18-369.

Warne, Frank Julian.
Warne's book of charts, a special feature of Warne's elementary course in chartography. . . Washington, D. C. [c1917] 2 p. l., 100 charts, f° Agr., HU, LC. 17-28210

Wenzel, John.
Graphic charts; the use of the logarithmic scale for charting statistics.
(Scientific American supplement, v. 83:236-37; Apr. 14, 1917) BA, HU, LC, NY.

Wenzel, John.
Graphic charts that mislead. Faulty constructions that obscure facts.
(Scientific American supplement, v. 83:380-81; June 16, 1917) B, BA, HU, LC, NY.

Wishart, James G.
Forms for complete rail and ballast records. A discussion of the advantages of the methods for keeping such information accurate and up to date.
(Railway age gazette, v. 56:378-81; Feb. 20, 1914) B, HU, LC, NY.

Woodruff, E. C.
. . . Graphic method for speed-time and distance time curves . . . [1914] p. 1689-92. 8° B, HU.
"To be presented at the 301st meeting of the American institute of electrical engineers, New York, November 13, 1914."
Also in American institute of electrical engineers, Proceedings, v. 33:1689-92; Nov., 1914. Discussion, v. 34:2804-46; Nov., 1915.
Abstract in Electric railway journal, v. 44:115-56; Nov. 21, 1914.

Woods publishing co., New York.
Report No. 11 on statistic and graphic charts. New York [c1908] 22 p. 4° HU.

Wyer, William.
Checking percentages by chart.
(Railway age, v. 66:1826-28; June 27, 1919) B, HU, LC, NY.
Percentage of change chart: p. 1827.
Also in Engineering and contracting, v. 52:80-81; July 16, 1919.

REPORT OF COMMITTEE XIX—ON CONSERVATION OF NATURAL RESOURCES

W. Forrest Ogle, *Chairman;*
E. E. King, *Vice-Chairman;*
F. T. Beckett,
F. A. Gaby,
C. M. Buck,
R. H. Howard,
Moses Burpee,
William McNab,
J. R. Caswell,
J. B. Myers,
O. P. Chamberlain,
J. L. Pickles,
J. B. Dawson,
S. N. Williams,
W. A. Duff,
R. C. Young,
C. H. Fisk,
Committee.

To the American Railway Engineering Association:

The following subjects were assigned the Committee on Conservation of Natural Resources for study and report:

1. Make thorough examination of the subject matter in the Manual, and submit definite recommendations for changes.
2. Make final report, if practicable, on reclamation of materials, submitting conclusions.
3. Make final report, if practicable, on tree planting, submitting conclusions.
4. Report on the conservation of human life and energy among engineering employees, conferring with the appropriate committee of the Association of Chief Railway Surgeons.
5. Report on progress of conservation in Canada.

Committee Meetings

Meetings of the Committee were held in Detroit, June 8th, and Chicago, October 5th. Names of members in attendance have been given in the Minutes of the meetings, which have been printed in the Bulletins.

(1) Revision of the Manual

It is the judgment of your Committee that the rules adopted last year for the prevention of the spread of forest and field fires are now in a good and condensed form, and need no revision. We are glad to report that several thousand copies of these rules have been requested by different railroads for distribution.

(2) Reclamation of Materials

In Appendix A your Committee submits its report, together with the methods and tabulated results adopted by several of the larger railroad systems. It also wishes to refer to the report of Division VI—Purchases and Stores, of the American Railway Association.

(3) Tree Planting and Reforestation

In Appendix B your Committee submits its study of this subject, and reports it as progress. It is the judgment of the Committee that there should be greater interest manifested by both State and Federal Governments in this subject, by enacting more lenient tax laws on growing timbers, and appropriations made for acquiring denuded lands, unsuitable for agricultural purposes, which should be reforested.

(4) Conservation of Human Life and Energy

In Appendix C your Committee submits its study of this subject, and reports it as progress.

(5) Progress of Conservation in Canada

In Appendix D your Committee submits its study of this subject, and reports it as progress.

Respectfully submitted,

THE COMMITTEE ON CONSERVATION OF NATURAL RESOURCES.

W. FORREST OGLE, *Chairman.*

Appendix A

RECLAMATION OF MATERIAL

R. C. Young, *Chairman;* J. B. Myers, R. H. Howard, Sub-Committee.

The results obtained in the reclamation of material by railroads are so well known and understood that it hardly seems necessary to restate the fact that "it pays." This report will therefore be confined to presenting typical examples of what has been accomplished along this line on a few railroads represented on this Committee. It is believed that this information will serve a useful purpose and stimulate still further interest in the reclaiming of scrap and material and thereby effect economy.

Wabash Railway

On this railway, during a period from August 19, 1919, to July, 1920, inclusive, new material costing $24,702.73 was reclaimed at an expense of $7,396.45, effecting a saving of $17,306.28.

These figures cover such track material as clawbars, lining bars, pinch bars, track chisels, track spikes, guard rail clamps, head rods, connecting rods, switch stands and targets, derails, etc.

The following is an illustration as to the accounting procedure:

(1) All material delivered to reclamation plant is accepted as miscellaneous scrap, whether it be tools, couplers, bolsters, switch stands, etc.

(2) Material in some cases is worked over into other items from its originality or it is repaired, or rebuilt by applying to new parts, etc.

(3) The cost of labor in repairing and assembling is charged direct to the particular item or material that has been handled.

(4) To the cost of labor is added the price of miscellaneous scrap used.

(5) To the cost of labor, new material and scrap also a pro rata charge is applied to the various items on percentage basis. This pro rata represents overhead charges, i. e., supervision, oil, power, light, telephone, and water. In other words, covering such expenses that cannot be accurately charged direct to any one item of material.

(6) Recapitulations of all charges are brought forward, which makes the total cost of reclaiming, we being allowed either current or contract prices for all material or, in other words, new value.

(7) The total cost of reclaiming any one item is deducted from the new value which leaves the net saving as compared with new value.

Atchison, Topeka & Santa Fe Railway

Details of the results obtained in the Corwith Scrap Reclamation Plant have been given in previous volumes of the Proceedings. Some additional interesting data is quoted below:

"If a switch stand can be repaired we allow credit to the division from which it came at the price of the new stand, giving the stand a symbol, and when it arrives on dock after going through shop it has been charged with time of each man's work and with the material used; then the office charges the division from which the stand comes with the actual cost of repairs, and by this method the division receives credit for the true value of the stand.

"All materials received are handled in this manner: frogs, switch points, guard rail and switch stands.

"If a frog is received that is good for nothing more than scrap, we allow credit for any parts that are serviceable, such as clamps, fillers and rods. Clamps at $3 each, cast fillers at $1.50, steel fillers at $3, and 25 cents each for the rods.

"We repaired

31 box stands at a cost of.....$4.13 each.	Total, $128.19.
6 low star stands at a cost of.$3.31 each.	Total, $19.87.
1 high star stand at a cost of.$6.84 each.	
32 switch stands at a cost of...$3.05 each.	Total, $97.95.

"The frogs would run in cost of repairs from $1 to $30. One new No. 10 90-lb. spring frog was repaired at 99 cents. The frog new is worth $103.70. Four No. 10 75 and 90 lb. spring frogs cost $82.24 to repair, or $20.56 each. These were above the average cost of repairs."

Baltimore & Ohio Railroad

The following is an extract from a report made to the Chief Engineer Maintenance on reclaiming repair rail by resawing:

"It has been the policy of the management to lay new rail out of face on important high speed passenger divisions and those carrying heavy traffic, renewing the worn rail, which is often of lighter weight, and relay the repair rail on branch lines where the passenger movement is less frequent and speed considerably lower, or on such branch lines where the traffic consists almost entirely of slow heavy freight trains. Therefore, in the relaying of these four different weights and sections, each has been assigned to some one branch line, consideration being given to the traffic over that line. In relaying this sawed-end rail on branch lines, it is laid with new bolts and bars. In resawing the rail, 15 inches is cut off each end of the rail. After the rail is sawed it is 30 ft. 6 in. long and is redrilled. When this sawed-end rail is laid on branch lines, as above detailed, the bad features of worn surface and line bent at ends and worn angle bars, which were always objectionable features to relaying rail, are entirely eliminated.

"When the relay rail arrives at the saw loaded in cars, the cars are placed on a siding back of the saw from which the rail is handled from the cars by a stiff leg derrick onto the skids. As the cars are made empty they are shifted to the siding in front of the saw, where they are loaded with finished rail.

"After the rail is unloaded on the skids, it is handled by the stiff leg derrick, above mentioned, with the assistance of four laborers, to the saw table. The rail is then sawed by friction saw, one end at a time. After both ends are sawed it is moved on rollers by hand to the double drill presses, where it is drilled. In drilling, the ends of four rails are drilled at one operation. The burrs are knocked off by the men handling the rail from the saw to the drill presses and at the drill presses.

"The organization used at the rail saw is as follows:

1 Foreman, in general charge of all work.
1 Engineer.
1 Fireman.
1 Sawman.
4 Laborers, handling rail from the skids to the saw. Of these four laborers one runs the air hoist, one handles either end of the rail, and the fourth handles the hooks.
2 Laborers, handling rail from the saw to the drill press skids.
4 Drill press men, handling drill presses.
4 Laborers, handling rail to drill press.
1 Laborer, straightening sawed rail in car.
Total, 19 men.

"During this calendar year there has been sawed a total of 499,137 feet of the four different sections, namely 85 A.S.C.E., 90 R.B., 100 R.B., 100 A.S.C.E. This represents the total number of feet of rail after it is sawed and drilled and is equivalent to a tonnage of 7,192 tons.

"In the sawing of the rail there was about 8 per cent lost and will be sold as scrap.

"The average cost of sawing this rail during the present year is $1.27 per ton. This cost includes all labor for unloading the rail at the saw; the labor and other direct costs incident to the actual operation of sawing the rail, and the labor cost of loading the rail into cars. This cost does not include the labor costs of loading the rail for shipment to the saw or the unloading of the sawed-end rail on the ground for laying. The loss on account of sawing off the ends of the rail or its credit when sold as scrap is not considered in the average cost previously given."

The Committee believes that the following report on welding cast manganese crossings will be of interest to the members:

"The welding of cast manganese construction and the service obtained under one year of traffic as demonstrated by the proposition warrants a considerable more extensive test of welding manganese frogs and crossings before they are worn to destruction. The damage to this crossing was rather unusual and the grinding out of the holes were deep and about 12 in. long. In actual maintenance, the wear on frogs and crossings is on the points and throats and usually is not over ½ inch deep at its maximum point. From the maximum near the points and throats the wear is reduced to zero, extending over a distance of 2 to 3 feet. The difficulty, therefore, of welding manganese is due to the manner of wear under ordinary maintenance conditions and the necessity of building up over a thin narrow surface which does not afford sufficient depth for proper bond to the original metal. Since the original welding as outlined in the report was done, experiments have been conducted on a manganese insert frog and a cast manganese crossing of about 60 degrees. In both cases the weld was not successful and spalled off after from 24 hours' to 7 days' service. It is felt, therefore, that while the welding under the conditions as outlined in the attached report was highly successful and maintained the crossing first for its normal life, it should not follow that this welding would be successful in prolonging the life of frogs and crossings of manganese construction which are worn under ordinary traffic loads. Until some method is discovered, therefore, which will permit a greater bond between the original metal and the weld, it is not recommended that the welding of manganese material be undertaken on a large scale. Experiments, however, will be conducted from time to time with a view of discovering a method of welding manganese which will be reasonably permanent."

Appendix B

(3) TREE PLANTING FROM RAILWAY STANDPOINT

But few roads own land on which to carry out any experiments in this line; but many roads traverse tracts of country which are not productive of any crop, and which, even where soil is unfit for agriculture, that might support a fair forest growth.

In a generally wooded country the reason for present unproductiveness lies probably in past forest fires; where if the original growth were heavy and furnished fuel for a strong fire, the soil has been burned too badly to recuperate until some years have elapsed. Yet frequently in the first or second year a heavy crop of firewood will be found, and soon thereafter the seeds of trees will germinate in the shallow layer of humas resulting from decaying woods and brakes.

Thus in a few years a new forest crop usually of alternate character will succeed the one which has been burnt off; for instance, a coniferous growth is likely to succeed a decidous one, and vice versa.

There does not appear to be any better method of reforestation than provided by nature. But it is possible to aid this method by protection, and possibly by thinning out the unlikely trees and encourage the best ones to quicker growth.

It is probable that artificial seeding in burnt over areas may not be entirely successful unless the natural humus has escaped destruction or serious injury. If, however, this be so, it is unwise to wait for natural results, but to seed the ground as soon as possible with the varieties which will soonest become the most valuable commercially.

The above does not apply to prairie country where of course tree planting is not handicapped by such destruction of soil by forest fires as may be the case in wooded country.

The impending shortage of timber with enhanced prices, and the failure so far to find a substitute for it in many of its uses, constitute a condition which at least demands serious consideration, and as railways always will be large consumers of timber as long as timber exists, they naturally view the situation with anxiety.

Railways are not only vitally interested in the timber supply for their own maintenance, but also in a very great degree in the amount of traffic which timber furnishes to them as carriers. It is fitting, therefore, that they should encourage and originate all possible means to maintain or increase forest growth.

In the majority of cases, however, railway companies have no authority in forestry matters. It is time, and we are glad to know it that the owners of wood lands are becoming more careful and more enlightened as to conservation of their properties, yet the problem of reforestation is scarcely getting the attention it deserves.

The problem of our Committee probably is to create greater publicity in this matter, and if there be found a degree of backwardness in the work or the plans necessary for reforestation to make such study of the subject as will enable it to bring these conditions to public notice, and create a sentiment favorable to the enforcement of intelligent and efficient methods of reforestation of waste or burnt over areas.

Such work as we may do would probably better be done or, indeed, can only be done, in co-ordination with the regular forestry organizations.

We give below in closing a quotation from a very valuable report of the State Forester of Maine, in which he points out the solution of the mainteenance of timber supply, viz., by Federal or State control of timber lands, or by purchase of burnt or heavily cut over land, where the necessary care is greater than private owners could give.

"When our forefathers lumbered they took only the very largest and best, which left quantities of seed trees and smaller growth. They did not do this with an idea of benefiting future generations, but lumber was plenty and the smaller trees were not in demand. But now with greatly increased demand for the smaller sizes, the pulp mills will even accept a mark of logs that will hardly average forty for a thousand feet, and portable mills, and even some permanent saw mills will not refuse lumber that is hardly more than poles and out of which they can saw but little more than a couple of laths between their slabs. Thus we are cutting much of our timberland so clean, taking little and big, crooked and seamed, everything no matter how small, that we are leaving practically no small trees to grow up and no mature trees for seeding and replenishing. And we are doing this not blindly but knowing full well that we are approaching the end of our soft wood supply, and that by our selfish and wasteful methods we will soon work great injury to the chief industry of our State."

"Federal or State ownership of timberlands, particularly of cut-over and neglected lands, is to be desired, and will in a great measure help to insure a future supply. On public reserves such forestry methods and regulations may be put into practice as it would not be practical for private owners to follow out. Private ownership must generally concern itself with some immediate return from timber investments. Interest charges and a heavy tax burden have a tendency to force the cutting of timberlands privately owned, while public ownership can defer the harvest until the most opportune time. Private ownership is always subject to change, while public ownership is permanent and a permanent forest policy can be carried through."

Tree Planting and Reforestation

In regions where there is sufficient rainfall for proper tree growth, the railways should plant on their waste grounds that are unsuitable for other cultivation, Catalpas, Scotch Pine, or other comparatively rapid-growing trees that are ordinarily free from insects and diseases. This growth of timber would assist in replenishing the supply necessary for ties, posts, poles, and other purposes of a similar nature. Experience has shown that the best results will be obtained at less expense by planting seedlings instead of sowing seed. The plantings should be done under the supervision of trained foresters.

The railways, together with State and Federal governments, should urge farmers and other land owners to utilize their waste, burnt over and cut over lands by planting trees. Co-operation in this way would furnish a large part of the timber required for buildings and roadway maintenance, for car construction and repairs, for paper used in various forms, and will materially aid in solving the fuel supply. Since they are such extensive users of forest products, the railways could well afford to have a sufficient forestry staff to help in carrying out a comprehensive planting program. The different states through their forestry officers could be called upon to assist in this work. By a series of demonstration lectures, newspaper articles and other publications, the land owners could be shown the benefits of such an undertaking, and could be taught the best methods of planting, growing and cutting timber and of protecting it against fire, insects and diseases.

Rough lands where the timber has been removed are being denuded of their soil by rainfall and their productiveness is being decreased. This is of vital interest to the railways, for most of them derive their incomes from the products along their lines. Many of the excessive floods that have brought much damage to railway property in recent years were aggravated by the lack of growing timber. Most of the trees that formerly grew along the streams and that checked the flow of water before it reached the streams and prevented much of it from getting to them at all, have been cut away. Wherever possible, these lands should be reforested to save the soil, to conserve the rainfall and to eliminate some of the damage from the floods.

The railways should plant trees along the right-of-way where there is difficulty with drifting snow, to eliminate snow fences. They should encourage land owners to plant trees for shelter belts where it is apparently not possible to get other plantings started at the present time. This would demonstrate what could be done in raising timber and would furnish for them a fuel supply.

The Lumber Situation

(From Circular of American Forestry Association.)

We are consuming lumber three times as fast as we are procuring it.

Experts predict our saw log lumber will be gone in fifty years.

The bulk of the original supplies of yellow pine in the South will be gone in ten years and within seven years 3,000 manufacturing plants there will go out of existence.

White pine in the lake states is nearing exhaustion and these states are paying $6,000,000 a year in freight bills to import timber.

New England, self-supporting in lumber twenty years ago, now has to import one-third of the amount used. It has $300,000,000 invested in wood and forest industries, employing over 90,000 wage-earners.

Fire destroys over $20,000,000 worth of timber every year and kills the reproduction upon thousands of acres of forest lands.

Within fifty years our present timber shortage will have become a blighting timber famine.

Forests can be protected from fire, regrowth can be encouraged, conservative cutting can be practiced, reforestation can be accomplished—but it takes from fifty to one hundred years to mature a timber crop.

Forest devastation must be stopped, lands now in forest must be kept continuously productive, forest lands now devastated and idle must be put to work.

Appendix C

(4) CONSERVATION OF HUMAN LIFE AND ENERGY

The subject of Conservation of Human Life and Energy is a lengthy one, and one in which the employers of labor should be very much interested. There could be volumes written on the subject, but as employers of railroad labor, we are especially interested in the prevention of sickness and accidents which result either in partial or permanent injury or death among our employees.

The quoting of statistics of man-hours lost through sickness and injury is almost useless, as we are all too familiar with these losses. You can, no doubt, recall instances of sickness which could probably have been avoided if the employee had had proper instructions as to the care of himself.

Several of the large railroad systems are now conducting a series of instructions to their employees in the proper ways of living and caring for themselves and families, and especially in connection with the prevention of malaria and typhoid fevers. They have also taken steps toward improving the living conditions of their employees, by the construction of more sanitary bunk houses and section quarters; extending and improving the sewerage system about the camps; providing better water supply; screening the living quarters against the house-fly and mosquito, and clearing and draining stagnant pools in the immediate vicinity. This, together with instructions for the care of the sick, and the necessity of cleanliness as a preventative, will show a decided gain in man-hours for the employer.

The "Safety-First" move has done much toward the prevention of injuries, both major and minor, and should be continuously advocated instead of periodically. We, as individuals, should school ourselves against the possible sickness and injury, and to remind our employees to do likewise. Railroads should not be afraid to display too many danger signs as reminders in and near their grounds and shops, and to impress upon all the necessity of prevention of injuries.

Foreword

An individual's life is his most precious asset, and cannot be measured in dollars; 82,000 lives were lost in 1919; 22,000 in industries and 60,000 in public accidents. Over 15,000 of these were children under ten years of age, our future labor supply. Over four-fifths of all accidents are preventable; 500,000 of the 38,000,000 wage earners in the United States were so seriously injured by industrial accidents in one year that they lost over four weeks of time, or were permanently disabled. Thus, 1,665 wage earners were seriously injured each one of the 300 working days. Personal carelessness was responsible for most of these calamities, and mania for high speed is the present plague.

Thousands of children die each year because parents do not protect them against colds or other diseases. Health department work is a preventative, and its value cannot be shown in dollars.

Importance of Right Eating

The stomach and intestines are the seat of 95 per cent. of all sickness, due to improper eating habits. Certain combinations of good foods will not mix properly in the stomach, but act and react chemically on each other, freeing quantities of gases and acids. Good foods rightly combined are the best tonic. The stomach is the furnace that converts the food into energy, which is used to reproduce all the elements of the body, keep its organs functioning properly, and cast off all its waste. Digestion and assimilation reconstructs the cells of the body, causing the reproduction of all its parts; hence, study of foods, their properties, and different effects upon the human system, will assist in developing both vitality and physical endurance, also ability to sleep or rest well.

Teeth

Dr. Percy Howe, of Boston, proves that dental decay is due to the lack of vitamines in one's diet, as the hard lime is partly removed from the teeth, leaving the spongy organic material. His conclusions from research work at the Forsythe Dental Infirmary, which cares for 90,000 school children unable to afford dental work done regularly and thoroughly, are that if the organs of the body are functioning properly, a blanched ration containing sufficient vitamines will keep the body in trim and develop the parts normally, including the teeth, which are an index to the general health. From 30 to 50 per cent. of the dental repair work could be eliminated by proper preventive care from two years up. He disproves the old theory that decay is caused by the fermentation of sugars and starches on the surface of the teeth, or by the formation of lactic acids. The deplorable dental conditions found in the schools merit serious consideration, especially from the age two to six. Dr. Harper, of Iowa, reports serious neglect of teeth among railroad men, which impairs them and interferes with their work.

Grade Crossings

Seventy per cent. of those killed or injured at grade crossings in a three-year period were motorists, and three times as many were killed in 1917, 1918 and 1919 as were killed or injured during the Revolutionary War; 6,600 casualties occurred in the principal battles, while 19,668 men, women and children were killed or injured during the three-year period, and 5,605 died within twenty-four hours after being hurt. In spite of the combined efforts of railroad and highway officials and automobile clubs, the total number of accidents continue annually at about the same rate, while deaths and accidents to motorists are steadily increasing each year.

For the six months ending June 30, 1920, 1,322 motorists were killed at grade crossings. One of the large railroads has already spent $66,000,000 in eliminating grade crossings, but it is estimated it will cost approximately $600,000,000 to wipe out the remaining 13,000 crossings. There are, however, thousands of grade crossings which could be eliminated by relocating the main highway and confining the bulk of the traffic to one side of the railroad. Not only should these be eliminated, but every possible effort should be made to protect the public from accident on existing crossings, and impress on the drivers of motor vehicles the necessity of extreme caution. Thanks are due the American Automobile Associations for their agitation on this subject.

Safety First

"The world does not need to be taught so much as to be reminded." Single solitary tragedies occur day after day with ceaseless regularity, and from apparently trivial little things that could have been corrected without any great effort on anyone's part. To prevent, observe and correct the unsafe conditions; report and take these up for correction promptly, and before some one gets hurt. Watch for and correct the fellow-employee who is seen in some specific unsafe act. Help create an atmosphere of safety among the great rank and file by personal effort—to do the latter thing they can correct and thereby obtain the best total results. "Safety First" should be taught at the family altar, in the public schools and in the churches. All of the important railway systems are continuing the work of accident prevention since their return to private operation. Some of the lines have actually enlarged the plan already adopted, and are pushing more aggressively. There is an apparent need to familiarize with the work of the National Safety Council, which is both educational and inspirational. Individual responsibility of officers and employees should be emphasized continually. Personal injuries and their causes should be investigated. Every road should have a representative in safety work at the meetings, as these are of the highest value.

Conclusion

In view of the transcendent importance to individual, family and associates, your Committee urges on members continuous, careful study of this entire subject, also faithful observance of all hygienic laws or directions which keep "Safety First" as a rule of action, and the indefinite prolongation of life as its great object. An able bodied person, trained in any useful activity, of steady and industrious habits, becomes the most valuable agent known for promoting the world's progress and prosperity. The essentials of good health, long life and happiness cost nothing.

Appendix D

(5) PROGRESS OF CONSERVATION IN CANADA

Lands

A Soil Fertility and Soil Fibre Conference was held at Winnipeg last July in connection with the semi-annual meeting of the Commission of Conservation. The subjects discussed included the prevention of soil drifting, the analysis and classification of soils, the maintenance of soil fibre by crop rotations and growing of legumes, the retention of moisture by suitable cultivation and the eradication of weeds. Many noted soil experts were present and their papers and findings will be embodied in a report which is now in press. An important "Dry Farming Conference," under the auspices of the Saskatchewan government, was held at Swift Current in June.

Sound precept is valuable, but practical demonstration is more convincing. To prove what *can* be done, the Commission of Conservation of Canada is carrying on illustration work in the county of Dundas, Ont. Two or three new horticultural societies have been established, the teaching of agriculture in the public schools has been encouraged, school fairs organized and improved methods of tillage demonstrated in a practical way on private farms run for profit,—not on experimental farms owned by the Government. The results of this work have been gratifying and have resulted not merely in better farming methods but in a better community spirit and a better appreciation of the worth of rural life.

Forests

That the forest is a crop, not a mine, ought to be an axiom, yet it is an idea that has only won very slow acceptance and even now is more ignored than recognized in practice. But, now that the forests of the United States, originally much vaster than those of Canada, have reached a serious stage of depletion in the east and south, the demand upon the woods of eastern Canada has become particularly heavy and the necessity for the practice of forestry is becoming more and more apparent.

There are two things which it is imperative to know before forestry can be established on a sound basis. These are: (1) the amount of standing timber and (2) the rate of reproduction. The Commission of Conservation of Canada has applied itself to collecting data on both these subjects. In other words, its investigatory activities have been applied to inventories and growth studies. A survey is now being made of the forest resources of Ontario along the same lines as the British Columbia survey, recently completed. In connection with this work, the co-operation of the Air Board has been obtained and seaplanes have been successfully used in the mapping of forest areas. It has been found quite feasible to distinguish hardwood from coniferous forests and to mark tracts of virgin forest, second growth, burned areas, swamps, etc., from the air. An observer in a plane can thus in a few hours gather preliminary data which it would take weeks of arduous travelling to obtain upon the ground. Of course, the results of aerial observation must be supplemented by ground surveys. The function of the 'plane is reconnaissance; by its aid a general classification of the various types of country can be carried out. The cruisers can then go direct to the timber and make their estimates of the density of the stands and observe the percentage of the various species. Wherever cruises have already been made, whether by private companies or by the Provincial authorities, an endeavor is made to obtain the information available and it is generally cheerfully given. Thus, the inventory of Ontario's forest resources is partly a task of original observation, but largely—and necessarily—a work of compiling data now very much scattered and unavailable to the legislator and administrator.

The growth studies are being carried on chiefly in Ontario, Quebec and New Brunswick, with the co-operation of various pulp and paper companies. Sample plots have been established in one district on which the position of every tree has been noted and marked on the maps. The progress of each tree will be noted from year to year and thus the rate of growth and the mortality due to fungous diseases, insect enemies, etc., can be determined. By comparison with control plots, the effects of various changes in conditions can be studied.

In another region, investigations were undertaken with a view to organizing a tract of land for continuous production. The foresters followed the logging operations and made growth and volume studies on 2,500 spruce and balsam as the trees were felled. By these stem analyses the growth of the trees during every decade of their life was ascertained. Using these data as a basis, volume tables can be constructed for timber estimates and for predictions of yield. A careful enumeration was also made of the young growth on logged-over areas. It is too early as yet to publish definite results of this investigation, but enough has been done to show the great value of young stands. Once the small saplings are released from the shade of the larger trees, they make very satisfactory growth and a second crop of merchantable timber may confidently be looked for, provided fires can be kept out. This applies particularly to purely coniferous stands; in mixed stands, the hardwoods make quicker growth and kill out the young softwoods so that a culled area of this type takes on the aspect of a purely hardwood tract.

Power and Fuel Problems

There is now available in published form a complete inventory of the water powers of Canada, giving their situation, head, stream flow data, etc., being altogether a compilation of great value to engineers, manufacturers, public authorities and others interested in hydro-electric developments. The latest report on the subject is "Waste Powers of British Columbia," published by the Commission of Conservation in 1919.

Canada's vast resources of water power should not, however, blind us to the importance of power developed from coal, natural gas and other fuels. In a province like Alberta, for instance, these sources are of prime importance, for the coal fields are convenient and of wide extent, while water power is not particularly abundant. Mr. James White, Deputy Head of the Commission of Conservation, has made a special study of the power and fuel situation of the Prairie Provinces, and the analysis of the situation has been published in two recent pamphlets, "Power in Alberta" and "Fuels of Western Canada," in which is emphasized the importance of the proper conservation of our resources of coal, gas and oil. A pamphlet on "Pulverized Fuel" has also been published in which it is shown how the low-grade lignites and bituminous coals can be utilized by reducing them to a very fine dust so that they can be burned in a manner very similar to a gas. Thus coals which are too soft to stand transportation for ordinary use can be made of service for power development.

Fire Waste

Notwithstanding the propaganda directed by the Dominion Fire Prevention Committee, the Ontario Fire Prevention League, the Commission of Conservation, the fire marshals or fire commissioners of the different provinces and others interested against the appalling destruction by fire in Canada—the highest per capita losses in the world—this form of waste shows no reduction and is, if anything, increasing. Yet the situation should not be given up as hopeless, for this much too high degree of loss is not inevitable. Better buildings, sane precautions and, above all, greater care, will eventually reduce it to reasonable limits. No effort should be slacked to bring this desirable result about.

Reclamation

The waste paper campaign is continuing with growing vigor. The schools all over the country are awaking to the value of paper collections and by this means are financing various schemes to buy libraries, sporting equipment, etc. The Commission of Conservation has received numerous inquiries as to the best means of marketing. The one drawback is the high freight rates, which leave little profit if the point of collection is far from the nearest paper mill.

Town Planning

For a new country, Canada has suffered severely and needlessly from haphazard city growth and from failure to exercise foresight in the control of areas in process of conversion from rural to urban uses. The Town Planning Branch of the Commission of Conservation has recently devoted serious study to this problem and a report on "Regional Planning" will probably be published some time in 1921.

Several important cities are now taking advantage of the town-planning acts enacted by the various provinces. Ottawa is the latest to join the movement and will probably seek the co-operation of the Dominion and Ontario Governments in establishing a zoning system and a scheme to provide for the future orderly growth of the national capital.

MONOGRAPHS

NOTE ON RAIL INCLINATION

AND

STANDARDIZATION OF TRACK APPLIANCES ON RAILWAYS OF FRANCE

By W. C. Cushing

Engineer of Standards, Pennsylvania System

For some years the railway engineers of the United States have given consideration to the canting or inclination of rails in track in order to furnish an axial bearing in conformity with the one in twenty inclination of the wheel treads of rolling stock, but have not yet adopted the practice on account of certain difficulties to be met, although some roads lay rail in that way under certain conditions.

It has seemed to American engineers that canting of the rail should be accomplished by an inclined surface of the tie plate, which would require plates on every tie, a practice which is not general in the United States, although it is becoming pretty nearly so on the large heavy-traffic systems and the practice is increasing owing to the greater necessity for the use of cross-ties of inferior wood treated with preservative fluid.

Another principal difficulty in the way has been the inconvenience and trouble of maintaining rail inclinations through turnouts and crossings without adopting the make-shift plan of torsion in the rail before reaching the turnouts and crossings so as to maintain the rails vertical through them.

In order to ascertain how this latter problem was handled by the European railways where rail inclination practice has been almost universal for many years, the writer addressed letters to the engineers of several railways in England and France, and presents herewith a brief memorandum of the practice showing that there is difference in taking care of the problem by the several companies. The writer is much indebted to these engineers for their careful answers to the questions, accompanied by many drawings in detail of the appliances used by them.

In the reply from the Chief Engineer of Works and Inspection, Compagnie du Chemins de Fer du Nord, I was quite surprised to read the following:

"I add that the large railway systems of France have just reached an agreement on new sections of rails which will be, for the future, placed vertical contrary to present practice.

"It follows that in the track appliances (switches, frogs and crossings) the different elements of these appliances shown herewith (switches, rails opposite switches, centers of frogs and points of crossings) will be placed vertical likewise."

This information was so unexpected that I addressed another letter to him asking if I was to understand from the latter part of his letter that there was a movement on foot with the larger railway systems of France to do away with the inclination of rails through turnouts, crossings, etc., and make them vertical instead, and if such was the case I would like to know the reasons for the proposed action and whether the French engineers were beginning to consider that the inclination of rails, one in twenty, was unnecessary refinement. I received a prompt confirmation of the former statements in the accompanying letter.

Inclination of Rail Through Turnouts and Crossovers
English and French Practice in 1920

Railroad	Running Rail Type	Switches	Turnout Frogs and Crossings
London & North Western Railway.	Bull Headed	Stock Rail inclined 1:20. Switch Rail vertical from point to separation, then twisted to incline heel and 1:20.	Single Frogs "V" rails vertical from point to separation, then twisted to incline heel end 1:20. Wing Rails inclined 1:20. Double Frogs wing and tongue rails inclined 1:20—guard rail vertical.
Great Eastern Railway.	Bull Headed	Stock Rail inclined 1:20. Switch Rail inclined 1:20.	Single Frogs all rails vertical from throat to separation of "V" rails, then twisted to incline heel and toe rails 1:20.
Lancashire and Yorkshire Railway.	Bull Headed	Stock Rail inclined 1:20. Switch Rail inclined 1:20.	Single Frogs all rails inclined 1:20 except portion of "V" rail between notch and point, which is vertical.
Chemin de fer de Paris a Orleans.	Bull Headed	Stock Rail inclined 1:20. Switch Rail inclined 1:20.	Single Frogs, bolted rail construction—"V" rails vertical from point to separation, then twisted to incline heel and 1:20, all other rails inclined 1:20. Cost construction—solid castings designed to provide connection with running rail inclined 1:20.
Chemin de fer de Paris a Lyon.	Not Mentioned	Stock Rail inclined 1:20. Switch Rail vertical. Special material used at heel to connect with inclined running rail.	Single and Double Frogs all rails vertical through main body of frogs and arms twisted to incline 1:20.
Chemins fer du Nord.	"T" section symmetrical "T" section base horizontal and web inclined 1:20.	Stock Rail "T" section, symmetrical, on plates which provide an inclination of 1:20. "T" section with inclined web placed on horizontal plates. Switch Rail in all cases made from special section with horizontal base and web inclined 1:20.	Single and Double Frogs made of rails, "T" section, symmetrical, with webs vertical in assembled portion of frog and twisted to incline arm ends 1:20.

Chemins de fer du L'Etat.	"T" section symmetrical Bull Headed	STOCK RAIL in all cases inclined 1:20. SWITCH RAIL "T" section, vertical. The running rail back of heel of switch twisted to 1:20. Bull headed section stock rail a special "T" section switch rail with base horizontal and web inclined 1:20 is used.	SINGLE FROGS "T" rail and bull headed rail. "V" rails vertical from point to separation, then twisted to incline heel end 1:20. All other rails inclined 1:20. Double Frogs same as above.

(Translation of letter from Compagnie du Chemins de Fer du Nord, Paris, France—September 22, 1920)

MR. W. C. CUSHING,
Engineer of Standards, Pennsylvania System,
Broad Street Station, Philadelphia, Pa.

Dear Sir:

In reply to your letter of July 28th, 1920, relative to the inclination of rails, I have the honor of confirming the statements of my letter of July 13th last, informing you that for the future in the case of the large railway systems of France, the rails, both of the running track and the track appliances, will be placed vertical.

With the rails vertical, the vehicles are as easily brought to the axis of the tracks as with the rails inclined, and on the other hand, the resistance of fastening by screw spikes of the vertical rail on ties of hard wood is also satisfactory.

The suppression of the inclination of one in twenty has been judged so much the more desirable because from the point of view of maintenance, there results greater facility for the performance of adzing in place of worn cross-ties and for the boring of holes for screw spikes and because, moreover, the construction of track appliances is rendered more simple by this suppression; finally the dapping to be obtained in the cross-ties being smaller than in the case of one in twenty inclination, their resistance will be increased.

Yours truly,

L'INGENIEUR ON CHEF
DES TRAVAUX ET DE LA SURVEILLANCE.

Since then the final action in connection with this subject has been given by the authorities and an abstract of the decision has been issued in Revue Generale des Chemins de Fer et des Tramways for November, 1920—No. 11, in the form of a note on the Standardization of Track Appliances for Railways of France—by M. Froebé, Engineer of Railway Plant of the State Railways, of which the following is a translation:

"The unification or standardization of track appliances on the railways of France was considered in July, 1917, in the course of a conference held by the Minister of War, at which the Directors of the large systems assisted.

"The Chief Engineers of the Permanent Way being consulted, decided in their conference of August 18, 1917, to entrust the detailed study of the question to a commission composed of the Engineers of Railway Plant; this commission convened for its first meeting on the 18th of September following.

"It considered at first the adoption of an American rail in its entirety, but after examination this rail was laid aside as not conforming to our type of laying, by reason of the small thickness of the extremities of the base. In fact, in France the cross-tie is slightly dapped to receive the rail and the shoulder of this dapping is counted on for the maintenance of the track gage; it is a matter of interest, therefore, not to have a base with cutting edges.

"In the American laying, the bases are supported laterally by large driven spikes, giving more resistance than our screw spikes in the transverse direction.

"After the study of numerous sections the Commission proposed to adopt three types of rails.

A type of 36 kilograms (figure 1) for the normal tracks of light traffic;

A type of 46 kilograms (figure 2) for the normal tracks of heavy traffic;

A type of 26 kilograms (figure 3) for narrow-gage tracks.

"The three types accepted by the Chief Engineers of Permanent Way, then by the Zone Committee, were presented to the Minister of War, who by letter of August 6, 1918, agreed to the recommendations accepted by the six large systems, and in a dispatch of the 19th of May, 1919, ratified the agreement.

"The three adopted types differ from the present rails by the inclination of the joint bearings, the thickness of the web and the dimensions of the base.

"These differences are explained below:

Joint Bearings

"The old rails of iron had an inclination of one in one for the joint bearings; this inclination, advantageous so far as rolling was concerned, offers inconvenience from the point of view of the work imposed upon the joint bar bolts.

"In fact, upon the passage of trains, the head of the rail becomes a wedge between the two joint bars and tends to spread them by a considerable force, which has to be resisted by the bolts. The more the inclination of the joint bar bearing is lessened the smaller is the force resisted by the bolts.

"When the manufacture of steel rails was commenced in France, the inclination was reduced to one in two. In foreign countries it has generally been placed at one to four.

"It is quite evident that with a slight inclination the rail is better supported. On the contrary, the inevitable wear which is brought about on the bearing surfaces of the joint brings the joint bars more nearly to their final seat. After comparative examination the French systems have adopted the inclination of one to four for the joint bar bearings.

Thickness of Web

"It has been the custom for some time in France to have a small web thickness; the metal there is harder and more brittle than in the head and base, and the fractures accumulate frequently in the holes of the joint bars.

"In foreign countries certain systems have adopted an arched web, thin in the portion next to the neutral axis, and thicker near the head and base; it is this arrangement, facilitating the rolling, which has been adopted for the French standard.

Dimensions of Base

"The old French rails have quite a narrow base. In the American rails, on the contrary, the width of the base is equal to the height of the rail. It is certain that the wider the base the better is the seat for the rail, but the rolling is more difficult.

"The French lines have adopted a mean between the two plans. It is fitting besides to remark that with screw fastenings it is not necessary to have as wide a base as with the spike, generally employed in the United States, for screw spikes have greater resistance than driven spikes to extraction.

"So far as the thickness of bases at their extremities is concerned, a thickness of 10.55 millimeters for the rail of 46 kilograms has been adopted and 10 millimeters for the rail of 36 kilograms, which results in giving to the upper part of the extremity of the base a different inclination from that of the bearing of the joint bars.

Tunnel Rails

"Independently of the three ordinary types of rails of 26 kilograms, 36 kilograms and 46 kilograms, the systems have likewise adopted a type of rail of 55 kilograms (figure 4) reserved for tunnels.

"The rails placed in tunnels are in fact submitted to action of moisture and of vapors and of gases which remain in these places, and they deteriorate rapidly and their service is short.

"To remedy this difficulty a reinforced rail has been provided which differs principally from the preceding types by a super-thickness of about 5 millimeters in the head and in the base. The web is straight and not arched and its thickness is uniformly of 19 millimeters. The joint bars of this rail will be the same as the joint bars of rails of 46 kilograms.

Position of Rails

"The standard rails will be laid vertically as is the practice in America and Belgium in place of being laid with the inclination of one in twenty, practiced in France to this day.

"It results from the information furnished by the American engineers that this position offers no difficulty, besides it is advantageous for the junctions with the appliances.

"The appliances (joint bars, bolts and screw spikes) corresponding with the standard rail are described as follows:

Joint Bars

"Numerous types of joint bars have been successfully tried on the different systems with the view of improving the old joint bars composed of two simple flat plates adapted to the rails.

"There have been employed joint bars with the base fixed on the ties, angle bars of different forms, and, for the rails with double head, supported joints with bars of large dimensions forming a chair and fixed on the ties of the opposite joint, joint bars type P. O., whose long splices are held in the chamber of the chairs by steel wedges.

"These different plans having offered but little advantage over the flat bars, above all since the adoption of laying the cross-ties of the opposite joint as close as possible, we have returned to the latter (figures 5 to 7) in the course of the study of standardization.

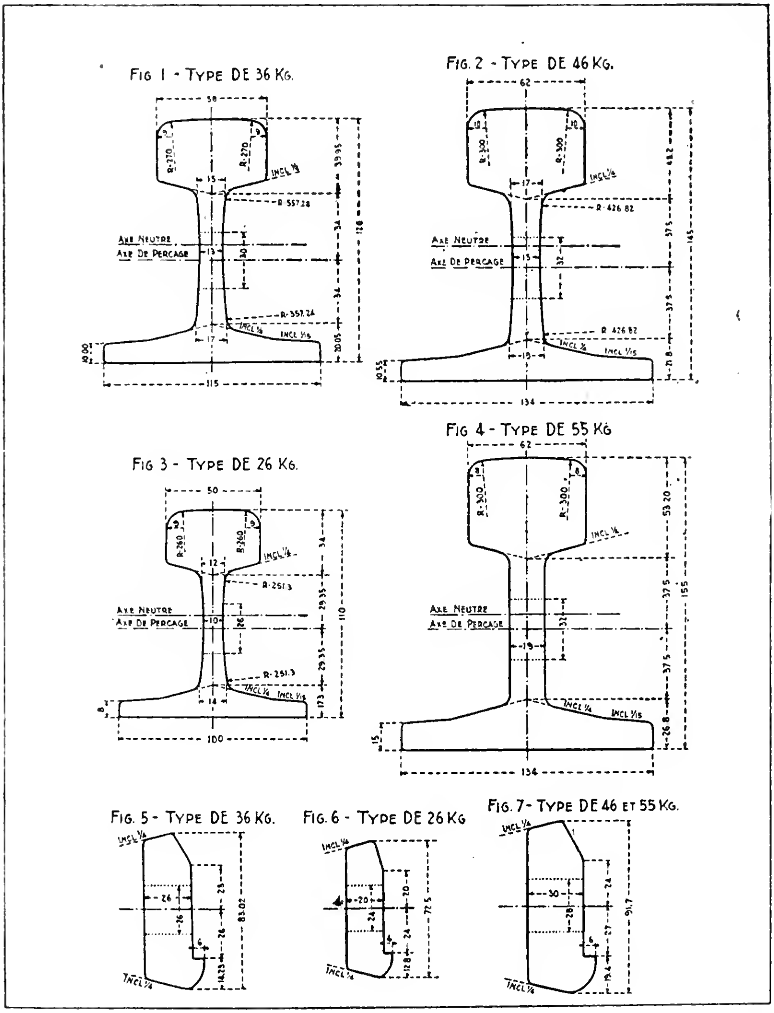
"At the same time the customary thickness has been increased and a distance of 0.420 meters, center to center, has been adopted for the spread of the cross-ties of the opposite joint.

Bolts and Screw Spikes

"The bolts have been provided with diameters of 24, 22 and 20 millimeters for the rails of 46, 36 and 26 kilograms, and the diameters of the holes of the rails corresponding, are of 32, 30 and 26 in order to permit the free movement of the rails.

"So far as the screw spikes are concerned, only two types have been arranged for in order to simplify the arrangements:

"One of a diameter of 26 millimeters will be employed for laying rails of 46 and 36 kilograms and the other a diameter of 23 millimeters for laying rails of 26 kilograms."



SUPPLEMENTAL NOTE ON RAIL INCLINATION

AND

Standardization of Track Appliances on Railways of France

By W. C. Cushing
Engineer of Standards, Pennsylvania System

Since writing the note on page 943, the report of the Commission of Engineers has been reviewed in Le Génie Civil (T LXXVIII—No. 22, May 28, 1921, page 458), at the close of which quotations are given from a very interesting letter from Mr. J. A. L. Waddell. In order to show the connection clearly, the following translation has been made from the article:

"On the subject of the position of the rails, M. Froché thus states the decision of the Commission:

"'The Standard rails will be laid vertically, as is the practice in America and Belgium in place of being laid with the inclination of one in twenty, practiced in France to this day. It results from the information furnished by the American engineers that this position offers no difficulty. Besides, it is advantageous for the junctions with appliances.'

"The reasons which have led the French engineers to supersede this arrangement, practiced, however, for a very long time, are then relative to the simplification of the laying. Notching the ties to form the seat for the rail would be avoided, and, further, the junctions with the appliances, frogs, switches, etc., should be easier.

"The necessity for notching the ties to form an oblique seat is evidently a complication, while at the same time it weakens to a certain degree the resistance of the pieces of wood from which the ties are made. It involves a work called "adzing," that is the preparation of the seat for the base of the rail, which is not negligible, above all under actual conditions, for which besides special automatic machines, called adzing machines, have been invented, as already described in *Le Génie Civil.**

"One of the arguments on which the Commission relied for adopting its decision is based on American practice, in which inclination of rails is avoided, probably counting upon the reciprocal abrasion of the rail-head and of the wheel-tread to form a rolling surface with maximum inclination.

"Now, it seems, according to the information which has reached us, that this practice has been abandoned on numerous American lines, and that many engineers of the United States see progress, on the contrary, in the inclination of one in twenty, the general adoption of which is desirable. In fact, we have received from Mr. J. A. L. Waddell, the well-known American engineer, membre correspondant de l'Académie des Sciences, a letter with the object of calling the attention of the French railway engineers to this question, the decision of the Commission having aroused a degree of astonishment among the American railway engineers.

Mr. Waddell cites the authority of Mr. W. C. Cushing, Engineer of Standard of the Pennsylvania System, on this subject. That engineer published in the Bulletin of the American Railway Engineering Association of last March an article in which he comments upon the modification proposed by the French Commission, which seems to him a renunciation of very real progress.

"After having spoken in his letter of the facts which we have just reviewed, Mr. Waddell thus expresses himself:

"'It follows from what precedes that the French engineers admit that the change from the scientific practice of the inclination of the rail is the result of information furnished by American engineers. What American engineers have furnished information the consequence of which leads to the adoption of a backward step in the scientific practice of railway construction? Have those engineers personally observed inclined rails, and in what place? I have followed very closely the adoption of the inclined rail in the United States and Canada, where more than 3,000 miles (4,828 Kilom.) have now been installed, the greater part in the last five years; these rails afford entire satisfaction from the point of view of wear, of preservation of the ties, and of reduction in cost of maintenance of way. This reduction is principally due to a new American method of preparation of the ties for receiving the supporting tie plates, by which the fiber of the wood is not even lightly injured by the setting of the plates; these plates maintain the gauge rigidly, being held by square spikes, the employment of screw-spikes offering no advantage in the case of such plates.'

"'It seems very strange that the French engineers accept the statements of some American engineers on the question of vertical rail and decide to return to a primitive method of placing rail, instead of defending their own scientific methods. If the French railway engineers should desire to probe the statements of the American engineers in question, they would doubtless find out that these statements arise from the fact that those American engineers have not had any experience with the rail inclined, and have only extolled the employment of upright rail because their fathers and their grandfathers have always employed this primitive method of placing rails.'

"'The summation of this question appears to be a real scientific pleasantry: the French engineers are persuaded to abandon their scientific method of placing the rail inclined, whilst in America, on the contrary, this practice is being extended very rapidly with the greatest satisfaction.'

"It is beneficial to quote this authoritative opinion of an American engineer well versed in the construction of railways in his country. Doubtless it should not be too late to study the question anew before renouncing an arrangement which competent engineers in America consider as an important improvement.

"Nevertheless, it is not unprofitable to remark that the alteration of orientation of American practice, which Mr. Waddell points out, is relatively small; it affects scarcely more than 5,000 kilom. of tracks in a total of 400,000 kilom. It must be admitted that the American practice of wide extent has not indicated any grave inconvenience due to the verticality of the rail; however, the American engineers do not generally use either the plate or the screw-spikes, which the French engineers consider the best complements of the Vignole rail.

"Besides, it is probable that the French companies, as well as the P.-L.-M. Company, which use the plate which inclines the rail, will continue to do so without change; the vertical rail will be used principally on lines of light traffic having hardwood ties. The softwood ties, pine or spruce, will probably be provided as yet with the plate or chair which provides for the inclined rail." P. C.

*See *Le Génie Civil* of 21st March, 1903 (t. XLII, No. 21, p. 321).

RAIL LAYING WITH LOCOMOTIVE CRANES AS PRACTICED ON THE LEHIGH VALLEY RAILROAD

By W. C. Barrett, Trainmaster, Lehigh Valley Railroad

For several years it has been the practice on the Lehigh Valley Railroad to lay all rail with locomotive cranes.

This method was developed by the Lehigh Valley Maintenance of Way forces, and has proven a decided success, and economical both from a labor standpoint, and also from the standpoint of transportation delays incident to rail laying. By the use of locomotive cranes several track miles of rail can be laid in one day and the total delay to trains will be less than if several days were used for the same work and all trains stopped and more or less delayed each day.

With the heavy sections of rail in use at the present time, the labor required to handle it by hand is almost prohibitive. The locomotive crane does the heavy lifting and thereby relieves the laborers for other lighter work.

A typical outline of the organization used for rail laying with a locomotive crane is given below:

1 Supervisor of Track—in general charge.
1 Foreman—20 men—pulling spikes.
1 Foreman—10 men—adzing, driving tie plugs and placing tie plates.
1 Foreman— 6 men—throwing out old rail and laying new rail with crane.
2 Foremen—15 men—gaging and driving quarter spikes.
3 Foremen—30 men—putting on joint bars.
3 Foremen—30 men—driving spikes.
2 Foremen—15 men—putting on anti-creepers and shimming where necessary.
1 Foreman— 7 men—drilling for bond wires with pneumatic drills.
1 Signal Supervisor or Assistant in charge of signals and bonding.
1 Signal Maintainer and one helper renewing signal wires and connections.
1 Foreman—4 Signalmen—bonding.
Total—18 Foremen—138 men.

This organization and number of men will keep the locomotive crane working practically continuously, and will enable it to lay from 100 to 150 rails per hour. The crane can be worked with any number of men from ten up, as it requires but six besides the operator to place the new rail. Very good progress can be made with 50 men, and more rail can be laid with this number of men, using the locomotive crane, than can be laid by hand with the same force.

Referring to the photographs, Fig. 1 shows the crane throwing the old rail out, ahead, and Figs. 2 and 3 show the method of placing the new rail, one at a time, ahead of the crane. Fig. 4 shows the men fastening the rail with a spike at each end and one in the middle, and the crane moving ahead so as to lay the next rail. Fig. 5 shows the bonding outfit, consisting of pneumatic tie tamper and four pneumatic drilling machines boring the holes for bonding. Seven men, including the tamper operator, handle this outfit and distribute the bond wires. No. 6 shows the drilling outfit moving ahead, after drilling four holes, or two joints, to the next two joints.

It is desirable to have two cranes laying when there is any number of miles of track to lay, having two organizations and each crane and organization laying one rail—the second crane working far enough behind the first so as not to interfere with each other. When only one crane is used, one rail is laid and the crane backs up to the beginning point and then lays the second rail in the same way as the first. The work of placing joint bars, full spiking, lining, placing anti-creepers, bonding, etc., is done behind the crane. The organization outlined will keep this work up so closely that in from 15 to 30 minutes after the crane has finished laying the rail, the track is ready for service. On a busy single track, main passenger line, of the Lehigh Valley, two cranes laid 565 rails in two hours and thirty minutes, from the time the track was broken until it was connected, and the automatic signals were in service again.

A recent development has been the use of pneumatic tie tampers to operate pneumatic drilling machines for bonding. One tie tamper operates four machines and one outfit will usually keep up with two locomotive cranes. However, where the cranes have a good opportunity to lay rapidly, it is desirable to have two drilling outfits, so as to avoid the possibility of delay when closing up at the end of the job.

By the use of the locomotive crane for laying and the pneumatic drilling machines for bonding, the heavy work is taken off the men, and rail laying is no longer the hard task it formerly was. The men like the new scheme and it means better working conditions, better satisfied men, and at the same time greater efficiency and decreased cost.

Since the foregoing article was written it has been found possible to operate the air compressor continuously and at the same time move the car under its own power from joint to joint, thereby eliminating the necessity of pushing the car by hand.

FIG. 1—CRANE THROWING OLD RAIL OUT, AHEAD.

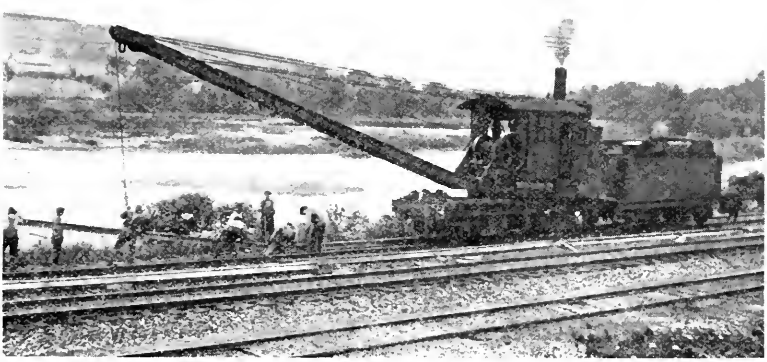


FIG. 2—METHOD OF PLACING NEW RAIL, ONE AT A TIME, AHEAD OF CRANE.

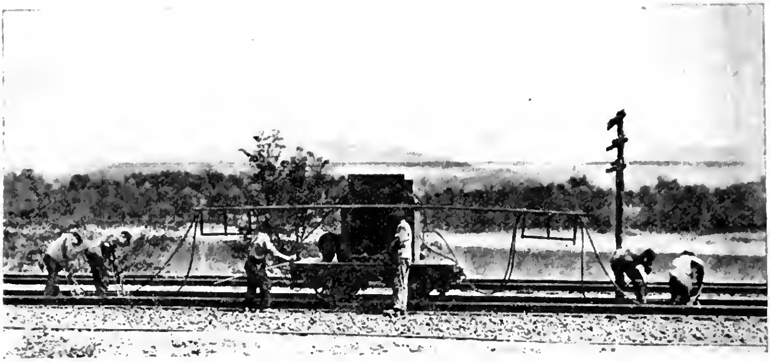


Fig. 3—Method of Placing New Rail.

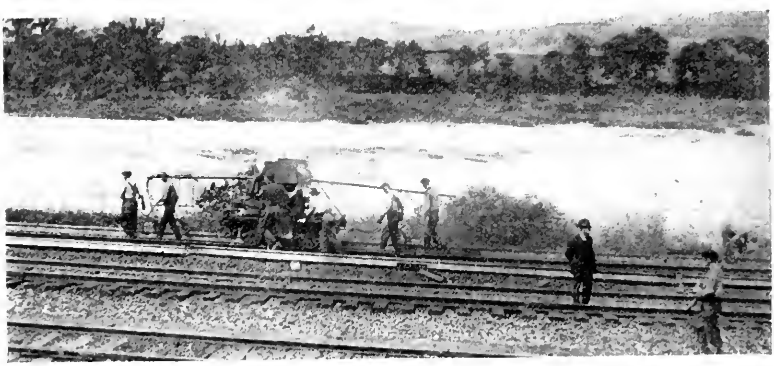


Fig. 4—Fastening Rail with Spike at Each End and One in Middle; Crane Moving Ahead to Lay Next Rail.

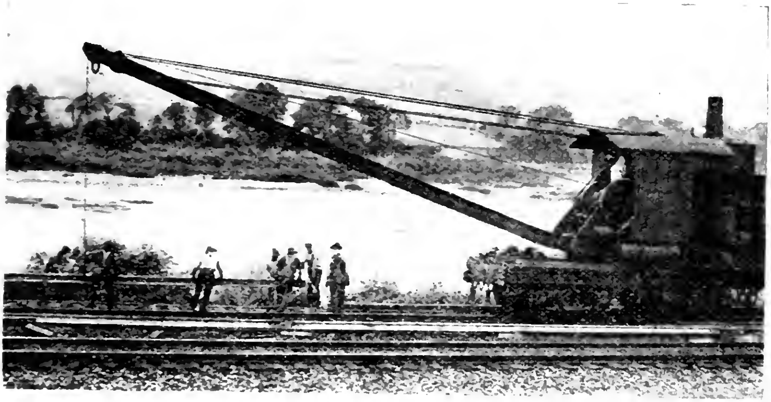


Fig. 5—Bonding Outfit.

Fig. 6—Drilling Outfit Moving Ahead, After Drilling Four Holes, or Two Joints, to Next Two Joints.

DISCUSSIONS

DISCUSSION ON SIGNALS AND INTERLOCKING

(For report, see pp. 65-74.)

Mr. W. J. Eck (Southern Railway):—The Committee on Signals and Interlocking reports on subjects (1) Revision of the Manual; (8) Automatic train control; (9) Methods of displaying signals for protection of track workers, and (13) Time release applied to signal or switch apparatus.

The Committee reports progress on the remainder of the assignments.

Subject (1), Revision of the Manual, is shown on page 69 as Appendix A. I move that the changes in the Manual, Appendix A, be approved and, if approved, substituted for the present recommendation in the Manual.

(The motion was duly seconded, put to vote and carried.)

Chairman Eck:—Subject (8), Automatic train control. The Committee submits certain data as Appendix B, and I move that the matter shown be received as information.

(Motion duly seconded, put to vote and carried.)

Chairman Eck:—The Committee submits a report on page 72 under instruction (9) for the display of signals for the protection of track workers, and recommends that the conclusions on the subject be approved and published in the Manual. I so move.

(Motion carried.)

Chairman Eck:—Subject (13), Time releases as applied to signal or switch apparatus. The Committee submits the matter appearing on page 73, and I move that only the conclusions be approved and published in the Manual.

(Motion carried.)

Mr. G. A. Mountain (Canadian Railway Commission):—I ask what regulates the speed of 30 miles?

Chairman Eck:—It was taken as an average figure, for average conditions. A rule or section of this sort must be carefully considered, as brought out in the last paragraph on page 68, as follows: "In interpreting and applying this recommendation it should be distinctly understood that it is only a guide and that the particular local conditions must, in the final analysis, govern the determination of this interval."

Mr. J. L. Campbell (El Paso & Southwestern):—I have only a minor suggestion. Does the Committee consider it essential to use the words "in the final analysis" in the third line, page 68?

Chairman Eck:—I see no particular objection to cutting them out, although they express the thought that in the "final analysis" local conditions must be considered—they bring out clearly that the rule is for average conditions, and that at any particular place the local conditions govern.

The Committee has nothing further on the subject; it has covered (9) and (13) completely, and at the present time we have nothing further to add.

DISCUSSION ON BALLAST

(For report, see pp. 75-106.)

Mr. H. L. Ripley (New York, New Haven & Hartford):—The work of the Ballast Committee for the past year has been largely in the nature of a review of the tentative report presented a year ago. It has been reviewed and corrected by the members of the Sub-Committee having charge of the particular section, and the work of the Sub-Committee in turn reviewed by the General Committee at its meeting, so that I feel we can say that the matter presented to you for adoption has had careful consideration by all the members of the Committee, and has the support of all the members of the Committee. It has been before you for a year in substantially the form in which it is to be presented now, and the matter now submitted was published and distributed in time so that every one who was interested has had an opportunity to read it, and the Chairman will assume whoever is interested has read it.

There are two or three points I would like to call your attention to in particular in Appendix C. At the top of page 94 there are two notes to be inserted. The second is simply a note to the editor of the Manual and should have appeared at the end of the appendix instead of in this place.

Appendix B on page 92, in two places the compound word "dress-up" is used, and the Committee would like to substitute the word "dressing." In Appendix D, on page 98, at the end of the Appendix on page 99, the Committee would like to insert two captions at the head of paragraph 5 and paragraph 6. Paragraph 5 should have the caption "Inspection," paragraph 6 the caption "Measurements."

The work, as I say, has been done by the Sub-Committee, and it was my hope that the report on each of these appendices could be presented by the Chairman of that Sub-Committee. Mr. Stimson is not here, and with your permission the Chairman will endeavor to present his portion of the report.

Instead of taking these appendices in order, I would like to leave Appendix A, which covers revision in the Manual, until the last. The Committee has rearranged the subject-matter in the Manual to a very considerable extent. The work of the Committee has grown from time to time, and the information has been put into the Manual perhaps more in chronological order than in natural order. If agreeable, Mr. Baldridge will present the report of the Committee on "Instructions to Govern Ballasting on an Operated Line." That could be presented in two ways, by a general statement, followed by the reading of the captions of the paragraphs—it does not seem necessary to read the report, as it is long—or it could be simply presented, and if anyone has any comment or objection to make about the general subjects he could make it after he has heard the statement.

The President prefers that you read the paragraph captions, Mr. Baldridge.

Mr. C. W. Baldridge (Atchison, Topeka & Santa Fe):—As stated in the opening paragraph of Appendix B, these instructions were presented to the Association last year as information, with the statement that they would be presented this year for adoption and inclusion in the Manual. Some few changes have been made since that time by the Committee and we now present them as follows:

(Mr. Baldridge then read the headings of the various paragraphs and said):

These instructions are intended as a guide to anyone who may care to look up something in regard to recommended practice on ballasting or re-ballasting of track.

Chairman Ripley:—I move the adoption of Appendix B, to be printed in the Manual as recommended practice.

(Motion duly seconded, put to vote and carried.)

Chairman Ripley:—The next matter covered by the Committee is Appendix C, "Specifications for Stone Ballast Material." If agreeable to the Association, we will handle it in the same way and simply read the captions and wait for any comments.

In offering these specifications the Committee realizes fully that it is not possible to write precise specifications for stone for ballast, as can be done with specifications for steel for instance, because the original material is not capable of the same treatment and one is compelled to use the raw material available. For that reason the Committee has presented this report in the form of a general statement of the desirable attributes and stated figures in a note to indicate what a good quality of stone should give in response to tests, the idea being that the road handling the material would be obliged to obtain the material from the best quarry available, and in writing its specification, write in its own figures, but for preliminary work and the guidance of one who perhaps is not familiar with the conditions, a note is put in, following each paragraph, showing what good practice would be.

(Chairman Ripley then read the various captions of Appendix C.)

Chairman Ripley:—I move the adoption of this Appendix for inclusion in the Manual as recommended practice.

Mr. J. R. W. Ambrose (Toronto Terminals Railway):—I would like to ask the Chairman to explain the meaning of a certain portion of paragraph 3, on page 96. It does not seem to read just right: "If in any of these tests a compressive strength greater than..........." is that what is meant?

Mr. Baldridge:—The paragraph mentioned refers to the tests for cementing qualities, and it is desirable that stone for ballast purposes have just as little cementing quality as possible, consequently in making a test the cementing quality should be low instead of high.

Mr. Ambrose:—Would the Committee accept a suggestion to put in the words "without cementing qualities," so that without going through it carefully one can understand the meaning?

Chairman Ripley:—I think there can be no possible objection to that. Possibly the implied criticism runs through the whole thing. These are set up under caption headings, and it would add very much to the volume without adding anything to the value, if that was done in every case. I have no objection to it in these paragraphs. Possibly the fact that someone reads it and gets an idea it is wrong shows that it would do no harm and they might look into it more carefully than otherwise.

The President:—Did you make that as a motion?

Mr. Ambrose:—No; I just offered it as a suggestion.

(Mr. Ripley's motion was duly seconded, put to vote and carried.)

Chairman Ripley:—Appendix D refers to a matter not directly referred to the Committee, "Specifications for Washed Gravel Ballast," but it seems so closely allied to the subject that was specifically given to the Committee for consideration and is a matter which some members of the Committee themselves found they were very much interested in at this time; therefore the Committee has drafted this set of specifications, which does not do violence to the other set just read, and the Committee feels warranted in suggesting that these specifications, if they meet with your approval, go into the Manual along with the others, although this is the first time you have had the matter definitely presented to you. If there is no objection, these will be read in the same way, or as they are new, if anyone desires it, they can be read in full. However, the specification is comparatively long.

(Chairman Ripley then read the headings of the specification.)

Mr. J. E. Willoughby (Atlantic Coast Line):—In connection with the first item of the specification, I notice it is proposed that the sand for the washed gravel ballast shall not exceed 20 per cent. I believe it is the more general custom where washed gravel ballast is used that the sand may exceed 20 per cent. On the Atlantic Coast Line we use gravel ballast with sand 25 per cent. and up to 33 per cent. We have a good deal of rain and do not have any trouble from the amount of sand causing retention of the water. The soils on which the ballast is placed, however, are usually sandy soils. In our practice we remove all sand in the working and remix the sand and gravel. The sand is the customary sand which occurs in sand pits and will pass through a ⅜-inch screen.

Chairman Ripley:—There is perhaps no question. In the various soils, and under the conditions found on the line of the Atlantic Coast Line Railroad, that is perfectly permissible, and the suggestion of the Committee would be that the Atlantic Coast Line would want to change that percentage to 25 or possibly even 30 per cent. We anticipated that. This is recommended, not as a standard, but recommended practice, to carry us under normal conditions, and that point you have touched on was debated by the Committee more than all the rest of the specifications put together. We finally decided as recommended practice we would offer it in this form, and the Committee would not oppose making that 25 per cent. if it seems good to the membership.

The Committee, however, is pretty thoroughly in accord, if not unanimous, in suggesting the percentages named here, and would be, frankly, more likely to reduce the 15 per cent. than to add to the 20 per cent., based on the experience of two members of the Committee who have used washed gravel very extensively and lately have had added experience with it. Mr. Stimson, the Chairman of the Sub-Committee, and Mr. Rice, of the Richmond, Fredericksburg & Potomac Railroad, would reduce the sand content down very much below our minimum.

The President:—Did the Committee take into consideration the fact that oftentimes a different specification might be required for washed gravel sand proportion; for example, in the case of bank washed gravel, as compared with river-bed washed gravel, the difference being largely due to the fact that in the river bed material the larger particles are quite smooth and round while with certain classes of bank gravel that is washed the aggregate is rough.

Chairman Ripley:—Yes, Mr. President, that matter was considered by the Committee, and possibly some of you are familiar with the gravel which comes from Massaponix Pit on the Richmond, Fredericksburg & Potomac. That gravel, although it is bank gravel, is worn and is comparatively round gravel. It is in a bank but is not greatly different from the gravel that you would ordinarily get out of the river bottom. An experiment was made by Mr. Rice, taking out absolutely all the sand that he could get out without actually drying the material; that is, taking all that would not stick to the wet stone. Something less than 7 per cent. of sand was retained in that gravel. He put down a trial section of that track with "ball-bearing" gravel, as it is called, and it held its line, held its grade, and there was no difficulty experienced.

Of course, the advantage in getting out the sand content is that if you are going to that amount of trouble to wash your gravel, it is desirable to keep down the dust, and the more sand you have in there, the worse the dust is going to be. This was perhaps a compromise on the part of the Committee, and I anticipated considerable discussion. I have no objection to lowering the minimum 5 per cent. or raising the maximum 5 per cent.

I believe, however, as a guide under normal conditions the percentages named are better than would be the case if a change was made either lowering or raising the limit of tolerance.

(Mr. Ripley's motion to adopt Appendix D carried.)

Chairman Ripley:—Appendix E, page 100, Standardization of Ballast Tools. This matter has been before the convention for two years, and the report will be made by the Chairman of the Sub-Committee, Mr. McBride.

Mr. J. S. McBride (Chicago & Eastern Illinois):—The specifications for ballast tools are shown on pp. 100 and 101 of Bulletin 230, and the plans on pp. 102 to 105.

Chairman Ripley:—Mr. President, I move the adoption of Appendix E, and that pp. 100 to 104, excluding page 105, be printed in the Manual as recommended practice.

The President:—May I ask the Committee whether in the designs of these tools there are any radical changes that will induce any manufacturing difficulties?

Chairman Ripley:—I think we can say positively, no; although the manufacturers have not responded to our request for criticism; but these tools were the composite result of a questionnaire sent out to different carriers, and pretty well responded to.

You will notice one thing, that with regard to the tamping bars and the forks particularly, a choice is given. These bars and forks represent perhaps what after a review of the diagrams sent in by different railroads, seemed to the Committee to represent the maximum and minimum practice, or rather, perhaps, two different ideas of practice. The bar, for instance on page 102, is shown with a straight end on the shaft. Then is shown the chisel and the spear-end as an alternative.

Some carriers, among which is our own, find very considerable use for the shovel end, the scoop end of some kind, and I think most carriers whose roads are largely ballasted with gravel will find that to their advantage. Another carrier may not care for it at all.

The forks are shown as what might be called wide and narrow forks. Neither one will do the work of the other under all conditions. The Committee shows both as the two designs for forks that will accomplish every purpose, in place of perhaps 20.

(Motion duly seconded, put to vote and carried.)

Chairman Ripley:—The fifth item which was given to the Committee covers the preparation of a general summary of previous reports made by the Ballast Committee of the A.R.E.A. The Committee did not get to this work at all. It feels that it is highly important, and in looking over the Proceedings in past years it finds a wealth of material there that was presented as a progress report, or presented for information, and never included in the Manual, and properly so. But after discussion your Committee feels that the work of the next year could not be devoted to better purpose than a review of this previous work that has been done, and presenting it in brief form, gathering the information available for the use of the carriers into one volume in the Proceedings, so that one looking for a particular subject could find it in one place instead of having to look through twenty.

The only other matter offered is the revision of the Manual, and there are one or two matters I want to call attention to in that connection.

On page 88 is shown the development of the ballast section. That should precede the information on page 86, instead of being at the end—I mean when it is set up in the Manual it should be set up in that order. Mr. Coon, Chairman of that Sub-Committee, will present the report.

(Mr. C. J. Coon (New York Central), submitted Appendix A, revision of Manual.)

Mr. Coon:—From page 78 to page 84 will be found the Committee's compilation. No subject matter was changed. There may have been a very few words that were changed in order to make the matter more clear, but we endeavored simply to compile what the Association had already approved and had placed in the Manual.

Chairman Ripley:—Mr. President, I do not know how to put this motion. Perhaps it would be as well to put it in this form, unless there is objection to it: We request permission to suggest to the man in charge of the Manual that the matter be rearranged and worded as stated in Appendix A. Possibly that work is left to the Secretary rather than to any committee. If so, I will amend my motion to that extent.

Mr. Willoughby:—I take it that it was one of the duties of the Committee to ascertain if the existing specifications on which no change is made fulfill what is now good practice, regardless of whether the convention have heretofore adopted the definition. On page 78 there is a definition for sub-ballast: "Any material of a character superior to that in the adjacent cuts." Now, the material in the adjacent cuts is sometimes very good ballasting material. Sometimes it may be gravel; it is possibly stone and it is frequently sand; all of which may be good ballast, not only as sub-ballast but as ballast. The purpose of the sub-ballast is to cover the roadbed. The sub-ballast material ought to be material which is better than the material underneath the roadbed.

Chairman Ripley:—Mr. Willoughby, taking the condition that you have stated, isn't it an open question, whether it is ballast or not, or whether you would handle it as ballast? If you went through a cut with material of that nature you would take it out only to a certain depth. If the adjacent fill was made with that material, you would make it up to a certain depth. I wonder whether under such conditions material handled out of that cut below a final ballast line would be considered and handled as ballast at all. That is our condition in New England, in many cases just exactly the condition that you have named; you might dig in some cases 20 ft., and you could not tell where the ballast stopped and the fill begins because they both came out of the same pit, and very likely the borrow was made from the gravel pit in its entirety. Of course, that is not a normal, general condition but it is by no means unique on the contrary, is a condition that obtains not infrequently.

Mr. Willoughby:—There is a condition in certain parts of the country, for instance, Florida, where the state is overlaid generally with a layer of sand that is sometimes 20 ft. or more in depth. In the cutting you may pass through sand, then sand will be in the adjacent cut. Sand will make a good sub-ballast, although sand will not make good ballast on account of its lightness in blowing away. Now, the cut being sand itself, you will not be entitled under the definition as proposed to call the sand which you place on the roadbed sub-ballast.

Chairman Ripley:—I think your point is well taken. I did not get it before. I think perhaps those are exceptional cases. It did not come to the attention of the Chairman, and I don't believe it did to the attention of the Sub-Committee. I wonder if that definition was made to read: "Any material of a superior character which is spread on the finished sub-grade of the roadbed and below the top-ballast, to provide better drainage, prevent upheaval by frost, and better distribute the load over the roadbed."

Mr. Willoughby:—Yes, sir.

Chairman Ripley:—Is there any objection on the part of the members of the Committee here, to substituting that language? Is that satisfactory to you, Mr. Willoughby?

Mr. Willoughby:—That is satisfactory to me.

The President:—In view of the fact that the Committee is in agreement that that change should be made, it can be incorporated and it is not necessary to make a separate motion.

Mr. H. Austill (Mobile & Ohio):—At the bottom of page 78, screened, the definition represents gravel in the pit that may be screened?

Chairman Ripley:—Perhaps I can explain what the Committee's intent was. The caption itself is "Gravel" and these are really definitions of different kinds of gravel. Is it your idea that "screened" should read, "Worn fragments of rock, occurring in natural deposits, that have been passed through a 2½ in. ring and retained upon a No. 10 screen?"

Mr. Austill:—Yes.

Chairman Ripley:—I think you are right. I think that that would express the intent of the Committee better than the language used. Does the Committee accept that? Paragraph (b), screened is changed so that the paragraph reads: "Worn fragments of rock, occurring in natural deposits, that have been passed through a 2½ in. ring"—that won't do. It would be expensive gravel by the time you passed it all through that 2½ in. ring. I wonder if there would be any confusion in anybody's mind as to what that means? I do not know how to put the thing into words. Won't you suggest the terminology for that paragraph? I am stuck.

Mr. Austill:—There isn't anything to indicate that it has been screened, and the definition refers to gravel that is in the pit before it has been screened.

Chairman Ripley:—Well, if it will pass through a 2½-in. ring and will be retained upon a No. 10 screen, I think you can call it screened gravel, whether it has finally and in fact gone through that process or not.

Mr. Austill:—It struck me it was misleading. The inference is it has been screened. It is a definition for the Manual, it is not a specification.

Chairman Ripley:—I will admit that the language is wrong, but I do not know how to put it right. If you can do it, I wish you would word it, and if not, it will not destroy the report at all if that is simply omitted, although I would rather see it go in as it is than to see it omitted entirely. I do not believe anybody would be confused about what is meant.

Mr. Austill:—I do not think the definition is clear.

Chairman Ripley:—We will admit that, but I do not know how to amend it.

The President:—Wasn't it the Committee's intention to apply this as to the process—the treatment of the material—rather than to differentiate all material that is used?

Chairman Ripley:—That was perhaps the thought the Committee had in mind. The basic idea was to get a certain product, and that product is one that has no stone in it that is larger than 2½ in. in diameter, and has nothing smaller in it than will be held on a No. 10 screen.

Mr. J. L. Campbell (El Paso & Southwestern):—I suggest that it be made to read: "Worn fragments of rock occurring in natural deposits that have been passed through a 2½-in. ring and been retained on a No. 10 screen."

Mr. Ambrose:—How would it be if you were simply to treat it as a noun and cut off the letters "ed" and let it stand as it is?

Mr. J. A. Stocker (Toledo & Ohio Central):—If the Committee has in mind specifically gravel which has been screened I suggest: "Worn fragments of rock, occurring in natural deposits, which have been screened, so that they will pass through a 2½-in. ring."

Mr. C. W. Baldridge (Santa Fe):—It seems to me that in defining screened gravel the question of the size of the hole through which it has passed is not material. It might be better and it seems to me it would be better to specify simply such ballast as is passed through a screening mechanism for regulating the size, maximum and minimum, of the material.

Mr. Porter:—How would it do to add to that clause, "whether screened or natural."

Mr. W. M. Camp (Railway Review):—I think this comes pretty close to another discussion on definitions. However, I think the wording should stand just as the Committee has left it. As I understand it, the Committee intended that if the gravel in its natural composition would meet these screen specifications, it does not have to be run through a machine if in its natural condition it is suitable. I think all that need be changed is just the heading. How would the words, "screen-grade gravel" suit the Committee?

Chairman Ripley:—I do not see any objection to that. I think that Mr. Ambrose's suggestion to just leave off the "ed" and make it a noun is sufficient, but I have no objection to the other.

The President:—As the matter now stands, the Committee has accepted the suggestion that the caption be "screen gravel" instead of "screened gravel." The purposes of this definition is to define certain classes of material which have been subjected to the ordinary method of treatment and to regulate the size of it.

Mr. Campbell:—I think this definition is all right as it is. If the gravel will pass through a 2½-in. ring, it has been screened, by nature if by no one else, and is screened gravel. I move that the definition for screened gravel given on page 78 be changed to read: "Screened gravel is gravel prepared for use as ballast by being passed through a screening mechanism."

Chairman Ripley:—The Committee would want to discuss that matter at a meeting. I would not want to go on record as saying that two materials exactly similar should not have the same definition, simply because one had been mechanically passed through a certain process and the other had not, if the result is identically the same.

Mr. Baldridge:—We have already adopted specifications for screened gravel, and in this case it is merely a definition of what constitutes screened gravel. I see no reason for any defining term, and if there is any other information wanted, our members can go to the specifications we have already adopted.

Chairman Ripley:—I think that we are taking more time of the Association in discussing this matter than it is worth, and if it is the desire of the Association to stop the discussion right here and refer the matter back to the Committee, that will be agreeable to the Committee. I do not think it is altogether right as it is. I agree with Mr. Campbell from his point of view it is correct in terminology, but I would rather prefer Mr. Ambrose's proposed amendment to leave off the "ed"; I do not care what is done, but we should bring the matter to a head.

Mr. Ambrose:—To bring the matter to a head I move that the "ed" be deleted.

The President:—The motion is that the caption should read "screen gravel" instead of "screened gravel."

(The motion was duly seconded, put to vote and carried.)

Chairman Ripley:—I make a motion that unless there is objection this matter be referred to the Secretary as a guide to him in arranging the matter in the Manual.

The President:—You have heard the motion that the text under revision of the Manual be adopted, with the provision that some rearrangement is necessary, which will be left with the Secretary.

Mr. C. R. Chevalier (Portland Terminals):—I notice on page 79, where a list is given of the comparative merits of material for ballast, there is no mention made of granite under the "stone" caption. I would like to ask if the Committee has made any investigation which would determine the proper place in that list for granite?

Chairman Ripley:—The Committee has not considered that, and this is not new matter. It is not even a recaptioning—it is stated in the exact words as the Manual now stands. The Committee made no change.

Mr. J. M. R. Fairbairn (Canadian Pacific):—My understanding is that the figures given on pages 86 and 87 form part of the matter we are passing on for the Manual. Is there any special reason why in these diagrams the crown of the sub-grade has been left off? It seems to me it would be better to show the crown of the sub-grade as it is shown by the Roadway Committee.

Chairman Ripley:—I will have to answer you as I did Mr. Chevalier. There is no change in form or substance in this part of the Manual. I know of no reason why the bottom should not be made to conform, but it would require special action by the Association to do so. This is the recommended practice of the Association at this time.

Mr. Fairbairn:—I make that in the form of a motion, that the sub-grade be shown with a crown in these diagrams similar to that used in the Roadway Committee report.

Mr. Campbell:—I think this matter should be handled in the reverse order and that the Committee on Roadway should conform its section to that of the Ballast Committee. I question the practicability of crowning the roadbed under the ties.

The President:—Is the Committee on Roadway making any radical change in the contour of the roadbed in its report this year?

Mr. Ambrose:—There is no change being recommended. I think this should be coördinated with what is now being recommended in the Manual by the Roadway Committee.

Mr. E. A. Frink (Seaboard Air Line):—The Committee on Roadway this year is presenting some diagrams of roadway sections with the sub-grade crowned. It is my recollection our Manual now contains diagrams with the sub-grade at the level and therefore this presentation of the Committee on Roadway is a change in the Manual.

(Mr. Fairbairn's motion was then put to vote and carried.)

The President:—The effect of that motion is that these diagrams will be revised by the Committee in coöperation with the Secretary before printing.

Chairman Ripley:—I think I can speak for the Ballast Committee in saying that it is the province of the Roadway Committee to show how the bottom line shall be drawn, and unless there is objection on the part of some member of the Committee, I am agreeable to leaving it just as it stands; that the depths are to be preserved and the bottom line modified to meet the line of the diagram to be presented by the Roadway Committee, because unless my memory is badly at fault there is no such thing now.

The President:—Without taking further time of the convention it follows that if, as the Chairman of the Committee fears, there is nothing in the present Manual that shows the roadbed outline with the crown contoured, then the effect of this motion is nil.

Mr. Fairbairn:—I would say the motion carries anyway, because it does not matter what you adopt in the Roadway Committee's report, the two should conform. All I am after is conformity between the two.

Chairman Ripley:—Then the only point the Ballast Committee cares to make is that the ballast depths as indicated in the figures should be preserved and the contour so modified as to preserve the depth of ballast under the tie.

DISCUSSION ON ELECTRICITY

(For report, see pp. 109-196.)

Mr. Edwin B. Katte (New York Central):—I know you will not expect me to apologize for the relatively small number of the members of the Committee on Electricity who are here to present their report, but the exigencies of the railroad situation has kept many of them away, rather than any lack of interest in the work of the Committee.

The report represents the work of a large percentage of the members of the Committee. Nine subjects were assigned to the Committee by the Board of Direction and one subject by the Committee on Standards. One subject will be reported as definitions for the Manual, two merely as progress reports, three specifications will be submitted and four sub-committee reports are submitted as information.

The revisions in the Manual consist of three definitions, which will be presented under the heading of Underground Conduit Construction.

Item 2, on page 110; no revision is recommended in the tables for clearances for third rail and overhead working conductors this year; considerable labor and cost is involved in this work, and it is thought that if the tables are brought up to date, every two years, it will be sufficient. The subject of electrolysis will be reported on as information. Item 4, Maintenance Organization, has received some consideration on the part of the sub-committee, but the report is deferred for another year. Item No. 5, Water Power, we submit as information and we give some statistics in regard to the electrification of one of the alternating current railroads. Last year you will remember the data was given for a high-tension, direct-current railroad.

The specification for insulated wires and cables, subject No. 6, has been completed this year and will be submitted. Subject No. 7, electrical interference, is presented as information, and subject No. 8, underground conduit construction, will be presented in the form of a specification for approval.

Item 9; the National Electrical Safety Code, which was prepared by the United States Bureau of Standards, will be presented as information. Under Standards will be submitted a specification or rather a schedule for incandescent lamps.

The first sub-committee report is that on Electrolysis and Insulation, to be found in Appendix A. Mr. Schreiber, the chairman of the sub-committee, could not be present, so I will briefly report for him.

(Chairman Katte briefly abstracted Appendix A.)

Chairman Katte:—In the absence of Mr. G. W. Kittredge, Chairman of the sub-committee on Water Power, the report will be presented by Mr. W. L. Morse, Vice-Chairman.

(Mr. Morse abstracted the report.)

Chairman Katte:—In Appendix C is submitted the Specifications for Insulated Wires and Cables.

(Chairman Katte then abstracted Appendix C, during which he said):

The American Engineering Standards Committee held a meeting on February 8th, at which these specifications were considered.

(Mr. Katte then gave a list of the societies and associations which were represented at the conference, and said):

The representatives of these various organizations agreed that it was desirable to unify the specifications and proposed to me the specification which is now submitted to you to-day as a groundwork upon which to build up, perhaps, a national specification. Your Board of Direction yesterday authorized the Committee on Electricity to send a representative to further conferences on this subject, with a view of having our specification used, so far as acceptable, or to discuss and agree upon desirable changes.

Mr. W. H. Elliott, Signal Engineer of the New York Central Railroad, wrote the Secretary on March 11th, regretting that he could not be present at this meeting, and I extract from his letter as follows:

"The specifications on wires and cables submitted by the Committee on Electricity should not be approved for signal purposes to take the place or supersede the specifications adopted by the Railway Signal Association in 1912 and revised and adopted by the Signal Section of the American Railway Association in 1920."

I have not had an opportunity to talk with Mr. Elliott, otherwise I think perhaps I might have made clear the intent of these specifications. They were not written to supersede the signal specifications. You will note that Mr. Law is a member of this sub-committee; also Mr. Lowry, who is also the chairman of the Insulated Wire Committee of the Signal Association. Mr. Vandersluis is on the Signals and Interlocking Committee, our Committee Number X. There has been very close co-operation with the Signal Section and the Signal Engineers, and there is nothing in this specification which supersedes or takes the place of any of the signal requirements. We hope in the course of a few years, or maybe months, that there will be one specification applicable to all the various uses of insulated wire. There will undoubtedly be clauses added to this specification from time to time, which will be included the special kind of insulation required by the Signal Departments and other railroad departments. I think it unlikely that the Telephone and Telegraph Association will use this specification, because of the different character of their cables.

The President has suggested that we briefly go over the specification which you will find beginning on page 150.

(Mr. Katte then abstracted some of the sections and in connection with Inspection said):

These specifications have been used in a slightly different form with success for eight or ten years on various railroads.

I hardly think it necessary to go over all these various sections—they run up to 112, and it would take some time to review all of them. The

Committee recommends that the Railroad Specifications for Electric Wires and Cables be approved and printed in the Manual as recommended practice.

(Motion duly seconded, put to vote and carried.)

Chairman Katte:—The next subject is "Underground Conduit Construction, Appendix E, and I will ask Mr. Brumley, Chairman of the sub-committee, to present the report.

(Mr. Brumley then abstracted Appendix E.)

Mr. D. J. Brumley (Illinois Central):—The Committee first thought of including these specifications as specifications for concrete, but since that is covered by other specifications the Association has passed on, we decided to omit it, although, in printing the report, there was reference made to concrete specifications in Section 38, and we recommend striking out the second sentence of Section 25.

Chairman Katte:—The Committee recommends for inclusion in the Manual the additional electrical definitions given on page 140 for "Duct or conduit," "Manhole," and "Mandrel."

(Motion duly seconded, put to vote and carried.)

Mr. J. R. W. Ambrose (Toronto Terminals):—Why does the Committee call these "stone conduits?"

Chairman Katte:—The manufacturers of this type of ducts call them "stone conduits." It seems immaterial whether we should call them stone ducts or concrete conduits. Perhaps it would be better to call them artificial stone conduits.

Mr. A. Chas. Irwin (Portland Cement Association):—Speaking a few words as to the terminology, it is a fact that this is a concrete conduit and that it should be called such. Artificial stone has no more place in the definition of concrete conduits than any other sort of thing you might think of. It really is concrete.

Chairman Katte:—In explanation I would say that stone conduit is really a trade name. It is a conduit that has been used in Chicago more extensively than anywhere else. The Edison companies make it themselves. Formerly there was a company, I understand, formed to make this stone conduit, and they could not produce it fast enough for the Edison Company's uses, so the Edison Company bought the rights and make this stone conduit and use it whenever they can build it fast enough for their own use. It has not been generally used; in fact I do not know of its having been used anywhere except in Chicago, but it has been used with such success here that the Committee felt the Association ought to have the benefit of a full description.

Mr. Irwin:—May I ask the Chairman of the Committee if the process of manufacture of this conduit is patented, and if not, I do not see why there should be a trade name attached to it.

Chairman Katte:—I do not understand that the name is patented. In construction it is nothing more than a pipe made of concrete, and I do not think you can patent a concrete pipe any more than you can patent a tin pipe. If we want to call it a concrete conduit, I do not think anybody will object.

(The definitions were approved as presented.)

Chairman Katte:—The Committee recommends that the Railroad Specification for Underground Conduit Construction for power cables, Appendix E, be approved and printed in the Manual.

(Motion duly seconded, put to a vote and carried.)

Chairman Katte:—I inadvertently passed Appendix D, which you will find on page 125, Electrical Interference. In the absence of the Chairman of the sub-committee, Mr. Vandersluis, the Vice-Chairman, will present the report.

(Mr. Vandersluis then abstracted the report.)

Chairman Katte:—The Committee recommends that the report on Electrical Interference, Appendix D, be accepted for information, published in the Proceedings and the subject continued.

(Motion duly seconded, put to vote and carried.)

(Chairman Katte submitted Appendix F, Item (9), coöperation with the Bureau of Standards, and said):

This is merely submitted for information and we ask that the object be continued and that we further coöperate with the Bureau of Standards.

(Chairman Katte abstracted Appendix G, page 144, and said:)

I would move, Mr. Chairman, that the Railroad Specifications for Incandescent Lamps be approved and printed in the Manual.

(Motion duly seconded, put to vote and carried.)

DISCUSSION ON STRESSES IN TRACK

(For report, see page 107.)

Prof. A. N. Talbot (University of Illinois):—Since the report was written considerable progress has been made in reducing the data. Attention may be called to the finding of large bending stresses in the inner rail under the fourth driver or the third driver (according to the type of locomotive). The bending stresses in this inner rail decreased with an increase of speed. For the outer rail there is considerable lateral bending under the front truck and first driver, and under the last driver and trailer, and this bending increases with increase of speed.

Measurements were made of the lateral bending of the rail section on itself (tilting) and also of the straightening and bending developed in the rail in a 6 ft. length, as would be produced as the engine passed at low speed. The slipping of drivers and wheels on curves was measured. Photographic track depression determinations under speed were made. Depression of track under static load to determine the constants of the track was also measured.

High stresses were found in the rail under wheels having flat spots. The method used for determining this is considered a practicable method and the results, so far as worked up, seem to encourage taking up further work in this line.

Tests in the laboratory are being carried on to learn how the splice bar and rails act at a joint and how the stresses are transmitted from rail to bar, as well as the amount of stress developed. Further tests on ballast are being conducted.

It may be said that we have still a large amount of work to do before the results of data already secured will be ready for presentation, or even for discussion. The Committee, however, is quite desirous that members of the Association will bring to the attention of the Committee any matters which they think should have consideration. The Committee feels, however, that the amount of work which it has on its hands is so large that not many new matters can be taken up. We should like, however, to have suggestions and discussion and criticisms by members of the Association at any time.

The President:—This submission is open for general discussion. There are no conclusions to be presented or action required of a formal nature, but I would like to supplement what the Chairman has said by a statement that I believe this is one of the most important pieces of work ever undertaken by a committee of this Association and it is important enough in its relation, not only to questions of track design, but locomotive design as to warrant the careful attention of every member. That support to the committee-work is wanted and the Committee especially desires suggestions as to the method of conducting tests, and of particular items that require investigation, and it would be to our interest to give special attention to this particular feature of the work. Have you any discussion from the floor? Any questions to be asked while the Committee is before us?

DISCUSSION ON TRACK

(For report, see pp. 649-694.)

Mr. W. P. Wiltsee (Norfolk & Western):—There were nine subjects assigned to the Track Committee this year. It has reported on six of them. On the first subject, the revision of the Manual, there are several revisions proposed. On the second subject, report on typical plans of turnouts, crossovers, etc., they have presented plans for quite a number of frogs and switches and also crossings. On the subject of gages and flanges for curved track, I will say that subject has been bothering the Committee for several years, and this year the Chairman of the Committee took it upon himself to appoint a Sub-Committee on that subject for report.

On the subject of plans and specifications for switchstands, switch lamps, etc., the Committee submits a progress report, and that is also true in the case of specifications for tie plates, derailers, etc.

Regarding the study and report on specifications and piece work schedules for contracting track maintenance work, we have made some investigations and have a progress report to make.

The subject of the reduction of taper of tread of wheel 1 in 38, and on canting the rail inward, is one which has been before this Committee for many years. The Committee has collected considerable data on the subject, but was unable to reach any conclusions this year.

Tests of tie plates subject to brine drippings is not ready for report as the Committee discarded the original tests and they have been for the past 18 months trying to collect material suitable for the rail used on the Chicago Junction Ry., where the tests are to be made and the different kinds of materials to be used in the test.

In regard to plans and specifications for track tools, the Committee has done considerable work on that subject, but did not consider it to be in such shape as to warrant its presentation to the Association.

As to the study and report on the limit of wear on frogs, including, if possible, rules for determining when frogs are sufficiently worn to warrant removal from track, the Committee has given considerable thought to the subject, but it is a difficult subject to handle and I doubt if the Committee will be able to reach any conclusions.

The matter relating to the revision of the Manual is shown in Appendix A.

(Mr. Wiltsee then abstracted Appendix A.)

I therefore move, Mr. President, the adoption of this spike, both the 5/8 and the 9/16 spike, for printing in the Manual as recommended practice.

Mr. A. W. Newton (Chicago, Burlington & Quincy):—A question came to me in looking over the Bulletin the other day, what prompted such a change in the head of the spike from the type that is being used by all the railroads at this time, and being manufactured at all the mills. I refer to the design of the head of the spike only, and I wonder why such a change is recommended, whether it was for economical distribution of metal or what.

Chairman Wiltsee:—The spike proposed increases the metal in the neck of the spike more particularly than any other place. That is the particular difference between this spike and most others. This spike was adopted by the Association, so far as that feature is concerned, in 1918.

(Motion duly seconded, put to vote and carried.)

The next item is specifications for switches, frogs, crossings and guard rails. The Committee recommends that we omit pages 168 to 186 inclusive, of the 1915 Manual, commencing with article on "Length of switches" and ending with an including article on "Crossovers," and substitute the matter shown on page 654 of the Bulletin.

(Chairman Wiltsee then abstracted item two of Appendix A, down to and including "Inspection" on page 659, and said):

I move you, Mr. President, that these specifications be adopted as recommended practice and substituted for those now in the Manual.

(Motion duly seconded, put to vote and carried.)

Chairman Wiltsee:—In Frog Designs, pages 660 to 671 inclusive, considerable detail is given to show how the Committee designed their frogs, which will enable anyone to design any other number than that for which the Committee had prepared plans. These take the place of the designs that are now in the Manual, and agree with the plans that we have already prepared. Therefore I move, Mr. President, their adoption as recommended practice and for printing in the Manual.

(Motion duly seconded, put to vote and carried.)

Chairman Wiltsee:—The tables of turnout leads shown on pages 672 and 673 are simply a revision of those tables now in the Manual to agree with the different frog lengths that have been approved by the Association. Therefore I move their adoption.

(Motion duly seconded, put to vote and carried.)

Chairman Wiltsee:—The next item in Revision of Manual is on switch-stands, but as that is so closely connected with the part of our report on that subject, we will pass over it for the time being.

Mr. Neubert, Chairman of the Sub-Committee on typical plans of turnouts, cross-overs and slip switches, is not present; therefore I will present the report shown in Appendix B.

(Chairman Wiltsee then abstracted Appendix B and said):

I move that these plans be adopted and published in the Manual.

(Motion duly seconded, put to vote and carried.)

Chairman Wiltsee:—The plans showing diagrams of preferred names of parts were published as information in Supplement to Bulletin 221 and in Volume 21 of the Proceedings, and are now offered supplementary to the definitions printed on pages 115, 116 and 117 in the 1915 Manual.

Therefore I move their adoption and printing in the Manual.

(Motion duly seconded, put to vote and carried.)

(Mr. Wiltsee then read the matter on page 67 relating to plan 501, and said):

In other words, as long as the standard frog has a flangeway of 1¾ in., this does not mean anything different, but in case of necessity of widening the flangeway, the Committee thinks that the gage which should be maintained is from the back of the guardrail to the frog point.

(Mr. Wiltsee then read the matter relating to plan 502 and said):

These plans were not reprinted, as they were adopted last year. The Committee wishes to make these two changes, and I therefore move their adoption.

Mr. J. R. W. Ambrose (Toronto Terminals Railway):—I will ask the Committee how they arrive at the distance 4 ft. 6¾ in.; in other words, how do they justify the flangeway of 1¾ in.?

Mr. Wiltsee:—The flangeway of 1¾ in. was adopted years ago as the flangeway required. I do not know how far that Committee investigated the subject. This Committee has not gone back to verify whether or not that is the correct flangeway, but the question has come up, especially in connection with the crossings, as to the widening of the flangeway.

Mr. Ambrose:—With a flangeway of 1¾ in. a pair of wheels cannot trail through without some shift in their position. From the various wheels I have measured I find that with a 2 in. flangeway, if one wheel is tight to the rail it will allow it to go through without any lateral movement, and I was wondering if you had any information regarding the distance between the inside of one flange to the outside of the other, if you know what that standard is.

Mr. Wiltsee:—My recollection is that it is definitely fixed at 4 ft. 5 in. back to back of the wheel flange. I cannot say offhand what tolerance is allowed.

(Motion duly seconded, put to vote and carried.)

(Mr. Wiltsee then abstracted the matter on pp. 677 and 678.)

Mr. C. W. F. Felt (Santa Fe):—I move that plans 331 to 335, being the plans just referred to, with the clamp frog, be published in the Manual.

Mr. J. L. Campbell (El Paso & Southwestern):—I compliment the Committee for the excellent designs of frogs which it has submitted from time to time in which the design for the clamped frog is included. The subject of clamped frogs was assigned to the Committee about three years ago for the purpose of having designs therefor submitted to the Association for inclusion in the Manual if found satisfactory. These plans were submitted last year. The Committee then desired further time in which to reconsider the plans and revise them if revisions were found necessary. The Committee now reports back these plans without change, saying it found changes unnecessary. The plans are submitted without recommendation, from which, I understand that it will be agreeable to the Committee to have them included as information in the Proceedings or as recommended practice in the Manual.

Speaking from an experience of 15 years with the clamped frog, I consider the designs therefor submitted by this Committtee second to no other design I have ever seen. I believe they will produce a clamped frog second to no other manufactured to any other design.

It is not the purpose of this Association unnecessarily to limit its recommended practice. If there is a choice between good articles or practice, the members of the Association should have freedom of choice. It rests with the individual members as to the choice that will be made. The Committee in submitting designs for frogs, is not submitting recommendations as to the use of frogs. It is merely recommending to the Association that if you desire this type of frog it will be good practice to construct it according to this design. That is all that is involved in the inclusion of the design of the clamped frog in the Manual.

(Motion duly seconded, put to vote and carried.)

Chairman Wiltsee:—The next subject is "Gages and Flangeways for Curved Crossings," which will be presented by Mr. Victor Angerer, Chairman of the Special Committee.

Mr. V. Angerer (William Wharton, Jr. & Co.):—This is a progress report for information and criticism only. During the preparation of the plans for crossings, the question arose as to the proper gage and width of flangeways in curved crossings and curves in general. There seemed to be no authoritative data available to determine this. The practice varied considerably, and the Chairman of this Committee appointed this Special Committee to investigate the matter. Former committees of the Association, dealing with the widening of the lead on curves, did not go very far into the matter of width of flangeways, which in crossings is important. Some roads have made investigations of their own on this subject which were naturally confined to some extent to the conditions existing on their roads. The Committee gathered information as to the practice of a number of railroads and also crossing manufacturers. The tabulation thereof is given in connection with our report on page 681, which although it is not complete, is sufficient to show the great diversity in practice in the width of gages and flangeways on curved crossings.

The Committee then decided to make a study as to how the different factors which affected the gage and width of flangeway would work out theoretically. Of course, the main factor is the locomotive. Car trucks, even six-wheel trucks, do not require any widening of the gage. The factors, which you all know are the determining points, the wheel base, the number of flanged wheels in rigid or semi-rigid connection and the diameter of the wheels. From these the Committee has worked out the formula and tables given in the inserts of the report. It was a comparatively easy job and took only the application of some mathematics; but the problem to discover how it would work out when applied to the various locomotives, that part of the work was more difficult. The Committee gathered data as to various locomotives in more general use, and found nearly 100, to be exact 96, locomotives in quite general use, not including the Mallet or articulated types, which differed in some respects in regard to the factors which have an influence upon these determinations. These were grouped into a number of divisions of the principal classes of locomotives and the results are given in the tables on pages 682, 683, 684 and 685.

I might say that the swing of the locomotive trucks given in these tabulations is the swing that would be necessary to allow the locomotive to take the curve, which the driver arrangement will permit, but is really in itself excessive, in some cases, and it may not always be practicable to give that much swing on the locomotive.

There are some factors which cannot be determined theoretically. One is the flexibility in the frame of the locomotive and its parts; also the flexibility of the tracks or the crossing, which, however, as we build them now, are not very flexible.

The Committee realizes that this study will only have practical value if, from it, in conjunction with tests and observation of experiences in the track, some concrete rules can be formulated for ready use of the Engineer in the field or the Engineer in the office, and if this study is continued it will be the task of the Committee to see if it cannot bring it down to some such concrete rules. For that purpose the Committee will appreciate very much the help of all of you who are in a position to make practical tests or observations, or who have made investigations, and would kindly communicate their experience to the Committee.

Mr. T. E. Rust (Waterloo, Cedar Falls & Northern):—If I am not very much mistaken this Association adopted in about 1917 standard flangeways for both straight and curved track. Committee IX made the recommendation and it was adopted. Committee IX this year is recommending that that portion of its work relating to flangeways be transferred to the Committee on Track, where I think it very properly belongs; but nevertheless I am under the impression that those standards have been adopted and are now in effect.

Mr. G. A. Mountain (Canadian Railway Commission):—I would like to know if this question is ever taken into consideration. Apparently it has been some years preceding. The question of curved crossings is certainly bad practice. Who would put in a curved crossing that could possibly be avoided? I have recommended to my Board a great many crossings of railroads, but I do not think I have ever passed one crossing on a curve. I do not think it is good practice.

Chairman Wiltsee:—The Committee realizes all that Mr. Camp says, and has fully considered this question. They expect to consult the locomotive builders, and the motive power departments of the railroads. The question was taken up with the Master Car Builders in 1908, and adopted, and it is printed in the 1915 Manual.

Mr. Rust:—You are referring to gages. I was referring to flangeways, which were adopted, I think, in 1917.

Mr. C. J. Coon (New York Central):—It might be of interest to the Association to know that in the Grand Central Terminal we use 4 ft. 9 in. gage. We have turnouts on as high as 18 degree curves under regular traffic. Where the gage is 4 ft. 9 in., the flangeway of the frogs is 1⅞ in. The distance the guard rail is set from the wing rail of the frog is 4 ft. 4⅞ in., and we have never had any derailment which was attributed to this gage or to the setting of these guard rails, using these distances. We have had a few derailments, but they were caused by condition of equipment.

We have one rather unique proposition, namely, multiple unit electric equipment which has standard trucks and we operate on 42 deg. and 40 min. curves with a 4 ft. 9 in. gage, and a flangeway in the frog of 2¼ in., without derailment. We have never had a derailment on the 42 deg. and 40 min. curves. If the motive power people give us equipment that will go around those sharp curves, we will not have any trouble in operating them. There is an element that enters into it that may have some effect on operation, viz.: This track, owing to the fact that it is operated by electricity, is level. The third rail shoes are in such position that we are not able to elevate curves and all tracks are level.

The President:—The Supplement to the Manual in 1918 provides for an inch and three-quarter width flange, or with provision for an increase of 1/16 of an inch for every 2 degrees of curvature. On that recommendation that is the practice now, as reflected by the Manual.

Chairman Wiltsee:—The next portion of the report is Appendix D. Mr. Macomb will present the report.

(Mr. Macomb read Appendix D, page 686, and also abstracted pp. 674 and 675, being item 3, Appendix D.)

Chairman Wiltsee:—Mr. President, it is the recommendation of the Committee that the matter printed on pp. 674 and 675 be adopted as recommended practice, and printed in the Manual. I therefore so move you.

(Motion duly seconded, put to vote and carried.)

Chairman Wiltsee:—Plans and specifications for tie plates, derailers and anti-creepers in Appendix E, page 687, of the report is simply a progress report, and no conclusions have been reached. Mr. H. T. Porter, Chairman of the Sub-Committee, will present the report.

Mr. H. T. Porter (Bessemer & Lake Erie):—We made some search to see what was published in railroad literature on the subject of tie plates, and did not succeed in locating very many articles on this matter. We thought that there might be some rule by which we could get the relation of the length of the tie plate outside of the base of the rail to the length of the tie plate inside of the base of the rail.

The report of the Special Committee on Stresses in Track gave us a start in this direction. Of course, we did not go very far or very deep into their investigation, but we find that there is an angle here of ten degrees that we can use in comparing with what has been done on the various railroads, and this table was worked up. After we had made the table on pp. 692 and 693, we discovered that we ought to have gone to the base of the tie plate instead of the top of the tie plate, but it did not make a great deal of variation in the distance, and we did not take the time to revise the tables. We simply call attention to it in this paragraph, so that you would know that we had discovered it.

(Mr. Porter read the first paragraph on page 688.)

That word "standard" there is probably not the right word. It is pretty hard to tell what is standard on your own road, let alone what is standard on somebody else's road.

This table was made up from a lot of letters that were written in answer to a series of questions, and anyone who has had personal experience in that kind of work will find that it is pretty hard to make the information agree and to make the report complete. I am inclined to think that we have probably made some statements in this table that do not look just exactly right to the Engineers on the railroads represented. What we were after particularly was two columns, the difference between outside and inside in inches, that is, in projection, and then to see how the computed difference compared with the difference that had been followed by the various railroads.

This is simply, of course, submitted for what it is worth, with the idea that next year we will get some information from those who have given this matter individual study.

In the second paragraph on page 688 we use the word "standard," and I will try to suggest some way of eliminating it without changing the meaning of the paragraph.

(Mr. Porter here read the balance of page 688, following the first paragraph.)

Chairman Wiltsee:—What we desire particularly is criticism on this subject during the coming year.

The President:—This report is offered as information, with the request for constructive criticism during the coming year, this subject being continued, but the matter is open for discussion, if there is anything to be offered now.

Chairman Wiltsee:—The next sub-division is "Study and Report on Specifications and Piece Work Schedules for Contracting Track Maintenance Work." This part of the report will be presented by Mr. E. T. Howson.

Mr. E. T. Howson (Railway Age):—Owing to the abnormal conditions with which we are all familiar which have prevailed during the past year in getting work done by contract or by any other means, it was very difficult for your Committee to find any clean-cut examples of contract work. The standard track work system which had been in effect for several years on the Baltimore & Ohio and for a shorter time on the Pennsylvania, prior to Federal control, and which was abandoned during that control, have not yet been re-established. Therefore, the Committee was unable to get any up-to-date information on which to base any report.

While a good many roads resorted to the cost-plus form of contract in one form or another last year, the Committee did not consider that that was the kind of contract the Board of Direction had in mind in assigning this subject to our Committee, the cost-plus form of contract being in most cases little more than paying the contractor a percentage on the cost of his work for recruiting the force. Therefore the Committee can only report progress, and comparatively little progress this year.

DISCUSSION ON RAIL

(For report, see pp. 197-234.)

(In the absence of both the Chairman and Vice-Chairman of the Rail Committee, the report was presented by Mr. J. M. R. Fairbairn.)

Mr. J. M. R. Fairbairn (Canadian Pacific):—Mr. President, our Chairman has written a letter in presentation of this report addressed to yourself, which I think it is in order to read, as I think it is the unanimous feeling of the Committee on this subject.

(Mr. Fairbairn then read the following letter from Mr. G. J. Ray, Chairman of the Committee):

Hoboken, N. J., March 10, 1921.

To the Chairman and Members of the American Railway Engineering Association:

"I regret very much indeed that I will not be present at the convention. I am especially sorry that I will not be on hand to present the Rail Committee report. Business matters over which I have no control will prevent me from being in Chicago during the week of the convention.

"Those not familiar with the activities of the Rail Committee during the past year may conclude from the Rail Committee's report that the Committee as a whole did not have a very busy year. I wish to assure you that the past year has been one of the most active in the history of the Rail Committee. Unfortunately, we can only report progress with most of the subjects assigned.

"The Board of Direction has, from time to time, instructed the committees to endeavor to complete at least one or two subjects each year. We submit for your approval revised rail record forms. We have no other conclusions to present to the Association. We hope to be able to present a more substantial report another year. As Chairman of the Rail Committee I feel that I should make a somewhat more complete statement concerning the Rail Committee work than the report submitted in Bulletin 231. What I present to you represents my own thought and has not been submitted to the Rail Committee for approval.

"In the spring of 1919 the Rail Committee submitted to the Association revised rail specifications with the request that these tentative specifications be carefully considered by all concerned for a period of a year, when they would again be presented to the Association for final adoption. In presenting the report in question the chairman invited written criticism and also advised the representatives of the manufacturers that they would be given a fair opportunity to present their recommendations. During that year and up until the next convention not one written discussion was submitted to the Committee by a member of the Association not connected with the Rail Committee. The Rail Committee met with the manufacturers and as you well know the specifications, somewhat revised, were adopted by the Association in 1920.

"So far as we are aware no rail has been rolled under the new specification. This is not at all surprising, considering the attitude of the manufacturers.

"On September 14th, last, the Rail Committee again met with the Rail Committee of the manufacturers. All phases of the specifications were freely discussed. Prior to and since the above meeting the chairman has conferred and corresponded with the Manufacturers' Committee.

"The manufacturers, as represented by their Rail Committee, have stated that they will not agree to roll rail of any weight under a contract requiring full compliance with all features of the 1920 Specifications. They have stated that they will roll rail up to 110 lb. per yard under the 1920 Specifications slightly modified so as to eliminate a few of the so-called objectionable paragraphs on manufacture or mill practice. This modified specification will take an extra price estimated at approximately $13.00 per ton for a base price of $57.00, or something in excess of $9.00 on a base price of $47.00. The Manufacturers' Committee have further stated that they will not meet the 1920 Specifications at all for rail 111 lb. per yard and over. The big extra demanded by the manufacturers has practically killed the new specification. Naturally, no railroad management will pay so large an extra for a standard specification until it has been proven beyond a doubt that rail manufactured under such specifications is sufficiently superior to warrant the extra price.

"The manufacturers contend that their recommendations and suggestions have not received the serious consideration they deserve and further contend that the new specifications would be an unnecessary burden to the manufacturer and that less severe specifications will meet the needs of the railroads.

"As a matter of fact the Rail Committee has had but little assistance from the manufacturers in the work of improving the specifications. Their suggestions to the Rail Committee have been confined, primarily, to reasons why the changes in the 1915 Specifications cannot be made without increased cost. They have not as yet offered any constructive criticism. They have frequently stated that they do not know what to do to improve the quality of the rail as now manufactured. They are only sure that our present specifications will prove costly without improving the quality of the rail.

"The manufacturers have, and I believe with just cause, criticized the Rail Committee's method of tabulating rail failures. The Committee now has under consideration a revised method of reporting rail failures, due consideration to be given to the tonnage carried.

"I am convinced that the manufacturers believe that the consumers as a whole are not sufficiently interested in purchasing a better wearing or safer rail to pay the extra cost of production. Their belief is founded on good ground, as many of the roads claim that the 1915 Specifications or the Manufacturers' Specifications with slight modifications produce quite satisfactory rail. Therefore, why should they have to pay more money for some other specification?

"On the other hand, many of the roads with excessively heavy traffic are not at all satisfied with the 1915 Specifications. Excessive wear and undue breakage have made it advisable to look for a better wearing and safer rail, even to the extent of paying a material premium for such rail.

"All concerned agree that part of the rail as rolled under the 1915 Specifications is entirely satisfactory, both from the standpoint of wear and breakage. Many roads have had trouble from breakage, the worst type of failure being the transverse fissure, and often part of the rails are soft and wear badly or flow rapidly under traffic.

"In the 1920 Report of the Committee on Safety of Railroad Operation to the National Association of Railway and Utility Commissioners you will find the following statement concerning rails: "The published annual statistics on rail failures signify that the margin in strength is in many cases exhausted by the conditions which now prevail in the track. It is obvious that increased durability and safety in rails must be attained in one or both of two ways, either the physical properties of the steei must be raised or the working stresses lowered." I am not an advocate of heavy wheel loads, but it is obvious that we cannot, consistent with economic or satisfactory operation, reduce the present average of the freight car axle load. The old light cars are gradually being replaced with heavier ones so that the average wheel load is constantly on the increase. Since the flow of metal either on the surface of the rail or at some distance below the surface is primarily caused by the heavier car wheel loads it is evident that the wear of the rail will be faster and the flow greater, unless some improvement is made in the physical properties of the steel. The working stresses in the rail can be lowered by the use of heavier rail, but increasing the rail section will not reduce the tendency of the metal to abrade or flow under wheel loads. A few years ago the manufacturers were strongly contending that excessive breakage and poor results with rail were due to the failure on the part of the roads to use a sufficiently heavy rail to take care of the heavy wheel loads and other requirements. The quite general use of much heavier rail in recent years has proven beyond a doubt that the use of heavier rail has not eliminated the difficulties. In fact, the heavier rail has in many cases proven to be fully as troublesome from a breakage standpoint as the lighter rail. In connection with this, it is interesting to note that since some of the roads have started to use a heavier section than 110 lb. per yard, the manufacturers now claim that these heavy sections cannot be rolled under as rigid a specification as the lighter sections. They are not willing to guarantee as good elongation for the heavy sections under the drop hammer.

"If all the rail rolled under the 1915 Specifications had equally as good physical qualities as the best 50 per cent. of the rail, there would be little cause for complaint and there would be little or no reason for a statement like that quoted above.

"The Rail Committee is at present somewhat confused as to what to do under the prevailing conditions. Those reasonably well satisfied with the quality of rail now being received are opposed to changing the specifications if by so doing the price of rail will be increased. They are also opposed to two standard specifications, one for a higher quality of rail to require an extra price. Naturally they do not wish to be placed in the position of purchasing an inferior brand of rail.

"With the present attitude of the rail manufacturers there is little that can be done by the Rail Committee to improve the 1915 Specifications without creating extra expense on the part of the purchaser.

"It is a fact that many of the mills are rolling rail under modified specifications and the rail manufacturers freely admit that they are willing to roll rail for individual roads under specifications containing many of the objectionable features of the 1920 Specifications. Some such specifications take a slight extra, in other cases no extra is charged. The Rail Committee has sought a reason from the manufacturers for their willingness to roll rail without extra charge under private specifications when they are not willing to have the special features of the private specifications included in the "A.R.E.A." Specifications. In answer the manufacturers give what appears to be a more or less reasonable explanation. Where the manufacturer and the individual road agree on a special specification, consideration is given to all features of the specification and the method of inspection together with the judgment and fairness of the inspector, or those responsible for the inspection. Where both the physical and chemical properties of the finished rail are limited as in the A.R.E.A. 1920 Specifications, a strict compliance with the specifications as to chemistry might be the cause of discarding more or less perfectly good rail, but where the railroad officials are inclined to be fair and reasonable, some of the manufacturers are willing to try out the specifications, although such specifications may vary materially from the standard. They are not willing to take chances with inspectors at large and claim that the general use of such a specification as the A.R.E.A. 1920 would cost the manufacturers a material amount of money, and in their opinion such refinement is not needed with the greater portion of the tonnage used throughout the country.

"There is undoubtedly some merit to the manufacturers' contention that the purchaser should not specify the method of manufacture and also place a limit on both the chemical and physical requirements of the finished rail. On the other hand, the consumer is anxious to have sufficient control over the mill practice and to place such limits on the physical and chemical properties of the finished rail as to insure the elimination of both the dangerous and poor wearing rail.

"It has been my experience that some rail manufacturers are more willing than others to assist in working out a new specification. I have personally been responsible for the acceptance of a material amount of rail on a strictly physical test without regard to chemistry, except as to the limit of phosphorus. I am frank to say that the manufacturers did their utmost to produce a high quality rail and the outcome was that very satisfactory results were secured.

"Speaking on behalf of the Rail Committee, the Chairman invites full discussion either on the floor of the convention or in writing in order that the Rail Committee shall have the benefit of your views on the subject.

"The Rail Committee will endeavor to reach a conclusion during the coming year—First: Should the Association adopt two specifications, one to be the best possible, without running into extra price; the other to be the 1920 Specification, possibly revised, but requiring an extra price. Second: Should we have one specification without extra cost over the manufacturer's base price, the Association to be given a list of specific refinements in the order of their importance (considering the probable cost) so that roads requiring a higher grade of rail will have the benefit of the Association's judgment on the most valuable of such refinements.

"Anything you can do to assist the Committee to work out this important problem will be appreciated."

Mr. Fairbairn:—I think Mr. Ray has so thoroughly covered the ground in presenting the report, that there is really nothing further to be said on the subject, except to proceed with the report itself, which the Committee respectfully submits to the twenty-second annual convention. The subjects assigned to the Committee are detailed in the Bulletin, and I presume it is not necessary to read these, or the accounts of the meeting, so subject (1), revision of the Manual, we can proceed to at once and I will ask Mr. A. W. Newton, Chairman of the Sub-Committee, to present that part of the report.

Mr. A. W. Newton (Chicago, Burlington & Quincy):—In announcing his Sub-Committees last year Chairman Ray assigned to our Committee the question of revision that should be made in that portion of the Manual which would be considered as under the jurisdiction of the Rail Committee. After a meeting of that Committee this conclusion was reached—that probably the best results would come from efforts to make a revision of the forms that had been so long printed in the Manual covering the production of rail and the records of rail failures and rail wear in track.

In order to ascertain the views of railroads respecting the use of these forms, a circular letter was sent out and replies were received from 49 different roads, which were tabulated and which show that of the 49 roads reporting there are practically only two of the forms that were generally used. One is the failed rail report, as it is commonly known, and that is made out by the section foreman and approved by the Roadmaster, and the other is the summarization of those reports that are submitted annually to the Rail Committee, an analysis of which is made generally under Mr. Wickhorst's direction, and with which you are all familiar.

Of the other 15 forms, out of 49 roads it appeared that only four or five of the roads were making any use of same. Only one or two roads made any attempt to use all of the forms as printed.

One thing that the Committee wishes brought to the attention of the convention is that probably much more valuable information would be available if all the roads interested would take a more active part in the compilation of data regarding rails, not only of the manufacture of rails, but of the service results obtained from rails in the past.

Referring to the revision of forms, there is little that needs to be said respecting the changes. Various members of the Rail Committee submitted suggestions to us, and these were, as a rule, included in the revised form. The changes that were made were such as would make it possible to give a little more detail in some respects and make it possible to apply the specifications of 1920 to record the results of any rail production under those specifications.

After the issuance of the Bulletin it was thought that probably we would receive criticisms as to the revised form. Up to this date there has been only one criticism submitted outside of the Rail Committee itself, and that suggested the addition of one column on one of the forms to make it possible to segregate a record which it was intended should be included in another column that had been provided in that report. I do not think it necessary to read anything regarding the changes that have been submitted.

Acting Chairman Fairbairn:—You have heard Mr. Newton's presentation of the conclusions with regard to subject (1). The forms about which he has been talking to you are now before you, and I move that the Association adopt these for inclusion in the Manual to replace the present forms.

Mr. C. F. Loweth (Chicago, Milwaukee & St. Paul):—In the report to be used by the section foreman the Committee show the gage side in plan, but do not provide for showing it in the section.

The President:—The Committee states that that suggestion will be incorporated in the drawing.

Mr. C. W. Baldridge (Atchison, Topeka & Santa Fe):—In checking over the rail failure reports under the form shown on page 208, I found the term "Rail section" gives the section foreman more trouble than most of the other matters in it, and I prepared a form for our own road, some two or three years ago, in which we proposed to do away with what is shown here as Nos. 1, 2, 3, 4, and 8, the lines under these numbers, and substituted one line clear across the page, just under the heavy line at the top, showing the brand of rail, and placed under that a little note to the foreman saying, "Show once on this line all letters and figures appearing in raised form on the rail." If that were done, it would do away with the foreman guessing what is meant. We know what is meant, but the foremen do not. If we can get the foreman to show everything that appears in raised form, all the questions are answered.

A second line can be made to serve for Nos. 5, 6 and 7 by showing a little note underneath, "Show once all letters and figures that appear stamped into the rail," and I believe we will get more accurate replies if we provide a blank in that form, and I would suggest to the Rail Committee that they consider such a change.

Mr. Newton:—That subject was considered, and I think it has been tried by other roads also. We tried it once, and when the reports came in it happened that there were three sets of numbers on the rail that failed. We started at one end and went to the other end, and we got all the figures. It is not a bad suggestion.

However, our Committee in giving study to that felt that the Roadmaster who has to approve these reports should certainly be conversant enough with the subject to have proper reports made by the section foreman, and before they receive his approval he undoubtedly would make correction of any misinformation of that sort the foreman might have put on the form. If it is the desire of the Association that that change be inserted, we are perfectly willing to abide by that.

Mr. Baldridge:—I realize that a good many foremen, if you simply leave it to them to show the brand without any instructions, or the heat number without any instructions, would repeat it, but by putting the note, "Show once all letters and figures appearing in raised form on the rail," I think we would get a pretty accurate report.

I have this to say in regard to the checking up of these reports by the Roadmasters—fully 50 per cent. of these reports come in without the Roadmaster seeing them. The clerks check them up, and a new clerk has to be broken in just about so often, and about half of these reports have to be sent back for correction, in our present form, and I think the form proposed is a big improvement over what we have at present.

Mr. A. L. Davis (Illinois Central):—On the Illinois Central we tried the same plan about two years ago, cutting out a lot of the questions and substituting one line across the top of the form. We found it does not work out at all, but that by having the separate questions, as the Committee has recommended, we get better results.

Mr. E. A. Frink (Seaboard Air Line):—It is obvious that this form is the most important form we have for our rail data, because upon it is based all the information we get as to the actual failure of the rail in the track.

There is one class of failures which is unfortunately becoming more prevalent in our track, and that is transverse fissures. I find that many of our section foremen—and I presume other roads have had the same experience—have not been educated to the point to know what a transverse fissure is, at any rate, not in all cases.

I think this form would be improved if a note was inserted on page 209, bringing out the fact that a transverse fissure, before it penetrates to the edge of the rail, is always white, and after it reaches the outside air is almost invariably black or dark in color. If you bring that out more strongly, a foreman will be more apt to report these breaks for what they really are, that is, transverse fissures.

Mr. J. L. Campbell (El Paso & Southwestern):—A good plan would be for the railroad company to provide the foremen with a photograph of a typical transverse fissure. That will give him an ocular illustration of what it looks like. It is not difficult to photograph this kind of failure so that it shows clearly, and it can be plainly blueprinted from the negative.

Acting Chairman Fairbairn:—On the Canadian Pacific we have inserted in our maintenance of way rule book a few pages on the subject of rail failures. They are really instructions to section foremen and Roadmasters as to the use of these forms. They illustrate and elucidate what is required for each of the numbered questions on the forms. They give an illustration of our own scheme of marking, showing from the location and character of the marking—what is the ingot number, what is the rail letter, what is the weight, etc. The sectionmen are given instructions on the whole thing and told what should be reported.

We give further an illustration by photographs of what a transverse fissure is, and we try to educate the foreman to such an extent that he can intelligently fill in these forms, and I believe if that system of advising the trackmen was generally practiced, the form as it now exists is in about as good shape as it can be put.

(Motion was duly seconded, put to vote and carried.)

Acting Chairman Fairbairn:—The next subject is report on rail failures, present statistics and conclusions as to causes, and submit suggestions for improvements in rail steel; continue special investigation of rail steel. Mr. Wickhorst will present that part of the report.

Mr. M. H. Wickhorst:—I am asked to talk on the two subjects, rail failures and investigations. I might dispose of number 3, the subject of investigations, by briefly calling your attention to the work along the line of transverse fissures. The work of the last few years has shown that fissures occur in steel that has been shattered interiorly, that is, the interior of the head contains numerous small cracks which are apparently in the rail at the time it is put into the track; at any rate there is a potential condition leading to shattering and a fissure is a development of one of the small shattering cracks. In other words, the interior of the rail head may have a shattered condition and exhibit millions of cracks from one end to the other, and some of these cracks develop in service and continually grow until they reach the surface of the rail and the rail breaks.

Referring to the paper in Appendix B on the Relation of Shattered Steel in Fissured Rails to the Mill End of the Rail. It has been known that the shattered condition does not extend to the surface, either at the top or the side, but remains about a half inch away, and this particular investigation shows that that shattered condition does not extend clear to the end of the rail as it was hot sawed. It terminates about a half inch away from the end; in other words, it is a purely interior condition, probably due to shrinkage checking.

Dr. Dudley has also presented the results of some of his work covering tests of a great many rails that have failed from fissures. The rails were drop tested and the results have given some very interesting information. One point is that fissures of the type called "coalescent," where there is a horizontal fissure extending lengthwise of the rail, occur largely in the A-rail. The point of origin or point of growth is from a longitudinal streak in the interior, apparently in most cases a streak of slag, or other non-metallic inclusion.

The type of simple transverse fissure occurs mostly in the B and C rails.

Dr. Dudley has also shown that such rails tested head down generally break without showing ductility, but frequently they may show very good ductility. In other words, these rails after they have been in service in the track may show ductile metal in the top of the head. Our belief has been that after a rail has been in service for a while, the top becomes so brittle that if the rail were to be bent with the head down it would break. It has been thought that service would always render the top metal brittle; but the Doctor has shown that the metal may be about as ductile as it was when it was originally laid.

As regards rail failure statistics, you will notice from the figures that when the record first started there were about 400 failures per 100 track miles for five years' service. Coming down to the last year covered by the five years' service, the failures got down to 74 failures per 100 track miles. That is a reduction of over 80 per cent. and a study of the detailed figures that have been given out indicates that it is probable that a further reduction of perhaps 80 per cent. can be made. This is the goal for us to aim at for the next six or eight or ten years, perhaps, although the rails made during the war period promise to give a bad record.

To bring about this further reduction of rail failures is the part of everyone having anything to do with the rail. It starts with the Engineer, who is responsible for the design. Some years ago when thin base sections were used largely, there were large numbers of broken bases or broken rails where the origin was a seam in the base, but that type of break has been largely overcome by the thickening of the base. I would suggest to those roads that are still using A.S.C.E. or other thin base rails, where the rails are in heavy service, that it would pay them to adopt sections with heavy bases.

Then the designer of the specifications has to take a part. The specifications should be so designed as to require good ductility and strength in the metal in the rail. Next the fellow who makes the steel has to take a part. The mill practice, and the methods of manufacture in general should be such as to eliminate such conditions as segregation in the ingot and inclusions of slag. Good practice is required from the making of the steel in the furnace to the cooling and straightening of the rails. Then we get down further to the inspection of the rail. The inspector has an important part. The specifications sometimes permit the inspector to test the rail with either head or base in tension, that is, with the head or base down. The early work of the Rail Committee showed that the results when the rail is tested with the head in tension, correlate pretty well with the interior condition of the ingot; that is, segregation of carbon and phosphorus and large amounts of slag inclusion. With the base in tension, however, the correlation is not so very good. The Bureau of Standards a short time ago came out with a valuable and interesting report, comparing Hadfield sink-head ingots with ordinary ingots and the drop test results also illustrated this non-correlation. The comparison as regards analyses and tensile tests showed in favor of the sink-head ingots, but the drop tests made with base in tension were not. It is safe to say from work of the Rail Committee that if the drop tests had been made with the head in tension, they would have paralleled the other tests.

Finally we get down to the fellow who uses the rail and maintains the track. On some roads the failures at or near the joint are considerable, and it is very probable that that is very largely a condition of rail laying and maintenance.

Acting Chairman Fairbairn:—The last four or five subjects in the report are subjects on which no conclusions have been reached, and we simply offer them as information.

Mr. C. W. Gennet, Jr.:—As one who is continually brought into very close contact with the rolling of steel rails, and frequently with their later use, I feel that some observations of the past year's work may be opportune. In general, the year's work at the various mills has not shown any marked variation from the customary practice employed for several years. Production was low, one mill rolling no rails at all, four others contributing only a small tonnage, and the remaining eight of the United States and Canada rolling at a rate much reduced from normal. Such operations do not, in my judgment, bespeak for the best of quality, for slow operation generally means intermittent rolling with much idle time and gives, therefore, opportunity for the workmen to get out of condition and perhaps become careless, while the effect of interruptions on some of the processes and machinery may easily result in bad quality. As a rule, the best results may be expected when the mills are rolling steadily, with the various details running smoothly with clock-like precision.

Perhaps the most curious fact apparent at the mills is their loathness to adopt any special means aiming toward the casting of sounder ingots. It is practically agreed that the segregated and physically unsound steel occurring in the top part of the ingots is the direct cause of virtually half of the troubles occurring with rails in service, for split, crushed, flowed, and mashed heads are mostly confined to "A" or top rails from ingots. The number of "A" rails constitute, roughly, fifteen per cent. of all that are rolled and, while they all bear a mark of suspicion, still their price is the same as for the less doubtful rails. It required about 2,500,000 tons of ingots last year to produce the 2,000,000 tons of rails rolled. Roughly speaking, ten per cent. of the difference represents the loss due to top discard, a loss having scrap value only and amounting to something like $750,000. If, by as simple a means as casting ingots with their big ends up, the top discard could have been reduced from ten per cent. to seven per cent., there would have been 15,000 tons more ingot metal available for other purposes and a saving of some $200,000 made in the loss due to top discard. Apparently, therefore, an increased yield to the mills of about $700,000, or nearly 30 cents per ton of ingot metal, would have followed the adoption of such a plan and been available to pay for the alterations necessary, while at the same time the quality of the "A" rails would have been greatly enhanced. Casting ingots with their large ends up has been successfully practiced on a small scale and it is surprising that the process is not extended and made common use of with so important a product as rails.

Several mills have recently widened the distance between the supports in the cold straightening presses and as much as 60 inches, instead of 42 inches, is now being used. Needless to say, the results are favorable and it is to be hoped that the practice will be adopted at all the mills and the punishment of the rails in the damaging process of straightening thus reduced.

A continued source of difficulty at most mills is the inability to make every heat of open-hearth steel analyze within the limits of the chemical composition specified for the particular order being worked. Frequently whole heats in the form of ingots or blooms have to be temporarily set aside to be later reheated and rolled on orders which their composition fits. Such cases invariably give rise to an increased number of flawed rails and the practice is manifestly unsatisfactory. Carbon is one of the chief causes of this trouble, and it would be extremely desirable to agree on a common standard to cover the carbon content of all rail steel and thus assist in eliminating a constant annoyance, the cause of which is of more detriment than benefit to the railroads.

It is worth noting that the Bureau of Standards, with a committee of the American Society for Testing Materials, is hard at work on a report covering conditions with respect to ladle test ingots. This important matter has been allowed to drag too long and the final adoption of a standardized ladle test ingot, with the insistance that the prescribed methods for conducting the chemical analysis must be followed, will assist materially in assuring that the steel from one mill is entirely comparable in composition with that from another.

It is difficult to say what specifications for rails are the most commonly used. Definite figures would probably show that the Manufacturer's Standard had been used on the largest tonnage; and following then would come the A.R.E.A. of 1915, often with modifications making it virtually that of the A.S.T.M.; and finally several others of the individual railroads. Practically all these specifications contain the clause governing ductility which requires that the drop test pieces show at least five per cent. elongation in two inches, or six per cent. in one inch. It is interesting to note that our records for the year show only four heats out of something like 600,000 tons that failed to comply with this seemingly important specification requirement. The measurements for ductility are obtained in a slow, inaccurate and expensive manner; reporting the results is equally laborious and expensive, and it is perfectly evident that no particular good comes from the requirement as it exists. The amount that the test piece deflects under the impact of the tup is sufficiently significant of certain physical properties to justify respecting it in place of the doubtful ductility requirements.

The question of interior defects showing at the drop test is important. The rejections at one mill due to interior defects were approximately ten times those at another. Such a diversity of results of course indicates a diversity of practice, and naturally raises again not only the question of making sound ingots, but also the desirability of treating each ingot as a unit and testing it accordingly, as was repeatedly done in war times with shell steel, and is easily accomplished at the Canadian mills on rails for that country.

Much of importance could be said with respect to the year's happenings with rails in track. According to the record, head defects constituted 51 per cent. of the total defects, while the report for 1913 showed that head defects were only about 35 per cent. of the total. No doubt, the increased traffic in the last few years is responsible for the marked increase, but the fact remains, as previously mentioned, that insufficient pains is taken to make, first, good sound ingots and, secondly, to thoroughly and convincingly test them. Internal fissures in rails—transverse, horizontal, and compound—constitute to-day the most serious hazard to which rails are subject. Head defects can be easily detected and such rails removed from track when desired, and it is well established now that the development of certain types of fissures can be detected by careful and painstaking inspection. The known existence of a horizontal fissure is apparently just suspicion for the presence in the same rail of transverse fissures, the danger from which is certainly very great. The investigation of sporadic cases and the experiences of individual roads with fissures has not been productive of information as to the definite cause of fissures. That remains an open question, as is also the railroad man's problem of how best to combat them, and these questions, I believe, will remain open until some positive effort is made to collect and coördinate all existing data covering known cases.

I am not unmindful that a prophet is not without honor save in his own country, nevertheless I dare to venture the statement that good steel cast into sound ingots of proper composition, followed by careful treatment in the soaking pits and rolling mills, may be expected to result in rails of such quality as to safely withstand, when laid on a roadbed of good ballast and ties, the heavy wheel loads of traffic for years to come.

DISCUSSION ON STANDARDIZATION

(For report, see pp. 243-246.)

Mr. E. A. Frink (Seaboard Air Line) :—The report this year is rather short; it has been before the members of the convention for some time and it does not seem to me necessary to read it. Your Committee has no conclusions to report this year, as its work has not progressed to a point where conclusions could be drawn. It hopes in its next year's work to be able to formulate some conclusions to present before you at the next meeting. This report is shown in Bulletin 231, on page 243, and is presented simply as information, but your attention is called to Exhibit A, which presents a list of various items which the Committee has suggested to the Committee on Outline of Work as fit subjects for standardization by the appropriate committee.

Mr. J. L. Campbell (El Paso & Southwestern) :—It would be of assistance to the Committee on Outline of Work and the Board of Direction if there was some discussion by the Committee itself as to what the work of the Committee on Standardization should be and how it ought to be done.

Chairman Frink:—Mr. Yates, I would like to hear from you on this subject, please.

Mr. J. J. Yates (Central Railroad of New Jersey) :—I have in mind the necessity of standardizing some articles. I have principally in mind one subject that is coming up, that has been up before our Association, that is, membership in the American Engineering Standards Committee. It is a very important committee for this Society to be represented on, as there are innumerable questions coming up that will interest the railroads. At the present time we have some voice in that committee, but not as an Association. Our Standardization Committee has suggested that this Association become a member so as to have representation in the standardization of articles that interest railroads.

Chairman Frink:—Mr. Fairbairn, I would like to hear from you.

Mr. J. M. R. Fairbairn (Canadian Pacific) :—I had not expected to say anything on the subject of standardization to-day at all, but I think that one of the most important things before the Association to-day is the question as to whether we are to continue as we have in the past to recommend practice, or whether we are to establish standards. Unless we do establish standards and give them all the kudos that they can have, I doubt if we will ever get the railroads of America to adopt our recommended practice to the same extent that they would if we establish standards. Further than that, I believe that we should keep ahead of the railroads. We are the people who are experimenting and trying out the various devices and articles used in ordinary railway maintenance, consequently we ought to be the people that have the best experience on the subject, and we, if anybody, ought to be able to keep ahead of the railroads and establish standards which can be arrived at if we adopt a spirit of compromise, not insisting upon what one railroad wants, but compromising upon what all roads can feel is right. If we can get together and establish standards on this basis, we are going to have standards which each railroad, when it comes to make changes, will adopt. If we do not keep ahead of the railroads in this matter, we will have to follow some one railroad and use what it has adopted and is having manufactured for it.

Chairman Frink:—Mr. Katte, may we have a few remarks from you?

Mr. Edwin B. Katte (New York Central):—I, too, would speak in behalf of this Association taking membership in the American Engineering Standards Committee. That committee is now formed of but four or five of the National Societies, and it is very desirable that the railroad interests and railroad engineers should also be represented.

The matter was first brought to attention of our Board of Direction a year ago, and met with favor at that time, but we have not yet taken out a membership. A committee of three, I understand, will be appointed by the President to look further into the matter, and I am sure that after they have familiarized themselves with the objects and aims of the American Engineering Standards Committee, that our Association will ask to be represented. Its sole purpose is to unify the requirements of all the various interests that use jointly one specific object or one specific material.

Chairman Frink:—We would like to call on Mr. Ambrose.

Mr. J. R. W. Ambrose (Toronto Terminals):—I believe there should be at least one Bolshevik on the Committee, and I am afraid I am that one. I do not agree with Mr. Katte at all. I think our Association is strong enough and able enough to stand upon its own feet.

Surely we know at least as much (or should know as much) about railroad work as some standardization committee made up of various members from all branches of the technical world, and I think this Association should handle and look after its own standards. I feel that the time has arrived when we should have standards, but it seems to me, the fact that this Association prepares a standard does not necessarily mean it will be used by the various roads; but if the Association could work in conjunction with the American Railway Association, and have the stamp of their approval on any standard we pass, it would seem then that it would be imperative that the standard be used. We all know that the standardization of any article in railroad service spells economy and that economy is the object we all want to attain.

Mr. Katte:—Mr. Ambrose has paid me the compliment of disagreeing with me, so perhaps I may be permitted to speak a little further. I think that the American Engineering Standards Committee wants this Association to join with them, because it is the recognized authority for all Railroad Standards. I do not think that there would be a dissenting voice, nor do I think any other members of the Standards Committee would care to criticize the specifications of this Association for rails, track spikes or other purely railway materials, but there are other articles which we employ largely, and which are also employed to an even greater extent by the other interests. For instance, the specification which we adopted yesterday for insulated wires and cables. The railroads of the country use a great many thousand dollars' worth of insulated wires and cables in a year, but that is only a very small part of the insulated wires and cables used throughout the country by the Edison companies and local lighting companies, traction companies, and for miscellaneous electrical installations. Now, if we can standardize on a half a dozen different kinds of insulated wires and cables, the cost to the railroads and to the Edison companies and to the other companies will be materially reduced.

DISCUSSION ON UNIFORM GENERAL CONTRACT FORMS

(For report, see pp. 247-266.)

(Vice-President Campbell in the Chair.)

(In the absence of the Chairman, Mr. W. D. Faucette, the Vice-Chairman, Mr. C. A. Wilson, presented the report.)

Vice-Chairman Wilson:—There were three subjects assigned to the Committee for attention this year. The first is "Make thorough examination of the subject-matter in the Manual and submit definite recommendations for changes." This subject was handled by a sub-committee, of which Mr. Clark Dillenbeck is chairman, and Mr. Dillenbeck will present this to the Convention.

Mr. Clark Dillenbeck (Philadelphia & Reading):—The Committee has carefully gone over the Manual and made recommendations for certain changes as here shown. The first is "Construction Contract Forms." We propose that the heading be changed to "Form of Construction Contract." In going over the Manual we noticed that the headings varied very much and it was the thought of the Committee it would be well to make them uniform.

With reference to Form of Proposal, page 655, it is recommended that this be placed to precede "(A) Agreement." It appeared to the Committee that this one page in the form is out of place and should be placed preceding the "(A) Agreement."

The next suggestion is Section 30, page 661, change heading and the first paragraph. It is proposed to change the heading to read "Land of Company, Use of, by Contractor." And there is a new proposed form under this heading.

Section 32, page 662, has reference to the annulment of contract and the present reading of it is that the contractor shall be paid for the work annulled. We simply change the reading of the last three lines and say that "payments shall be made for work done on such portion so abandoned, as provided in Section 38 of this contract."

Section 34, page 663, it is simply suggested to omit the words "30 days" from the second and third lines. Under the present reading after a contract has been annulled, the contractor would be permitted to continue the work for 30 days, and it is the thought of the Committee that it is frequently the case when contracts are annulled, work must be stopped at once.

On page 666, change the heading "Bond" to "Form of Bond."

In Bulletin 189 no change is recommended.

In Bulletin 207, "Industrial Track Agreement," pp. 103 to 107, change the heading to read "Form of Industry Track Agreement." The Committee realizes that changes are necessary in the form and regrets that definite recommendations must be postponed to a later date. The principal reason for this is that the matter was under consideration by the Corporate Engineers. I believe they had reported to the executives, and their report had not been approved, and also the Freight Traffic Department were expecting an order from the I.C.C. With these things staring us in the face, we did not see that we could properly go ahead and correct this agreement.

On pages 109 to 115, Agreement for Interlocking Plant, change the heading to read: "Form of Agreement for Interlocking Plant," and omit the whole of Section 9, Wage Rates, page 113.

Owing to the present rules of the Labor Board we thought that it was not compatible with present practice.

In Bulletin 217, Agreement for Grade Crossings, change the heading to read: "Form of Agreement for Crossing of Railroads at Grade." The present heading simply reads: "Agreement for Grade Crossings," and grade crossings are generally spoken of as highway crossings, and it was the thought of the Committee we had better change it as noted. We also suggest omitting the first note which refers to federal control, and change the words "Grade Crossing" to "Railroad Crossing at Grade" in second note under "Whereas," second line, and in Section 3, page 42, under "Construction," second line.

The Committee recommends that the above changes in the Manual be approved and that when the Manual is reprinted the changes be incorporated therein.

(Motion was duly seconded, put to vote and carried.)

Vice-Chairman Wilson:—The second subject is "(2) Report on forms of agreement embodying rules governing the construction of undercrossing of railways with electrical conductors, conduits, pipe lines and drains, conferring with Committee on Roadway and Electricity." This will be presented by Mr. J. C. Irwin.

Mr. J. C. Irwin (Boston & Albany):—The sub-committee on the preparation of this form collected a large number of agreements used by American railroads and of course found a great diversity of practice in the majority of these cases. The specification formed part of the license for wires, pipes, conduits and drains on railroad property, but in some there are other forms of license which seem to better apply to this particular case, and the Committee proceeded on that basis. At the same time we also bore in mind that a paper of this character could be used to advantage for all conduits and wires and pipes on the railroad property, whether they passed under the railroad or not, and the proposed license, as we call it, which was prepared would cover such cases as well as the cases of lines crossing under the railroad.

This suggested agreement is found on pages 254 and 255 of Bulletin 232, and it is presented in tentative form. This is the first time it has been brought before the convention, and while we believe it is approximately correct, it is submitted for discussion—merely as information, with the request that it be laid over until next year for final action.

Vice-President Campbell:—If there are no objections, this subject will be left with the Committee for further study and report. The Committee invites written criticism by the membership during the year.

(Vice-Chairman Wilson read (3) Lease Agreement for Industrial Site, page 248 and 249, and (3) on page 249 under "Conclusions.")

Vice-Chairman Wilson:—I move this recommendation be adopted.

(Motion duly seconded, put to vote and carried.)

Vice-Chairman Wilson:—The recommendations for further work are of course merely tentative, and contain probably more suggestion than will be adopted by the Committee of the Board of Direction, but it was intended, I suppose, largely for their assistance, and to pick out what they want us to do in the future.

At the request of the Chairman of the Standardization Committee, the Chairman sent a questionnaire relative to the work that has been done, and as to its being satisfactory, and those answers are shown in Appendix D.

That closes the report of the Committee to the convention.

DISCUSSION ON SIGNS, FENCES AND CROSSINGS

(For report, see pp. 267-314.)

Mr. Arthur Crumpton (Grand Trunk):—The report of the Committee will be found in Bulletin 232, on page 267, and the reports upon the subjects assigned by the Association will be presented by the Chairmen of the sub-committees which conducted the studies and prepared the reports.

The first subject assigned to the Committee was Revision of the Manual. In Appendix A the Committee submits proposed changes in the Manual, together with the reasons therefor, and I will ask Mr. Rust, Chairman, to present the report.

Mr. T. E. Rust (Waterloo, Cedar Falls & Northern):—Your Committee, somewhat against its inclination, has recommended quite a number of changes in the Manual.

We hesitated to do this, but after carefully studying the matter we felt it was necessary. We did not pay any attention to the subject of signs, which was being handled by another sub-committee, but we left it to them to suggest what changes they thought proper in the Manual as far as signs were concerned.

(Mr. Rust submitted Appendix A, abstracting pages 269, 270 and 271, and said):

All reference to concrete line posts covered by paragraphs 10, 11, 12 and 13, of the specification now appearing in the Manual, we recommend should be omitted, because the specifications for these concrete line posts were largely amended by the conclusions adopted by the Association in 1918. We also felt that a fence with concrete line posts would require entirely different specifications, and that all reference to concrete posts should be left out of this specification for fence with wooden posts.

The Committee recommends that the two paragraphs on page 303 of the Manual headed "Galvanized Wire Fencing" be omitted.

In the first place, they are rather conflicting. In one case they say that an electrically welded fence should be regalvanized after fabrication, and in the second place they say it should be galvanized after fabrication. The second paragraph also says that only wire of the specification of the Association should be used in the fences. That part of it, it seems to me, is entirely unnecessary. The adoption of the specification carries with it the recommendation that it should be used.

As to the regalvanizing of woven wire fencing, it is felt that this is impractical. We have received communications from some of the principal manufacturers of woven wire fencing, and they state a number of excellent reasons why this specification cannot be followed. In the first place, when the wire is to be coated with spelter, it is drawn through the bath at such a speed that it will acquire the temperature of the spelter before it leaves the bath. If that is done, obviously the spelter which is first put on the wire will be melted off during its second progress through the bath, and no more spelter will remain on the wire than remained after the first immersion. In the second place, metal which has been exposed to the atmosphere even for a few moments slightly oxidizes, and in order to be properly coated with zinc, it is necessary that it should be chemically clean. There is no known method of chemically cleaning wire after it has been once zinc-coated so that it will take a second zinc coat.

As to galvanizing after fabrication, I think that if the members will consider what the results would be, even if such a process were practical, they would not desire to have a fence that had been galvanized after fabrication. Large knots of spelter would unquestionably accumulate at the junction of the wires, and when the fence was unrolled for stretching, they would break off, and portions of the original metal would be exposed. At the present time there are no facilities in the United States for galvanizing woven wire fencing, so far as this Committee has been able to discover; the principal manufacturers say that they have no machinery for doing it.

Unless the Association has some criticisms or comments to the cutting out of these two paragraphs, I will pass on to some of the other recommendations of the Committee.

(Mr. Rust read (4) and (5), page 272.)

We had a good illustration of that yesterday when the Committee on Track was making its report. They had a sub-committee, which was studying flangeways for straight and curved track on crossings, and they were apparently entirely unaware that these dimensions for flangeways had already been adopted by the Association.

I believe that that closes the work of this Sub-Committee.

Chairman Crumpton:—I may say in connection with this subject, that the changes, which are rather drastic, call for the elimination of some of the articles and a revision of the specifications for Standard Right-of-Way Fences in order to harmonize the material appearing in the Manual. With that in view I move the adoption of the Committee's conclusions.

(Motion duly seconded, put to vote and carried.)

(Chairman Crumpton read subject (2), Signs, page 267.)

Chairman Crumpton:—The report of the Committee will be found in Appendix B, and I will ask Mr. Batchellor to present it. Mr. Edmondson is Chairman of the Sub-Committee, but he was unavoidably prevented from being present.

(Mr. Batchellor submitted Appendix B.)

Chairman Crumpton:—I may say in connection with this subject that the question of signs has been up for quite a number of years, and the Committee from time to time has recommended individual signs. This year they attempted to cover the whole field, and feel that the signs that have been referred to this morning, together with those that have been recommended by this Committee before, and also those that were recommended by the Signal Committee and adopted, will practically cover the field of roadway signs. You probably will notice that some signs are missing. It was felt that any that are omitted were of minor importance, and could be dealt with better by each road individually. The Committee has endeavored to provide standards for all the signs which it felt would be necessary in the operation of a railway.

The Committee moves the adoption of its recommendation in connection with this subject, which will be found on page 268.

Mr. G. A. Mountain (Canadian Railway Commission):—I would like to ask the Committee why they omit the private crossing signs? My experience is that they are very important.

Chairman Crumpton:—One of the reasons that sign was omitted is that we found the practice on the different roads in the country, both in the United States and Canada, varied so much that we thought it was practically impossible to get anything that would meet the conditions. On some roads they hang up a small sign on the crossing gate and on others a sign similar to the large highway crossing sign is used. Between these two extremes there are all kinds of signs used and on many roads private crossings are not marked by a sign at all. We felt it was a matter that involved considerable expense to the railroads, not, of course, that the expense should be considered unduly, and inasmuch as most of the roads seem to get along without these signs, and those that did use them used them of all kinds, the conclusion of the Committee was that we had better leave the matter alone and let each road do as it chose.

Mr. Hadley Baldwin (Cleveland, Cincinnati, Chicago & St. Louis):—I notice that the Committee recommends a sign for the beginning and end of the double track similar to the sign for the end of a block. The signal is different, and I wonder why they recommend the same kind of sign. They should be distinct, it seems to me.

Chairman Crumpton:—Some time ago the question of signs was brought up and they were divided into two classes—one for the guidance of the enginemen and those having to do with the operation of the road, and the other class for the information of the employees. Those used in connection with the operation of the road were considered the more important and they were dealt with by the Signal Committee, which adopted very distinctive designs, as you will remember. There was a very distinctive design for each kind—the stop sign had the arm horizontal, while the arm of the caution sign was thrown up at an angle. This Committee was of the opinion that these signs should be given great prominence, but that the balance of the signs, those used for conveying information, should be comparatively inconspicuous, and one form of small sign was adopted for information purposes. This sign was used as much as possible without any variation, the idea being to save expense and throw into prominence the signs having to do with the movement of trains.

Mr. John V. Hanna (Kansas City Terminals):—As to the use of the 2½ in. wrought-iron rod provided in some of these signs, I ask whether the Committee has tried to work out a concrete rod for that purpose, and if so, what difficulties they found?

Chairman Crumpton:—As to the question of the 2½-in. pipes, all railroaders learn to use the thing that comes to hand, and on every railroad there are a great many old boiler tubes on hand. In getting up the standard for information signs it was found that a great many roads used pipes, and as they were as cheap and handy to get as anything else, the Committee carried on that idea, and it was approved by the Association some years ago. The matter was gone into pretty thoroughly at the time, and the conclusion reached by the Committee dealing with it, after taking everything into account, that the old boiler tubes and in some cases possibly new boiler tubes were as good as anything that could be used.

Mr. John B. Hunley (Cleveland, Cincinnati, Chicago & St. Louis):—I note that the valuation section sign is a cast-iron sign, and the section post and the sub-division section post, which are practically the same, are of steel plates. I am wondering why that difference was made. Of course, the section posts will be moved more frequently than the valuation section signs, and may be considered as of a less permanent nature, but, on the other hand, when they are moved they will be used again, and used until they are worn out. A cast-iron sign would be more expensive, and I did not understand the significance of the use of different materials.

Mr. F. D. Batchellor (Baltimore & Ohio):—I have not anything special to say on that, other than that we took into consideration that the valuation sign was more permanent and not so frequently used as a section sign. On a great many railroads there would be very few valuation signs, and a lot of section signs, and a valuation sign was of a more permanent nature to cover those roads which might want to establish that practice.

Mr. Hunley:—That is true, but on the other hand the section signs, even if they are moved, will undoubtedly be used until they are worn out. The only reason for it that I can see is that with the cast letters it is absolutely permanent and fixed. I wondered what the idea of the Committee was in recommending this?

Chairman Crumpton:—The Chairman of the Sub-Committee is not here, and that is a detail I do not know about. I know that the Committee felt these valuation signs were permanent, and therefore should be put up once for all; this applies also to the section signs.

Mr. Hadley Baldwin:—Is it part of the recommendation of the Committee that mileposts carry the numbers in both directions?

Chairman Crumpton:—The Committee discussed that matter and got information as to how mileposts should be numbered, and this is given merely as an illustration. It seemed to the Committee that question should be settled, that is, roads should number from one terminal right through, and omit the double number. At a matter of fact since the question of valuation has come into prominence this double numbering is leading to trouble, and I know of one railroad on which they have done away with it and changed from the double numbering, returning to the single numbering, to meet the valuation conditions and save confusion.

The Committee considered the matter, but so many roads have different practices, it was practically dropped, as far as this report is concerned, and we showed the mileposts following the ordinary practice. The designs are therefore merely illustrative and not mandatory.

Mr. E. A. Frink (Seaboard Air Line):—I ask if the Committee has developed any way of permanently marking the concrete posts and concrete signs?

Chairman Crumpton:—You mean in the way of coloring it black? An indentation is made; the letters are indented.

Mr. Frink:—The ordinary wooden post has to be painted periodically. Has the Committee developed any permanent marking for the concrete posts that will not have to be renewed?

Chairman Crumpton:—It is indented and the indentation blackened; it lasts a long time, but in the course of years it will have to be touched up, that is all. It lasts quite a long time, because it is more or less protected, being indented.

The third assignment to the Committee was "on Grade Crossings, Crossing Gates, Crossing Signal Bells, Warning Signals." This matter was assigned to a Sub-Committee, of which Mr. Maro Johnson is Chairman.

Mr. Maro Johnson (Illinois Central):—A summary of the requirements and of practice of the various states and Canada pertaining to width of roadway, grade of approach, etc., so far as the Committee has been able to obtain them, is given beginning on page 288. This matter should have been printed following the specifications on page 287, and preceding the subject of Crossing Gates. The Committee is responsible for the misarrangement.

For highways where the requirements are not stipulated by law, the following specifications, which it is believed will provide an adequate crossing, are presented as information with a view to their consideration at a later date for insertion in the Manual. These specifications are presented with the idea of bringing out the views of the members, and the Committee will welcome suggestions, either oral or written.

The Committee wishes to call attention to the opportunity for reducing the number of grade crossings by judicious coöperation with state authorities in the re-location of existing highways, and especially at this time in which the improvement of highways has taken hold of the entire country.

In correspondence with highway officials, this matter was brought out several times. As illustrating this feeling, I would like to read two or three paragraphs of a letter received from one State Highway Department:

"The Department, as far as possible, is eliminating grade crossings, and, as an example, on one proposed project the old traveled road now has six grade crossings within 24 miles, and the new location will have but one, which it is impossible to cut out, as the railroad travels the state north and south, while the highways run east and west.

"If you will permit the suggestion, I think a little closer coöperation of the railroad authorities and the highway officials would tend to much greater good in the location of highways, and where grade crossings are eliminated possibly at an increased cost to the construction of the road, the company in my opinion should be willing to show some favor to the county or state in return. For instance, on one of our projects where two grade crossings were cut out, it was found that in another place our roadbed extended some ten feet over on the railroad right-of-way. The right-of-way was not marked and the encroachment was not intentional on the part of the Department. The roadbed was completed, and upon taking the matter up with the Superintendent, he recommended to the headquarters that an easement should be granted, but headquarters refused, resulting in the Department having to relocate and regrade about 1,000 feet of roadbed.

"I am giving this just as an instance, and while I know that the elimination of even one grade crossings may save many lives, and is primarily to the interest of those traveling the highway, yet it is of vast importance to railroad companies, and there will be numerous cases where the companies can well afford to contribute a few feet of unused right-of-way in return for the elimination of one or more grade crossings."

The Committee is not informed as to the merits of this particular case, and presents it as an example. I might say that the State of Wisconsin has already given consideration to this feature and empowered the Public Service Commission to assess railroad companies for benefits where grade crossings are eliminated by relocation of the highways.

The matter pertaining to crossing gates, warning signals and bells is given on page 287. It is quite general in its nature and is presented as information. The Committee has not made definite recommendations on this subject.

The information presented at the 1918 convention pertaining to the laws of the various states affecting grade separation and the apportionment of cost of such projects has been revised and is printed beginning on page 291. A bibliography on this subject, prepared by the Engineering Societies Library, appears on page 303.

Mr. C. E. Johnston (Kansas City Southern):—It seems to me that part of the report just read is a very important one, and something in which the members of this Association can accomplish a great deal if organized in some manner to investigate new road projects and ascertain in advance where grade crossings might be eliminated.

Taking our own section, Missouri, Kansas, Arkansas, Louisiana and Texas, they are very active in road building, and while we have not arranged to meet the Commissions in each of the districts, we have been able to find cases where we can bring about grade separation at very low costs, in some cases probably as cheaply as in the crossing of the old route.

If in many cases the management of these lines were advised of points where the roads might be changed, even with little additional cost to the railroads, it would mean saving to the lines. As far as we are concerned, it has put an idea into my mind to canvas the entire territory to see where we can eliminate grade crossings.

Mr. Mountain:—Is it meant, in connection with the matter on page 287, that where a flagman is on duty, bells should not be installed? Our experience is, where we have a fairly heavily traveled route, somewhat dangerous, more particularly traveled in the daytime, we have found it advantageous to put a watchman on and also install a bell. The bell is cut out during the daytime and it is cut in by the watchman for use at night, when the travel is not so heavy as in the daytime. I wonder if the Committee has given that consideration. It has worked all right in our case.

Mr. Maro Johnson:—I think that is the situation the Committee has in mind. Mr. Mountain states the bell is cut out when the flagman is on duty, and that corresponds with our view of the matter—that the bell and the flagman should not be there at the same time.

Mr. Mountain:—The wording says that the bell should not be installed.

Mr. Maro Johnson:—That conveys the wrong idea.

Mr. Mountain:—In connection with page 288, paragraph 2, it says: "On double track lines operation of warning devices is usually in the normal direction only." I would like to ask the Committee if they will give consideration to that. Our view of it is that for wigwags and bells the bonding should be in both directions against the current of traffic, and there you are in a very dangerous position. You are operating a bell in the direction of traffic. You are operating against the traffic and there is no warning there at all. It seems to me if anybody is injured under those circumstances, you are absolutely out of court.

Mr. Maro Johnson:—The Committee found this was the practice on a number of railroads and followed that suggestion with the assumption that traffic in opposite directions is protected by a flag.

Mr. C. F. Loweth (Chicago, Milwaukee & St. Paul):—I desire to congratulate the Committee, especially on that part of the report, Appendix C, which contains an abstract of recent legislation with reference to grade crossing elimination, and more especially to the reference pertaining to the apportioning of the cost between municipalities, states and railroads. I recently had occasion to read into the records of a committee hearing of one of our state legislatures, portions of this report, which showed the trend of recent legislation in respect to the apportionment of the cost of grade separation between the public and the railroads. The trend of recent legislation in requiring a portion of these costs to be assumed by the public is very clearly brought out in the Committee's summary, and is very gratifying.

The Chairman has referred to a recent law in Wisconsin. I assume that he referred to that law which provides that whenever a highway is relocated so as to divert the travel from a railroad grade crossing, or where the grade crossing is eliminated by the separation of grades, that the Railroad Commission may apportion to the railroad such proportion of the cost of the improvement as would represent the capitalization of the protection which the railroad might be required to provide. That law has, in some cases, worked out very unfairly to the railroads, in that it has placed on them the entire cost of a highway improvement, and has left the highway authorities with a very much improved highway at little or no cost. The fair and equitable apportionment of the cost of highway grade separation between the railroads and the public, as represented by the town, county, municipality or state, one or more, is one of very great importance and one that the railroads should keep in close touch with. A spirit of fairness in dividing the costs of improvements of this nature results not only in a larger number of grade crossings being eliminated, but in the improvements being much more satisfactorily made, especially from the standpoint of the public.

Mr. J. L. Campbell (El Paso & Southwestern):—In the matter of coöperation between the railroad and the community on the question of cost of grade separation, the members of this Association can render a useful and just service in their several communities, where this subject is under consideration, by a presentation of the mutual interest and joint obligation existing between the railway and the community.

As a rule, the railway alone is not responsible for the grade separation problem. Generally the communities have built up around the railways after the latter were built, thereby creating the major part of the problem. It is quite proper that the community should assume its part of the responsibility. The railway property should not bear the total cost.

Every member here doubtless has in mind communities along the line of his railway where the growth of the community around the railway has created a multiplicity of grade crossings that did not exist when the railway was constructed.

I believe that eventually the community will understand its responsibility and obligation and will to a considerable extent participate in an equitable distribution of cost, provided it is made to comprehend the mutual interest and obligation existing.

DISCUSSION ON TIES

(For report, see pp. 315-374.)

Mr. F. R. Layng (Bessemer & Lake Erie):—The report will be found in Bulletin 232, starting with page 315. The first subject to be presented will be the revision of the Manual, which will be presented by Mr. Foley, Chairman of the Sub-Committee.

Mr. John Foley (Pennsylvania System):—On pages 317 to 319 are the recommendations of the Committee on Ties for the revision of the definitions in the Manual; mostly additions, but several corrections, and some omissions.

Chairman Layng:—I move, Mr. President, that that portion of the revision of Manual, shown under Appendix A, on pages 317, 318 and 319, down to "Specifications" be adopted for printing in the Manual.

(Motion duly seconded, put to vote and carried.)

Mr. Foley:—On pages 320 to 323 is summarized the material gathered by the Committee on Ties in its consideration of a specification for cross-ties. The recommendations based on a study of past and present standards and of the present and prospective requirements are on pages 328 to 332. This specification for cross-ties is in the standard form prescribed by the Board of Direction, and the consequent slight rearrangement of its matter makes the specification seem somewhat unfamiliar at first glance.

(Mr. Foley then read the chapter and paragraph headings, pausing after each long enough for comments or queries to be made, and said in reference to "Inspection"):

This whole chapter is a departure in a specification for cross-ties, but it is the judgment of the Committee on Ties that it is a development which improves the specification very much. It brings to the manufacturers as well as to the railroad the standard practices which have been evolved to govern tie inspectors and which have been successfully tried out during recent years.

The Committee on Ties desires to substitute for the last and the fourth last paragraph under "Inspection" the following:

"The lengths, thicknesses, and widths specified are minimum dimensions. Ties over 1 in. and under 2 in. more in thickness than the maximum specified will be accepted as one grade below the largest tie specified. Those 2 in. to 3 in. more in thickness than the maximum specified will be accepted as two grades below the largest tie specified. Those over 3 in. more in thickness or width or over 2 in. 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."

The combining and recasting of these paragraphs do not alter the effect of the specification as it was printed. The change not only expresses our meaning more clearly; but makes it possible to apply the degrading rules to ties purchased by a railroad which objects to sizes larger than Grade 3. As the rules were printed originally, a railroad that desired ties no larger than Grade 3 or Grade 4, could not apply them without alterations.

On page 331 is the chapter covering "Delivery;" on page 332 that covering "Shipment."

Mr. F. J. Angier (Baltimore & Ohio) :—I would like to ask the Committee if they have any objection to changing some ties from group T-c to group T-d? I ask this because we classify gum with the softer ties.

Mr. Foley:—Are you speaking for the Committee on Wood Preservation? Have they considered the matter and do they recommend a change?

Mr. Angier:—I do not know that they have considered it, but from our treating standpoint it would be a very good change to make.

Mr. Foley:—The Committee on Ties thinks that if changes are needed in the groups of ties which have been standard for several years, the Committee on Wood Preservation would have studied the subject and acquainted us with their opinions. Since they have not done so, we believe the groups which have prevailed should continue.

Mr. W. G. Arn (Illinois Central) :—In the paragraph on resistance to wear, I would like to ask what we are to do in the case where a railroad uses loblolly and woods of that kind—where they are used quite extensively.

Mr. Foley:—The specification does not bar the acceptance of any tie that any railroad might believe it can use for some purpose, whether unsound, small, sappy, or of coarse wood. It provides a designation for each character and size of tie. Ties of coarse wood are identified and distinguished for the benefit of the railroads which desire to use them as much as for the benefit of those wishing to use ties of compact wood only. In restricted localities a railroad may have to order ties of coarse wood to get a sufficient local supply, which is not to the discredit of either the forest or the railroad, but as a general proposition there is no justification for fear that the requirement for resistance to wear will curtail the supply. Ties otherwise fit for acceptance which do not meet the revised rule for compact wood are not common throughout the country.

Mr. C. F. Loweth (Chicago, Milwaukee & St. Paul) :—Under the heading "Kinds of Wood," it would seem to answer the same purpose as the present wording and to make the specifications much more definite and explicit if for the first two lines the following were substituted: "Cross-ties of the following kinds of wood will be accepted." Each particular railroad would then include the kinds of wood it would accept for ties.

Mr. Foley:—The Committee on Ties regard its recommended specification for cross-ties as a general one of universal application which will be widely circulated. While each railroad will list in its issue of the standard specification only the kind or kinds of wood it will purchase in ties, some railroads buy over extensive territory, often in several sections producing similar ties, but each used by a given railroad for its supply of only one kind of wood. The manufacturer of ties who know only that a certain railroad uses ties of woods that he can cut might begin the production of them and end by finding some of his trees are not saleable when converted into ties because the railroad he had in mind gets a full supply elsewhere. Our aim in the expressions with which the chapters "Kinds of Wood" and "Dimensions" are opened is to have makers of ties first find out from railroads what the latter desire in individual cases, and thus avoid disappointment and dissatisfaction.

Mr. E. A. Frink (Seaboard Air Line):—Mr. President, I would like to call to the attention of the Committee that we have this year presented to us three specifications for ties; this present one; Committee on Wooden Bridges and Trestles (on page 527 of Bulletin 233), Bridge Ties, and on page 513, Sawn Ties and Guard Rails. It seems to me that these specifications should be made to harmonize before they are presented.

Chairman Layng:—The Committee felt it was certainly not the province of the Committee on Wooden Bridges to present specifications for either cross-ties or switch-ties. We feel that it is the duty of the Tie Committee to handle that, and if they have presented a specification, we feel that they should withdraw it.

Mr. Foley:—On pages 332 to 335 is summarized the material gathered by the Committee on Ties in its consideration of a specification for switch-ties.

Since switch-ties are used as are cross-ties, we believe the specification for one should correspond with that for the other as far as possible. This principle prevailed in the adoption of the existing standard in 1916. The revision we recommend follows the standard form for a specification prescribed by the Board of Direction.

(Mr. Foley then read the chapter and paragraph headings, pausing after each long enough for comments or queries to be made, and said in reference to "Design"):

The bills of material for sets of switch-ties are omitted this year because the Committee desires more time to consider the variations in length which prevail under present practices. A study of the data in Table 2 and of the standard plans for frogs and switches by the Committee on Track which were adopted last year should make possible acceptable standard bills of material for switch-ties.

Chairman Layng:—Mr. President, I move the adoption of the specification for cross-ties and the specification for switch-ties for printing in the Manual.

(The motion was duly seconded, put to a vote and carried.)

Chairman Layng:—The next subject assigned to the Committee on which to report this year is shown in Appendix B, page 336, and will be presented by Mr. W. A. Clark, Chairman of the Sub-Committee.

Mr. W. A. Clark (Duluth & Iron Range):—A year ago the Association approved of the test section method of collecting data on the life of cross-ties. This Committee was asked to report on methods of installing and keeping records of test sections. It developed from the information received by the Committee that while many roads have installed test sections, there is no uniform method adopted for installing or keeping the records. With a view of promoting uniformity, the Committee had formulated the recommendations found on pages 337 and 338. The Committee would be glad to have recommendations and criticisms of these forms with the idea in mind that if desired they could be revised and presented next year for printing in the Manual.

Mr. Angier:—I would like to suggest that in Form No. 1, page 339, they leave a line for the average annual rainfall. It seems to me this is a factor that should be considered in any test tie section.

The President:—The Committee say they will take that suggestion under consideration.

Chairman Layng:—Appendix C, page 341, in the absence of Mr. Burton, Chairman of this Sub-Committee, will be presented by Mr. Palmer.

(Appendix C was abstracted by Mr. Palmer.)

Chairman Layng:—Appendix D will be presented by Mr. Riegler, Chairman of the Sub-Committee.

Mr. L. J. Riegler (Pennsylvania System):—This report is the usual one on the experience of the railways with substitute ties under tests. Following the policy adopted by the Tie Committee some years ago, this does not disclose new inventions of ties, but is limited entirely to the ties under test on the different railroads. It is presented as a matter of information.

DISCUSSION ON IRON AND STEEL STRUCTURES

(For report, see pp. 375-404.)

Mr. O. E. Selby (Cleveland, Cincinnati, Chicago & St. Louis):—(Mr. Selby presented (1) Revision of the Manual on page 376.) You will recognize the distinction between rating existing bridges and the classification. Rating is figuring the unit stresses and deciding the capacity of the bridge. The classification is the assembling of the bridges on a railroad or on a division, together with the classification of the locomotives to be operated, and putting the information in the hands of the Transportation Department, so that it may be available in assigning locomotives to the division, and for operating locomotives and other loads in emergency. The conclusion on this subject will be taken up later at the proper point.

(Mr. Selby read (2), (3) and (4) on page 376, and said):

I want to emphasize this last sentence. It is the biggest subject and possibly the most important after the specifications for steel bridges that the Committee has ever undertaken. We expect to devote most of our time this coming year to it, and if we get the right kind of coöperation from the members of the Association, we hope to be able to make a final report.

I might say with regret that the loss of our member, Mr. W. H. Moore, who was Chairman of this Sub-Committee, has also operated to delay work on this subject.

(Mr. Selby read (6), (7) and (8) on page 377, and referring to (8) said):

On this subject we expect to coöperate with and receive considerable assistance from the committee of the American Society of Civil Engineers appointed recently to prepare specifications for bridges. The duty of that committee covers the entire subject of bridges. This Committee is represented on the American Society's committee by three able members, and the spirit of coöperation between the associations has been very gratifying.

Mr. Selby read (9) on page 377, and said):

This is a new subject, and the Committee is working in coöperation with the Committee on Electricity. The subject was assigned by the Board of Direction.

(Mr. Selby read Conclusion (1) on page 377, and said:)

Before moving the adoption of this conclusion, I want to read some changes which the Committee agreed at its last meeting to offer at this convention:

Page 379, Article 3, fourth line, the word "unusual" before "eccentric" should be moved to a position before the word "secondary."

On page 380, the top of the page, at the end of Article 6, add the sentence: "Where maximum live load stress is produced by heavy cars or electric locomotives, impact stresses shall be taken as one-half of those given by the formula above."

At the bottom of page 380, in the definition of the small letter "l," the words "in inches" should be inserted after "length."

The next to the last line on page 380 should read: "b equals flange width in inches."

On page 381, Article 11, has two insertions. I will read the whole article as it should read: "In members subject to stresses produced by a combination of dead load, live load, impact, centrifugal force, and eccentric application of dead and live load, with lateral forces or bending due to lateral action, unit stresses 25 per cent. greater than those given in Article 10 may be followed; but, in such cases, the unit stresses due wholly to dead load, live load, impact, centrifugal force, and eccentric application of dead and live load, shall not exceed those given therein."

At the end of Article 14 add: "When these limits are closely approached, or when the physical condition of the structure is not good, it shall be kept under close inspection as long as it is continued in service."

The purpose of this last addition is to emphasize the fact that it is not the intention to keep indefinitely in service structures in which these unit stresses are closely approached. With these changes I move the adoption of Conclusion No. 1.

Mr. John B. Hunley (Cleveland, Cincinnati, Chicago & St. Louis) :— I was particularly sorry that there was not more discussion given after Bulletin 228 was sent out. To my mind this is really more important than the specification for designing. There are a good many good specifications for designing new structures in circulation, but there seem to be varied ideas as to the rating of old structures.

The rating stresses and designing stresses are not consistent, for instance, for open-hearth steel the designing stress is 16,000, rating stress 26,000, an increase of 62½ per cent. Tension extreme fiber of beams, designing stress 16,000, rating stress 24,000, or 50 per cent. increase. Compression in flange of girders and I beams, rating stress is 87 per cent. higher for a small ratio of $\frac{L}{B}$ such as 6 and is 100 per cent. higher for ratio $\frac{L}{B} = 20$. For shear in webs the rating stress is 80 per cent. higher than the designing stress, etc. In other words, if we were to design a bridge for E-60 under our new specifications and rate it to-morrow, we would find one portion of the span would rate E-90 while the other portions would rate E-120.

It seems to me the permitted stresses are quite high, considering that even with the best inspection we cannot always find out the true condition of the bridge. We are permitting under this proposed rating method stresses of 22,000 lb. for axial tension, net section, that is, for wrought-iron or Bessemer steel.

A good many tests have been made and some that were made at the Watertown Arsenal, I think in 1888, or at some time when wrought-iron was in common use, gave the true elastic limit on ⅜-in. sections as 32,000 lb. and the apparent elastic limit 40,000 lb., and I find that on the 2-in. sections the elastic limit dropped, as the weight of the section increased, to 16,500 lb. true elastic limit, and 23,000 lb. apparent elastic limit.

I think we are going pretty far in recommending such high stresses, particularly in old bridges of wrought-iron and Bessemer steel. It is, to my mind, practically impossible to determine all the defects of a bridge by any inspection which will ordinarily be made, and I hope before these are finally adopted we will have a rather broad discussion of the subject.

Chairman Selby:—I will answer Mr. Hunley's first point in which he called attention to the inconsistency between the stresses by saying that in this case the designing stress is the one that is inconsistent and the proposed rating stress is correct. I will have to admit that the designing stress in Article 48 of the Specifications is too low and is unduly conservative.

Mr. E. A. Frink (Seaboard Air Line):—This subject the Committee has handled is possibly the most important one that ever comes before a Bridge Engineer of a railroad that has any old bridges. It is a subject that has been discussed by Engineers, not only before this convention, but among themselves a great many years. It probably calls for the exercise of more judgment than almost anything else connected with bridges. Now, these values that the Committee has put forward, as I read them, seem to me to be about in line with practice of Bridge Engineers whom I have learned to look up to as the heads of their profession, as men who know better, perhaps, than anyone else what a bridge can carry. In other words, they are values that have been proven by experience, by actual use, to be safe and conservative.

At first sight it looks as though a stress of 20,000 lb. on ordinary iron is too large, but there are a number of factors that come into play in figuring the safety of carrying capacity of an existing bridge, which we cannot put down on paper, for which we can find no definite algebraic expression. In every structure that is at all well designed, every part will help out—almost every part will help out another part. We have all of us seen instances where bridges have carried traffic safely with a part entirely gone. In my own experience I have seen a bridge with the end post broken in two still carry traffic. I will not say that it carried ordinary traffic, but it carried traffic. I have seen bridges with the first main diagonal broken in two and still carry traffic. Of course, we can only explain that by saying that the adjacent parts really carried the load, but they carried it, and I should be very sorry to see the Committee reduce these stresses. I think the stresses as the Committee has put them up are very easily defensible.

Mr. C. F. Loweth (Chicago, Milwaukee & St. Paul):—I am in accord with the expressions of the first speaker in this discussion and do not agree with the remarks which have just been made. The older bridges with which railroad engineers have to deal with were, in many cases, not well designed and frequently the material in them is more or less uncertain in quality. Bridge material was not as good 20 and 30 years ago as it is to-day, and probably was not as thoroughly inspected and tested; in some cases there is no record, or at best but a poor record, of the character of the workmanship and the quality of the material, such as it was.

In my own practice, I have on occasions found it necessary to carry in service old structures with unit stresses fully as high, or perhaps higher, than those recommended by this Committee. Where this has been done, it has followed careful inspection of the structures and investigations as to the loads which could safely be imposed, and precautions have been taken to see that these loads were not exceeded. Such structures have been inspected much more frequently and thoroughly than is generally the practice, and the fact that structures of that character were in service was not allowed to be overlooked, and preparations were made for the replacement of such structures as quickly as could be.

However, it is not always possible to promptly replace structures which are overstressed; it may even be necessary at times to carry them longer than intended on account of other improvements which may be pending, such as second track, change of grade or other changes which would affect the design of the new structure. In our own practice we have had to guard against a tendency to assume that the structure was and would continue to render proper service so long as restrictions of speed and weight of traffic over it were not exceeded. Such a position would, of course, be wrong, but in a large organization where there might be many structures in this class, the tendency in this direction is possible and must be guarded against. For all of these reasons it would seem desirable not to go to the high unit stresses referred to in the Committee's report, but to specify them somewhat lower so that the structures to which they apply will not come in the category which should be immediately strengthened or replaced. I realize that the corrections or modifications that the Committee has just made were with the view of making it clear that the specifications were not intended to apply to bridges to be carried indefinitely in service. It seems to me that these do not place sufficient emphasis on the fact that structures with such high stresses, notwithstanding additional supervision and inspection, will not be desirable structures to retain in service.

Chairman Selby:—It seems to me that Mr. Loweth has answered himself. The addition to Article 14, which I read, and which Mr. Loweth called attention to, I think covers the case precisely.

(Mr. Selby read Article 14, page 389.)

If it is admitted, as Mr. Loweth seems to admit, that these stresses are safe under close inspection and watching, I do not see why we should not say so and go on record.

Mr. Hunley:—That is one of the points I have in mind. We have practically gone the limit on stresses and at the same time depend on each and every instruction here given being followed out. We all know that is not always the case. I think we should allow a little leeway for some such oversight as that.

Mr. Loweth:—Perhaps the Committee would be willing to lower the proposed unit stresses, changing the limit of 26,000 lb. to 24,000 lb. and other stresses proportionately, and add a clause to the effect that there would not infrequently be occasions which for various reasons would justify the continuance in service of structures exceeding the unit stresses given up to a maximum of 26,000 lb. for axial tension on steel, and other stresses proportionately, providing all such structures were in line for prompt replacement, and meanwhile were supervised and inspected with more than the usual thoroughness. If the specifications were so modified, it would allow a larger margin of time for renewals or strengthening and would place a greater emphasis upon the responsibility for maintaining a structure with high unit stresses.

Mr. G. H. Tinker (New York, Chicago & St. Louis):—I think it would be a mistake to adopt a lower unit in the specifications and then remove that limit by a permissive clause. In that case we have no standard whatever, simply the judgment of the man. When his successor or someone else looks at the question his judgment may be different. We would thus have no standard guide, and be worse off than with no specification whatever. I think the better procedure is to adopt a top limit beyond which we should not go, and to use units somewhat lower in particular cases, rather than to adopt a limit beyond which we may go under certain conditions. In line with that I feel that paragraph 110 is a mistake and should be omitted. Let the unit stress be fixed at a limit beyond which we may not go, and omit all provisions for a permissive stretching of those limits which this paragraph evidently does.

I am aware that the combination of stresses which is indicated, does not apply upon every application of the load, but it is applied with more or less frequency, and when so applied we are stressing the material beyond the limit which we considered safe. We do not know just how far beyond that limit the stress might go in a particular instance. I think to adopt such a practice would be unsafe.

Mr. John V. Hanna (Kansas City Terminal):—The suggestion of the last speaker is very good. I know that it would be helpful to some of us, who do not specialize in bridge work, if there could be an ultimate limit beyond which we should not go in continuing an old bridge in service.

Mr. J. R. W. Ambrose (Toronto Terminals Railway):—May we have a statement of the practice on the Canadian Pacific, by Mr. Motley? That may be helpful.

Mr. P. B. Motley (Canadian Pacific):—The units suggested by the Committee, I think, are about correct as general practice, but as has been mentioned on other occasions, no set of rules, however good, is intended to take the place of a qualified Engineer. In addition to technical specifications, common-sense must be brought to bear, and I am almost inclined to believe that after all much reliance should be placed on the extensometer, which should be used freely, as computations are not necessarily a true criterion of existing conditions. We have adopted, on the Canadian Pacific, stresses generally in accordance with these recommendations for the systematic classification of old structures, for over twenty years. I think, however, that structures, which have been subjected to physical injury should receive special consideration, and in such cases only the judgment of the Engineer can decide what variation should be made for the overload, which would otherwise be permissible. This brings up the question of the responsibility belonging the man whose duty it is to call a halt to the continued retention of overloaded spans in service, and it requires personality of considerable weight to bring home to the management of a large railway corporation, especially in these times when the idea of spending considerable large sums of money is not relished, the view that the continued overstress of steel structures beyond the limits for which they were designed is not intended to be permanent. I think this fact cannot be too prominently kept in mind.

Mr. O. B. Robbins (Interstate Commerce Commission):—I find myself in close agreement with the last speaker in regard to the use of the extensometer in determining stresses. Some years ago when I was connected with the Great Northern Railway, we tested the spans in the Columbia River bridge in the state of Washington. We found our computations on the truss members checked closely with the extensometer tests, but there were other members where we found stresses far greater than we had anticipated, especially in the end floor-beams of the long spans. There was one 250-foot span and one 416-foot span in the bridge. We found by the extensometer compression stresses and also tension stresses, in the end floor-beams as high as 29,000 lb., while there were only 21,000 or 22,000 lb. in the truss members.

Any Bridge Engineer will recognize that this condition was due to the secondary stress developed by the extension of the lower chord under stress, with the lack of proper provision for slip joints in the stringers; but it illustrates the fact that the computations do not take into account within several thousand pounds to the square inch the stresses that may be developed in floor-beams.

There is one question I want to ask in regard to these specifications. It seems to me that no provision is made for carrying structures by reducing the speed limit of trains over the bridge, which could be done by reducing the impact stress by an arbitrary limit of speed. Has that matter been considered?

Chairman Selby:—Article 7 provides for limiting the speed.

Mr. Robbins:—That covers the point.

Mr. Loweth:—The report refers to absolute control of speeds. Does the Committee think there is such a thing as an absolute control?

Chairman Selby:—The Committee thinks there is, in the sense used here. There are places where physical conditions at the site limit the speed, and there are other conditions where an operating control that is practically certain may be secured. We do not want to go on record as advocating a reduction in impact in cases where the speed is not controlled by anything better than a train order.

Mr. Loweth:—The point is, I think, that we carry certain bridges because we minimize the effect of the load upon the structure by arbitrarily restricting the speed of trains. Sometimes these speed restrictions, because of location, grade or other conditions, are easily enforced, but in many cases the restriction is purely arbitrary and is difficult of enforcement with certainty. If these speed restrictions are not adhered to, the unit stresses may be very largely increased, and the Committee's recommendations do not provide a sufficient margin for contingencies of this kind.

One of the last speakers said he thought it was desirable to have definite unit stresses which could be considered safe, because there were many railroad engineers, not bridge engineers, who might have to determine the question of continuing old structures in service, and would be glad to know just how far they could go in matters of that kind. This, I think, is the danger of the situation—that the specifications in question will lead to the belief that they can be used with impunity. I do not think that is the case. The tendency with a specification of this kind will be that in many cases the determination of the safe carrying capacity of an old structure will be put up to the drawing room, and men perfectly competent to compute stresses, but without experiences as to the practical effect as to the action of overstressed structures, will determine the question perfunctorily on the basis of whether the specified unit stresses are or are not exceeded by any given load, and there is danger that his decision may be perfunctorily accepted. I think there may be many cases where the Bridge Engineer ought not to be required to assume the entire responsibility of carrying a structure stressed as high as these specifications permit; that the responsibility in such cases should be shared with the Chief Engineer, and possibly with the management. If low unit stresses are fixed in these specifications, what would happen? Not necessarily that when a bridge is stressed to exceed these limits, that it is thrown out of service, but that it had the special consideration of the Bridge Engineer and others, and it was so hedged about with such precautions as would insure its proper attention. This would seem to be simple justice to the Bridge Engineer, his immediate superiors, to the railroad they serve, and to the public.

Chairman Selby:—If anyone puts these rules in the drafting room and leaves them there without any other responsibility he is doing a very unwise thing and certainly it is not the intention of the Committee that the rules should be so abused. Mr. Motley calls attention to the fact that no set of rules can take the place of the personal responsibility of the Engineer.

Article 1 certainly cannot be complied with in the drafting room. "In fixing the carrying capacity of any bridge for traffic, its location, design, material, workmanship, behavior and physical condition must be taken into account." No one can tell in the drafting room what the behavior of the bridge is.

Prof. W. M. Wilson (University of Illinois):—The discussion of the rating of old bridges has centered to a considerable extent, at least in the written discussion, on the life of the bridge under high stresses. We seem to be pretty much in accord that for a comparatively short time a steel structure can be subjected to stresses of 24,000 to 26,000 lb. per sq. in. without danger of failure. The question in which we are interested is, how long will the bridge continue serviceable under these excessive stresses. Our work on fatigue of metals has demonstrated that as far as the physical properties of the material itself is concerned, we have very little reason to fear that the material will deteriorate. A stress of 24,000 to 26,000 lb. for steel in tension is below the stress which will cause failure due to a large number of repetitions.

Furthermore, I think it is our experience that where a bridge shows signs of weakening it is not because of the deterioration of the metal, but because of the working loose of the parts that are connected. In other words, it is the joints which make us expect trouble, as the bridge is subjected to continuous service at these high stresses.

Tests of riveted joints have demonstrated that as the stresses increase, the members that are connected slip relative to each other at a stress below the stress that is used in design. This deformation is the slipping of one piece upon another and is not an elastic strain.

We would naturally expect, then, that if this slip is repeated a large number of times that some wear will take place and the joint become loose, for we know the joint holds not by virtue of the strength of the rivet in shear, but by virtue of the friction between the plates induced by the tension in the rivet.

The Experiment Station of the University of Illinois has tried to determine the effect of repeated stresses upon riveted connections. While we do not feel that these tests have been carried far enough to prove anything definitely, I would like to present to the Association some of the indications of our tests.

For one thing we find that repeated stresses, in which the stress is only one-half as great as the A.R.E.A. specifications permit us to use in design, will work the rivets loose if the stress is repeated a sufficient number of times. This result was obtained with a reversal from 3,000 lb. per sq. in. in one direction to 3,000 lb. per sq. in. in the other direction, will loosen the rivet.

In the new specifications for old bridges it is proposed to increase the allowable stress on rivets approximately 80 per cent. The tests which we have made indicate that such a stress will loosen a rivet, not in two or three reversals, but in a few hundred reversals, so that the passing of the trains for a period of one or two or three years will cause the rivets to work loose. Therefore, in the rating of the old bridges I think we should focus our attention upon the effect of the overstresses upon the rivets rather than upon the material itself. Because tests have demonstrated that the stress imposed will not injure the material itself, but the stresses proposed will loosen the joint. So it seems to me the point we should study is the effect of the overstresses on the riveted joints, and the possibilities of strengthening the joints without necessarily replacing the members.

Mr. Albert Reichmann (American Bridge Company) :—There were several good points which were brought out in the discussion of these specifications. I don't agree with Mr. Loweth's statement that it is undesirable to fix an upper limit for refiguring old bridges. In case the Chief or Bridge Engineer does not feel warranted in having his subordinates pass on bridges which are figured to the upper limit, he could inaugurate a rule in his office whereby any bridge which figured within, say 10 or 15 per cent of the upper limit—should be referred to him for special consideration and investigation.

The question was raised this morning regarding very thick eyebars. Where exceptionally heavy material is used, the unit stresses must necessarily be reduced in proportion. In going beyond two inches in thickness in steel eyebars, the strength of the material decreases very rapidly. I am not in favor of using too heavy material and I think the point well taken. In other respects, I believe the specifications conform to modern practice for refiguring old structures.

Mr. F. E. Schall (Lehigh Valley) :—I desire to support Mr. Loweth's contention. If I remember correctly, Mr. Loweth, several years ago, prepared a table of permissible unit stresses for existing bridges; I believe these unit stresses were about the same limit as those presented by the Committee. Evidently Mr. Loweth has experienced some difficulties in the use of such unit stresses and now feels that we should be more conservative.

I feel that the permissible stresses proposed by the Committee are higher than the organization should support, indicating thereby that it is perfectly safe to use bridges to the extent proposed by the Committee. It is not always possible to find the weakest point in a bridge by careful inspection.

Wrought-iron, as generally used for bridges, has an elastic limit of from 26,000 to 28,000 lb. per sq. in.

I think it was demonstrated by Woehler that the elastic limit need not fully be reached to cause failure by a great number of applications of loads causing stresses near the elastic limit, and, considering all the features of present day operation, I think we ought to be more conservative in the rating of structures built of wrought iron during the early eighties, when the details were not what to-day is considered good design.

Chairman Selby:—These rules are not intended to be put out for indiscriminate use by inexperienced men. They are intended only as a guide for an experienced Bridge Engineer to use in passing on the safety of the bridge, and the necessity for keeping it in service. If articles 1, 2 and 14 of the rules are not strong enough on that point, it might be well to make them stronger, but it should be kept in mind all the time that there is a great deal in passing on the capacity of an old bridge besides the figuring. The figures are only one of the means used to arrive at the capacity of the bridge. The other things are the physical condition, the design, details, material and the general knowledge and judgment of the Bridge Engineer. I think it might be well to add to these rules something stronger to that effect.

The Committee has just received a written discussion from Mr. Hans Ibsen, of the Michigan Central Railroad, which I will not take the time to read, but Mr. Ibsen thinks the unit stresses in wrought-iron are too high.

One more change has been suggested by a member of the Committee and if there is no objection from members of the Committee I will offer it as an additional change in the rules as printed.

On page 380, Article 10 reads: "Tension in extreme fibers of rolled shapes (except rolled beams);" the suggestion is to add to the exception "channels" so that it will read: "(except rolled beams and channels)," and similarly in the following line, "Tension in extreme fibers of rolled beams and channels." The unit stresses penalize rolled beams as against other rolled shapes, and the desire is to include channels in that penalization.

Mr. H. Ibsen (Michigan Central—by letter):—I think the unit stresses specified by the Committee are too high, especially those applying to trusses and in particular those applying to iron truss members. I have in our records a report of full-sized tests of iron eye-bars, for a bridge built about 40 years ago, and the ultimate tensile strength of these bars is only 41,280 lb. and the elastic limit is only 24,200 lb. per sq. in.

The specimen tests for part of the structural shapes used in important members have an elastic limit of only 26,200 lb. For this particular structure I have also some strain gage readings on eye-bars and built-up members, which in some cases show a variation of 20 per cent. for some eye-bars, above the average unit stress of all the eye-bars of the same member of the bridge, and the same variation for various parts of built-up members. These members are not subject to marked secondary effects and there is no apparent reason for the difference in unit stresses, it is simply caused by accidental variations in material and workmanship such as one must expect in the ordinary run of work and which can not be detected by inspection, after the bridge is built.

I believe that there are still in existence a good many bridges built 30 or 40 years ago in which the same conditions mentioned above exist. With a unit stress of 22,000 lb. in the bars to start with and 20 per cent. added for uneven distribution the bars referred to above would be stressed to the elastic limit which is evidently too high. I realize that the stresses proposed by the Committee are the same as those already given, for "Classification of Bridges as to Safe Carrying Capacity," in the Manual. As stated there, however, attention is clearly called to the fact that these high stresses cannot be imposed on a structure with impunity, (note: line 3, article 1, and line 5, article 2, on page 506 of the Manual), while the rules and unit stresses as given in Bulletin 232 are more in the form of a specification and do not give one the impression that the stresses there proposed are out of the ordinary at all.

I think that in most cases a straight, unreserved statement is the best, but in this case I do not think that it is safe to give it with the high unit stresses proposed by the Committee. It also seems to me that there is some inconsistency between the unit stresses proposed for rating existing bridges and those given for designing new bridges. If it is safe to run, unrestricted and for an unlimited length of time, a loading over our old bridges that will produce the unit stresses given in Bulletin 232, it certainly looks as if the unit stresses used for designing new bridges are too low.

I would like to see the unit stresses for axial tension reduced to 24,000 lb. per sq. in. for steel and 20,000 lb. per sq. in. for iron and those for compression members and other truss members reduced in proportion. The stresses for girders are higher than I would like to see them, but girders will stand overstrain and give more warning than truss bridges so that for this reason I have less objection to the unit stresses proposed for them.

I think that attention should be called to the fact that bridges operated under these high unit stresses need frequent inspection and that their life will be shortened.

Mr. B. R. Leffler (New York Central):—The criticism has been made that these unit stresses are too high. In connection with that I think it might be well to call attention to the secondary stresses, which usually or quite often are not included in the calculation of stresses in bridges. The Committee in recommending these unit stresses had in mind that every legitimate or possible stress was to be calculated. I think that in the past many of the bridges have been rated on what is known as the axial stress, that is, the primary stresses were calculated and then a rating based on them, but in view of the fact that the Committee has distinctly stated that all stresses of whatever character are to be included, it seems to me that the so-called high unit stresses are justifiable. I think we should remember that these recommendations are not to be thrown into the drafting room and stresses calculated and a ruling given on that perfunctory operation. The specifications distinctly call for an exercise of judgment, and it is not intended that the Bridge Engineers will simply take these rules and pay no further attention to the structures. They are supposed to watch the structure in the light of what they have found in the field as well as in the office. I notice that while these stresses have been criticized as being too high, no one has suggested lower stresses. We should have constructive criticism as well as destructive criticism.

Mr. Reichmann:—These specifications are drafted for well designed structures. At present there are many structures which were designed for lighter loading than at present, which, however, were well designed. As the loading increases, we will continue to have a number of well designed structures to refigure for heavier loading. It is, therefore, desirable to have the maximum unit stresses to apply to bridges which are well designed. In cases where the structures are not well designed, the unit stress must be reduced to take care of the imperfections in the design.

Mr. Leffler:—I think it is impossible to recommend limiting stresses for poor design. If a design is so poor that the defective details, such as eccentric connections and unsymmetrical spacing of rivets, cannot be calculated, you must rely on your judgment anyhow.

Mr. Tinker:—I think stress should be laid on the interpretation of the specification and the physical condition of the structure. Its behavior under traffic should be considered of primarily greater importance than the stresses which may be computed.

As to the matter of the repetition of stresses which has been mentioned, where there is a reversal of stress. The majority of the members in a structure will not have reversal of stress, and those that have will have been designed with that fact in mind. I believe it is true that it will require a great many more repetitions to produce failures where the stress is in one direction, and that the upper limit may approach considerably closer to the elastic limit than when there is reversal.

I have in mind a wrought iron structure which is a plate girder viaduct. That bridge has been carrying a load 75 per cent. greater than it was designed for, for a number of years, and it shows no loosening of the riveted joints at any point.

I do not feel that the stresses given here are too high if they are read in connection with the remaining paragraphs of the specification which I believe are fully as important as the unit stresses.

I wish to refer once more to paragraph 11 and ask the Committee if they will not agree to remove the paragraph, because it does open the way for a large and more or less indefinite increase over the unit stresses in the table. It permits a man to carry those stresses to a point which might be unsafe.

Mr. I. L. Simmons (Chicago, Rock Island & Pacific):—In regard to paragraph 11, it seems to me that it should remain. It states definitely what loads are to be considered, and establishes the limits of the unit stresses produced by those loads. The latter part of the paragraph states that the unit stresses due to dead load, live load, impact, and centrifugal forces alone shall not exceed those given as allowable unit stresses. It is only when the stresses due to these loads are combined with the stresses due to the wind that we are allowed to increase the allowable unit stress. While it is possible, it is quite improbable that we will get a maximum live load, dead load, impact, centrifugal force, and a maximum wind at the same time. This paragraph was written to prevent a computer from allowing an increase in the unit stresses for any load except the wind load.

Mr. Tinker:—I do not agree with the member that we are not likely to get all the stresses at one time. If you do get the wind load when there is a live load on the bridge we may get the secondary stresses as well. Suppose the unit stress, omitting the windload, is 22,000 lb. per sq. in. Twenty-five per cent. of that is 4,500 lb. That condition will be repeated at intervals. The specification would not save us should there be a failure under these extreme conditions.

Mr. Simmons:—I will agree that these maximum loads might possibly occur at the same time, but considering any railroad system where various types of locomotives are used, it is highly improbable that they would occur, but should they occasionally occur, I do not believe that in such isolated cases the bridge will feel the unit stresses given above.

Mr. Leffler:—I think we should remember that in proposing this, we are not exceeding the elastic limit of the material, and we all know that one application of the stress up to the elastic limit, maybe once a month, will do no harm. I seems to me that unusual combinations such as are covered in paragraph 11 with occasional stresses up to 28,000 or 30,000 lb. will do no harm.

Mr. Hunley:—I cannot agree that a stress of that sort will not exceed the elastic limit. There are all sorts of reports and tests which go to show that the elastic limit of wrought iron is considerably less than 22,000, even as low as 16,000 lb.

Chairman Selby:—Referring to Appendix C, on page 395, I will say these principles were published a year ago, submitted as information, and are now without substantial change offered as a conclusion.

On behalf of the Committee, I move the adoption of conclusion No. 2.

(Motion duly seconded, put to vote and carried.)

Chairman Selby:—I want to call attention to an error in the discussion printed on page 388; 100 at the beginning of the last line should be 400.

The Committee has no further conclusions to offer.

DISCUSSION ON WATER SERVICE

(For report, see pp. 405-441.)

Mr. A. F. Dorley (Missouri Pacific):—The report of the Committee on Water Service will be found in Bulletin 232. The subjects assigned to the Committee for study and report, eight in number, are given on page 405 of the Bulletin.

The first subject is the revision of the Manual. Last year the Committee recommended an entire rearrangement of the subject-matter in the section of the Manual given over to Water Service. They also recommended certain changes in the recommended practice pertaining to water supply and water purification; the Committee has no changes to submit this year.

The second subject, Supply of Drinking Water on Trains and Premises of Railroads, has been in the hands of a special committee, of which Mr. Bardwell is Chairman. The Committee has kept in touch with the development of the regulations of the federal and state authorities, and the report of the Sub-Committee will be found in Appendix A on page 408. I will call attention to the fact that the work of this Sub-Committee is being closely followed by the health authorities at Washington, a representative of the office of the Surgeon-General having attended one meeting of this Sub-Committee last June. This report is offered as information, but I would like to call attention to the recommendations of the Sub-Committee.

(Chairman Dorley read the recommendations in Appendix A.)

It is not an uncommon sight in railroad terminals to see employees dragging the hose, through which water is passed from the hydrant into car-containers, along the ground and into the accumulation of filth that is generally around tracks at terminals, and it is not difficult to imagine that the chances of polluting an otherwise pure drinking water are very great by permitting a practice of this kind. One large mid-western railroad has made an effort to prevent such pollution by using a protection for the hose, illustrated on pages 410 and 411. This has only recently been devised and put into service, and it is offered with the suggestion that other railroads try either this or some similar device.

The third subject is, "Making final report, if practicable, on plans and specifications for typical water station layouts." The views of the Committee on this subject will be found in a brief report, Appendix B, page 412.

The Committee feels that this subject should more properly come within the scope of the committee that has in hand the design of yard terminals, and that the work of the Water Service Committee be confined to devising facilities to supply water to locomotives and for other uses.

Subject (4) is, "The Extent and Effect of Incrustation in Pipe Lines and Methods of Cleaning."

The Sub-Committee that had this subject in hand, of which Mr. LaBach is Chairman, offers the report given in Appendix C, on page 413. This report is very largely, almost entirely, in fact, the work of Mr. LaBach; he reviews the subject, beginning with the causes leading up to incrustation, the operating costs affected, the methods for cleaning, suggestions for prevention, as well as the condition under which the cleaning of pipes is economical. In this connection I would like to call attention to the report given by Mr. Yeaton, which appears on page 421, which illustrates the experience with the cleaning of one particular pipe line on the Chicago & Northwestern.

I wish also to call attention to a monograph by Dr. C. H. Koyl, which is given on page 419, on the subject of after-precipitation from treated water, its cause and prevention. This monograph is made part of the report on the incrustation of pipe lines.

Subject (5), "Disposition of Waste Water at Water Stations and Keeping Track Free from Ice," is covered by the report appearing in Appendix D, on page 427. We believe the lesson to be drawn from this study is that railroads should, as far as possible, eliminate the wasting of water. There are several railroads, particularly the Illinois Central, that have had under way for several years a campaign to eliminate water waste, and the results in the saving of money have been astonishing. Water is too frequently looked upon as free as air. It may be as free as air while it is going by in a river, but it takes money to put water into a tank or to put it under pressure in a pipe line. Railroad officials who sign vouchers in payment of water purchased from city or water companies realize that waste of water means real money flowing into sewers or into drainage ditches.

Subject (6), "Specifications for Contracting Water Service Work." The Committee reports progress..

Subject (7) is the "Effect of Local Deposits on Pollution of Surface or Shallow Well-Water Supplies." The report on this subject will be found in Appendix E, page 429, the work of the Sub-Committee, of which Mr. Holmes is Chairman. I would like to call particular attention to the section on page 430, which makes reference to the pollution of well water and surface supplies from the storage of coal and cinder deposits. This source of pollution only recently attracted the attention of this Committee. We will have more to say on this subject in the final report which we hope to make next year. In the meantime we will caution railroads against the very serious possibility of polluting reservoirs or wells by storing coal adjacent to the water supply.

This brings us up to the last subject (8), "Specifications for Sub-Structures of Wood and Steel for Water Tanks." The final report on this subject will be found in Appendix F, page 431. The preparation of these specifications and the typical plans is the work of the Sub-Committee of which Mr. Knowles is Chairman; in fact, the work is practically the personal effort of Mr. Knowles. There is so wide a variation in designing tank towers on American railroads that the Committee feels the adoption of these standards and these specifications is very timely. Many of the details in use in tank towers all over the country are very uneconomical, and without much justification.

I would like to call attention to the omission of the word "typical" in the second line of the paragraph under sub-head "general" on pages 434 and 435. On both pages it should read: "As shown on attached typical plan."

These specifications and typical plans are offered as a final report with the recommendation that they be placed in the Manual, and I will ask Mr. Knowles to read the report.

(Mr. Knowles abstracted Appendix F.)

Chairman Dorley:—Mr. President, I move that specifications for steel sub-structures for water tanks, on page 434, and specifications for timber sub-structures for water tanks, on page 435, and the typical plans appearing on pages 436 to 441, inclusive, be adopted and published in the Manual.

(Motion duly seconded, put to vote and carried.)

Chairman Dorley:—Before being dismissed, Mr. President, I would like to call attention to No. 5 of the suggested subjects for next year's study and report.

(Mr. Dorley read the subject referred to.)

The pitting of boiler tubes is something that is becoming a very serious problem on American railroads, and the effect of this pitting represents one of the very large items in the expense of locomotive maintenance to-day. At first thought it might appear that the problem is one that the mechanical department should handle, but the Water Service Engineer is vitally interested, for the reason that pitting is generally ascribed to water conditions. The most disquieting thing about the whole problem is that it is beginning to show up on districts where years ago it did not appear, districts where the water is either naturally good, or where the water is now being treated.

It is the recommendation of this Committee that an arrangement be made to have a committee of the Mechanical Division of the American Railway Association and possibly a committee of the American Society for Testing Materials coöperate with this Committee in the handling of this subject. We think that it is about the most important problem that the Water Service Engineer has confronting him at the present time.

DISCUSSION ON ECONOMICS OF RAILWAY LABOR

(For report, see pp. 235-242.)

Mr. C. E. Johnston (Kansas City Southern) :—What the Committee on Economics of Railway Labor has to offer may be found beginning on page 235 of Bulletin 231.

The activities of the Committee during the past year have been assembling information as a foundation upon which we might reach conclusions. The subjects assigned are, we think, so important, that we must go into all the details very carefully and endeavor to find some solution or arrive at some real honest-to-goodness recommendation in the handling of our maintenance labor, and what we have shown here in the report is to be taken as information; and, as I have said, it is assembled with the idea of laying a foundation for our further study of the particular subject. As to item (3), the Committee feels that no progress has been made on that subject during the year. We felt that items (1) and (2) should be studied first and disposed of in a manner, at least.

As I said to you, we have gathered a great deal of information with respect to maintenance of way labor, and I will have to admit it is a very hard or difficult thing to find a beginning point. We find that most lines have their own way of handling labor, and our questionnaires are giving us a very good line on the practices over the different parts of the country. In order to get the benefit of the views of the membership, we would like to invite discussion of these items, so first I will call upon Mr. Ford to read what we have said here with respect to the first subject.

Mr. R. H. Ford (Chicago, Rock Island & Pacific) :—Replies were received from fully 85 per cent. of the roads interrogated, which, when studied carefully, thoroughly indicate that no plan for recruiting railway labor could be reported that would apply equally to all sections of the country. This problem presents many angles and has developed some very serious aspects; among these being: the misuse of free transportation for laborers, as well as corrupt practice and flagrant evils in engaging men, especially by labor agents and labor scalpers. In comparison with other lines of industry, there is an unduly excessive turnover with its resultant wasteful methods and disastrous effect on organized effort, and while these appear to be appreciated to a more or less extent, it is evident from the replies that the matter has not been given the thought that the subject demands.

It is earnestly recommended to this Association that serious study be given to this subject so that the Committee may have the benefit during the year of constructive suggestions. Certainly no one has been able to offer any practical remedy that is susceptible of general or regional application. The Committee earnestly invites criticisms and suggestions from the floor of this convention in order that they may have some additional light on this subject in their consideration of the matter during the year. As the Chairman has stated, some aspects are very complex and it is the desire of the Committee to ultimately report a conclusion that will not only provide a remedy for these evils but will permit of constructive advances for the future.

Chairman Johnston:—In connection with that matter, I am glad to call upon Mr. Backes to state his views.

Mr. W. J. Backes (New York, New Haven & Hartford):—Your Committee sent out a questionnaire and you have noted how well it has been answered. It would indicate that the majority of the railroads of the country have a divisional form of organization—that is, 75 per cent. divisional and 25 per cent. departmental. On the other hand, even though they have a divisional organization, the majority of the Division Engineers and Roadmasters are Engineers; that is, 72 per cent. of the replies had Engineers in charge of their maintenance of way departments; 65 per cent. of the Division Engineers and 50 per cent. of the Roadmasters and Track Supervisors were men with an engineering training. In the East the tendency is to develop young men with an engineering training, because we have a good many more of them available, and where the railroads take the time to give the men the training and establish a good line of promotion, they are able to attract some very promising young men into their service and give them a thorough training in the maintenance work, as well as in the engineering side of railroading. All of us who have had to do with maintenance appreciate the value of the combination of a man who has had the practical experience of handling men, and at the same time has the foundation of an engineering training.

The territory covered by Roadmasters and track supervisors generally averages about 110 miles of main track and 75 miles of side-track. That is pretty close to the average on the Eastern railroads and with the longer sections in the West, that average is somewhat greater. The average age of Roadmasters and track supervisors is 45 years. On railroads where they are training young Engineers you will find the average age probably nearer 35.

The length of track sections under section foremen is 6.7 miles of main track and 3.1 miles of side-track. That, I think, averages pretty well over the country, with the possible exception of where they have long motor car sections. Motor cars are now used on approximately 69 per cent. of the mileage, and I believe there is a tendency for those who have had long motor car sections to shorten them.

The questionnaire also indicated that 99 per cent. of our track foremen are selected from common labor. It has been very difficult to get young men to take positions as section foremen, although it has been possible on some of the lines to get young men to take positions as general foremen.

The percentage of different classes of men employed indicate 40 per cent. native white; 17 per cent. negro; 10 per cent. Mexican, and 33 per cent. foreign labor. That, of course, is the average for the country. I think you will find in the East, where there is a very large foreign population, that the number of men who are of foreign birth would show a higher percentage.

The subject is a very important one, and I do not believe there is anything that we can do to strengthen our maintenance organization more than to attract young men into our service who have had an engineering training. That is the foundation of our work, and if we are going to develop the highest degree of efficiency, we must have men who have the power to analyze the costs of their work and improve the methods of doing the work. Those railroads who have been doing experimental work and using labor-saving devices are beginning to find out that material economies can be obtained through their use. We cannot expect men to use various mechanical labor-saving devices intelligently without giving them proper instruction and supervision in their use.

Your Committee has spent much time on the question this last year, but I believe that in another year we will be able to give you information that will be more conclusive.

Chairman Johnston:—The more we go into the subject, the more we feel that it needs attention. We devote a great deal of thought and time and money to specifications for rails, ties, and all other material, and we overlook to a considerable extent proper attention to labor and selecting the men to develop foremen and other supervising positions in the future. There seems to be a lack of uniformity all over the country—some do it one way, some do it another, some do not do it at all. Most of us do not do it at all, and I think that at the present time we are impressed with the importance of giving this entire subject a great deal more thought than we have in the past. I, as Chairman of the Committee, have given it quite a little thought this year, have reached some conclusions and backed off of them. The balance of the Committee I think are in the same position. I generally get back to the one thing after thinking over it and studying the different conditions, that we must get closer to the human side of it. Personal contact probably will give us more results than anything else. Just how that can be brought about I am unable to say. I think each and every one of us have a pretty good idea of what we need on our own railroads. We have a little organization down on the line that I am with called the "Maintenance of Way Association."

We have monthly meetings of our foremen and discuss things of interest—kind of handshaking proposition—but at the same time we can notice a big improvement in feeling, in the fact that we are acquainted with the men. As Dean Potter said this morning with respect to the engineering students, I think the time has come when our maintenance men must be sorted and tested out. I think the time has come when our track laborers must be sorted and tested out, if we are going to go along with the procession.

As I have said, the Committee is very anxious for suggestions. Maybe some of you can spring something on us that will give us a lead to a solution of these problems. We would like very much for you to start something, and during the year the Committee has outlined its work so that we think we will be able to show some results at the next meeting.

Mr. Earl Stimson (Baltimore & Ohio):—I hesitate to criticize a committee, because we assume that the committee represents the best thought on the subject that is in hand. I particularly hesitate to criticize in this case, because my criticism is going to be rather severe. In my opinion the Committee has the cart before the horse. They have the thing turned around, they are not following the proper sequence. No. (3), the subject which they say depends upon the determination of (1) and (2), is really the essential one, and the one that should come first.

I think you will all agree that the first thing to do, when we undertake an enterprise, is to establish what we are going to do and how we are going to do it. Then we get together our organization, the supervising force that is going to handle the work, and train and instruct them. The third and last thing to do is to assemble the men that are actually going to do the work. We are then prepared to handle it. The Committee has gone just the other way around.

To my mind the first thing that the Committee should take up is this subject No. (3), "Study and report on standard methods for performing maintenance of way work, with the view of establishing units of measure of work performed." I think it is a mistake to report on elaborate preparations to get men and care for them without first providing methods for economically directing them at their work. We have some men all the time. We do not have to organize a labor department, and build elaborate camps to get and keep them. We have plenty of men already to start in with and handle in accordance with any plan for the economic conduct of work the Committee may formulate.

Sometime ago I undertook an assignment which called for a review of what has been done on "Economics of Railway Labor." I thought that would be an easy thing to do because all I would have to do would be to look up the reports of this Committee on "Economics of Railway Labor," which has been in existence some three or four years. When I looked over their reports I found there had not been one single conclusion or one single recommendation put up to the Association by the Committee, and that this particular subject, which is the backbone of the whole thing, had been ignored. It is my suggestion to the Committee that they pass over subjects Nos. (1) and (2), and buckle down to work on No. (3). When they come to a conclusion next year on the subject I hope it will not be to blandly indulge in the ancient and honorable American pastime of "passing the buck," by suggesting "that the railroads take immediate individual action to improve their labor situation and put forth organized effort to increase labor efficiency."

I think it is the duty of the Committee to point the way and not leave it to the individual effort, because the individual effort has been put forth on railroads for nearly a hundred years, and we have not gotten anywhere yet. The Committee has been in existence four years and they have not gotten anywhere yet.

Chairman Johnston:—It is not proper to consider subject No. (3), the study and report on standard methods for performing maintenance of way work, with a view of establishing a measure of work performed, and say that is what we want first. It is true we are seeking that end, and we will get to it in time. If we had experienced a plentiful supply of men in the past, it would seem proper, at this time, to consider the measure of work, but the inadequate supply the past few years seems to impress upon us that first consideration should be given to the supply and training with later consideration of a measure of work performed. Suggestions are what your Committee desires, and if the membership present has anything in their system, please let us have it.

Mr. W. M. Camp (Railway Review):—I served on this Committee for a couple of years, and I want to say that in some ways I sympathize with the Committee and in other ways I am more impressed with what Mr. Stimson has said. I agree with the Chairman that it is a hard nut to crack. There is no use in handling the question with gloves and we might as well speak the plain truth.

The Committee has done some good work in determining what the composition of our maintenance forces is. They tell us that we have 40 per cent. native white; that is, American-born. How much of that is American-bred we do not know. All the American-born people are not necessarily American-bred. Then we have negroes 17 per cent., Mexicans 10 per cent., and other foreigners 33 per cent.

I do not think that any permanent results will be accomplished with foreigners simply by feeding them extra well. I believe in sanitary surroundings and all that, as does everyone else, and in many cases the railroads must furnish quarters and arrange for boarding accommodations, but they can not hold that class of labor permanently. There is no way of making progress in the quality of maintenance of way labor without inculcating into it what may, perhaps, be high sounding here, and that is an *esprit de corps*.

You have got to get men who will take pride in their work, who have something to look forward to, not necessarily promotion, but, for one thing, steady labor the year round. But how can one condemn a man for losing interest in his job when his work is only intermittent? Track labor has been the cat that has been slung by the tail. You know that.

This is not a new proposal, that track and bridge labor and other maintenance of way forces should be regularly employed the year around. That is one thing that can be done for them, and unless you can do that you are not going to secure and hold a desirable class of labor.

As you know, only part of maintenance of way labor is now organized. Trade unionism may not be an acceptable question to discuss in a body like this, perhaps, but if you wait until all of the maintenance forces are organized you will not be able to get into the sympathies of these men.

It seems to me that the class of labor that is worth an effort to improve is the native-born American, white and black; and skilled workmen rather than the so-called "common labor" is the end that should be striven for. As a class the labor from southern Europe is inefficient. The old American or Irish trackman will do as much as three of them.

The question of wages is another thing. In pre-war days that was a matter which received very little attention. At the present time it is recognized that maintenance of way labor is being paid very well. My opinion is that in pre-war days efficient track labor was not paid enough, either the laborers or the foremen.

I think the Committee has some ground to go to work on, and I do not think they should hesitate to recommend what they believe is going to produce results, notwithstanding that all they may say may not strike the management of the roads in exactly a pleasing way.

Mr. Ford:—From the remarks of the last two speakers it would seem that either they have not grasped what the Committee has tried to express in this report or perhaps they have not read the report at all. This Committee is desirous of obtaining suggestions or criticisms from this convention. To our mind the first step will be for the members to read the report as presented and then give the benefit of their suggestions. During the past three years that this Committee has been in existence, it has been endeavoring to keep in touch and deal with conditions which, within this short period, has covered the most abnormal fluctuation in the entire history of railroading. This has been primarily due to four causes which may be stated generally as follows:

(1) The increase in business throughout the country;
(2) A reaction from the paralysis caused by the sudden termination of the war;
(3) Industrial intoxication prevalent in all lines of industrial endeavor;

(4) The greatest labor demoralization that the world has ever known.

So far as maintenance of way labor is concerned, it started with a volunteer adjustment in wages and to some extent in working conditions during the early stages of Federal administration; later revolutionized by General Order No. 27, followed up by National Agreements for working conditions, classifying men and creating a condition completely new for track labor.

It would be idle to expect this Committee to report anything of constructive value during this chaotic period which would have been out of date before the ink was dry on the paper. The first speaker in this discussion is no more desirous than the individual members of this Committee to work out some definite plan for obtaining higher efficiency and economy in labor for maintenance of way, as well as to develop practical units by which maintenance of way and structure work may be gauged, but during the life of this Committee conditions have been too hectic to permit anything more than the collection of information looking towards a time when an approach to more nearly normal conditions would permit a solution as a result of the experiences in past years and the lessons learned during the war, including therein the probable changes that the new Transportation Act must, of necessity, cause in the general problem of railway maintenance and operation.

Mr. Camp:—I do not think the Committee can discover any question that is new to work on. If the Committee felt that intermittent labor was not the proper thing, why did it not make a conclusion to that effect and put it in the report?

Mr. J. E. Willoughby (Atlantic Coast Line):—On the Atlantic Coast Line we have laid out our maintenance of way work so that the same number of men are employed throughout the year; that is, we do not increase or decrease the labor allowance on account of weather conditions. Our labor is principally negro labor and we put on the foreman in charge of the gang the duty of recruiting that labor. It is as much a part of the foreman's duty to secure his labor as it is to accomplish efficient work. We hold the foreman responsible for the work accomplished.

So far as the negro labor is concerned, the suggestion of the Committee should be that the foreman ought to be made responsible, and then measure the work accomplished by the force. Hold the foreman responsible for the class of labor he employs and for the results accomplished.

Mr. Stimson:—The real pity of it is that Mr. Ford has committed the same error with which he charged me, that is, he has shot wide of the mark.

The whole thing is this—that it makes no difference whether labor is intermittent or not, whether you have ten men in January and one hundred men in July—that the Committee on Economics of Railway Labor is to formulate some plan whereby you can economically direct the force you have. You can do this by standardizing methods of work and then setting up standards of performance by those methods as the measure for actual performance. This is the whole thing in a nutshell. You can then determine whether your labor is performing according to the standard or not.

The Committee has asked for help and I gladly make the offer of mine.

In the last seven or eight years I have given a great deal of thought to this subject. I was permitted by my company to develop and put in practice a system which had for its purpose the "Economics of Railway Labor." The practical application of this system has been established. I think we owe the Association some results along this line and if the Committee is sincere in its desire for those results, it can accept my services and have at its disposal the use of my experience.

Chairman Johnston:—We will accept the offer of that service without further question. The Committee had the benefit of the advice of a gentleman from Mr. Stimson's road on that question when we formulated this report and we thought we had his system pretty well in mind, but we probably are mistaken about that.

Mr. Stein of the Central Railroad of New Jersey has some remarks to make on the subject.

Mr. C. H. Stein (Central of Jersey):—I feel that it would be little short of an act of cowardice on my part if I did not make some reply to the statement of Mr. Stimson and narrate the history of the proposition.

One would be led to believe by what Mr. Stimson has said in regard to subject No. 3, that this was a new question for the Committee on Economics of Railway Labor to solve. As a matter of fact, it is not a new subject. It is simply an old subject dressed up in a new suit of clothes. The old term by which it was known was "Equated track sections or equated mileage." The same subject under the latter name on previous occasions had been assigned to other committees for consideration. I was a member of a committee that for four years had this subject under consideration. We secured copious data from about twenty to twenty-five different railroads, having each railroad prepare for us a statement of hours consumed on different classes of railroad work, for each of four typical sections on said railroads. These reports were furnished monthly for nearly two years.

The data in the meantime was being tabulated and compiled. At the conclusion of this compilation, and when we had reached the point where the accumulation of further data seemed to be unnecessary, we made an effort to group it in some synthetic form so that legitimate and proper conclusions could be drawn. The chart on which this statistical data was recorded was about as long as this table. After it had been grouped in as complete a manner as was possible, we endeavored to arrive at some substantial and satisfactory conclusions in order to establish certain principles. The size of the map, the crisscrossing of it, and the groupings were so complicated that it looked like the map of Europe, and the varying conditions shown thereon were just as impossible of reconciliation. Our final conclusion was that it was utterly impossible to focus this matter in such a manner as to make any definite recommendations and the entire information, therefore, was discarded.

During the consideration of the subject we had before us plans that were in effect on the various railroads throughout the country, including the Grand Trunk, the Erie, and the bonus system of the Baltimore & Ohio. After studying these various schemes, we concluded that we were not prepared to recommend any one of them. We felt certain that if we did we would not get a single approving vote of any recommendation that we might make unless we recommended the Baltimore & Ohio scheme, when we might have gotten Mr. Stimson's approval. It resulted in an utterly impossible problem so far as we could determine from the data at hand, and the subject therefore was temporarily withdrawn. Within the last several years this same subject was turned over to the Committee on Economics of Railway Labor.

In confirmation of our conclusion to the effect that we could not reach any point where we would be justified in making any definite and satisfactory recommendations, and that would obtain the approval of even a reasonable number of the members of this Association, only last evening I was talking with one of the authors of a system of equating track mileage. He was a representative of one of the largest systems in the country. He told me that they had ultimately discarded their scheme of equating mileage because they had reached the conclusion that the proposition was one for a hard-headed, hard-fisted track supervisor or Roadmaster, who knew actually what the needs of any particular section of track were, and that they could not accomplish anything of a practical nature by the expounding of theories and action thereon that were so constantly open to the objections of practical conditions and considerations.

Therefore, I feel that I am justified in saying that the cart has not been put before the horse, and that the horse was in its proper position five or six years ago when this same question was considered by another committee, which reached practically the same conclusion that we have reached here.

I furthermore want to make clear in this particular instance, that there was no failure on our part to go actively into the discussion of this particular subject. This Committee has not been indolent, and it has not neglected the most important and essential one of the subjects assigned to it. Mr. Stimson says, "You want to look at your work, formulate your program, and know what you want to do." I want to say, however, that above and beyond that, as a matter of primary consideration you want to know what you want to do your work with, and that is the man element.

It was during 1915 and 1916, as I remember, that this proposition of equating track sections was first considered, and we reached the conclusion that we could not at that time do anything with it; that the state of the art or science, as you are pleased to call it, had not advanced to the point where we could in a mathematical form express conclusions that would be substantial and effective, if applied, in producing the results that this convention desired. All of the subjects assigned to this Committee have been subjects for grave consideration by previous committees. The labor situation is not a new one, and committees of this organization have spent much thought upon it before. Engineers of Maintenance of Way and other supervisory forces of the Track Department have been striving for a great many years to improve the competency and efficiency of the labor employed under them, and prior to 1915 they had reached a point where they were within speaking acquaintance of the one-hundred-per-cent-efficiency man. Everybody knows what the experience of 1915 to 1920 has been. There never has been, in all the history of this country, a state of unrest among our laboring classes such as we have had to contend with during that period, and particularly during the years of 1918, 1919 and 1920. Every man in this room knows but too well what actuating forces were responsible for these restless conditions that had affected our labor situation generally. They know into what a turbulent state our entire labor structure had been brought by the effects of Government control. The results of it were that the managements of the railroads had practically no control over their men. Inefficiency ran rampant. They know, too, how the discipline on the railroads of the country was completely demoralized and how the men, because of the scarcity of labor and because of the pinnacle that they had been placed upon by Government control, felt themselves greater and more powerful than the managing officers who were trying to direct them into paths of efficiency and accomplishment. As Grover Cleveland said, "This is not a theory, but a condition that confronts us." During that period every railroad manager used his utmost endeavors and exercised his ability to the limit to correct the existing situation, or at least hold it in suspense, hoping that as we emerged from the period of Federal control we would be able to save something, at least, from the wreck, and upon the foundation of effort that we were putting forth we would be able to do something sooner or later that would make it possible for us to restore the oldtime morale of our forces.

These men, who have been spoiled by unbridled license, are the ones that we must use to accomplish our programs of work, and, therefore, I contend that before we can map out and determine upon definite programs for doing work we must restore the aforetime efficiency and morale of the workers; that their present condition is the problem that immediately confronts us, and it was the problem that the Committee was trying to solve. I quite agree with one of the preceding speakers that this has become not only a financial and economic problem but it has become more and more, as it was tending to become in 1914 to 1916, a psychological problem. We must get nearer to our men. We must be the guideposts and point out the way to them that will lead to their own peace and happiness, as well as to the success of the railroads and the prosperity of the Nation. It is a well-established fact, and there is no use of our closing our eyes to it, that we need not expect the labor leaders to point that way. They have been responsible for much of the present unrest. We were getting close to the men. It was the sentiment and feeling of every managing officer that he wanted to know his men. This knowledge of the individual was the potent force of Napoleon in the war in the early part of the nineteenth century. He was near to his men and he knew them; he called many of the privates in the ranks by their names, and this familiarity did not breed contempt, but gave him power. This was the dominant thought with managing officers during the period from 1900 to 1915; that we had to get close to the men and study the human element; that we had to know them as Napoleon knew his men. We recognized it as an asset in our organization. Unfortunately, we were distracted from these things during the turbulent period that we have just passed through. We must now turn back and study this subject again from a psychological standpoint, taking up the program where we left off in 1914, and improve on what we were only able to do in a perfunctory manner during the past five years. We must make our men know that we are interested in their work, and that there is a common bond between us.

The Kansas City Southern, as Mr. Johnston has just explained, is making this very effort to get close to their men. Other railroads have followed a similar practice but perhaps not to the extent his road has. I hope it may be pardonable for me to make a personal allusion to a practice I followed as long as fifteen years ago. It was our custom to call a meeting of all the maintenance of way foremen. We did this about once every three months, and we talked over the things that concerned them, the things that were their problems, the things that were their work-a-day life. We sometimes talked about their personal matters, and it had the effect of wonderfully improving the morale of these men. If you can improve the morale of the foremen, its influence will spread out from them as a nucleus, and affect the men working under them, and, sooner or later the efforts thus put forth are worked out into achievable and successful results.

We have these two propositions before us as they are embodied in subjects (1) and (2) assigned this Committee, and it is not putting the cart before the horse when the most earnest and emphatic consideration is given these subjects first. The third subject can follow after you have been successful in restoring the equilibrium of your forces, and this equilibrium can only be established by having approximately one-hundred per cent men. When you have reached that status in the situation, then you can prepare your schedule and program, and have some hope of arriving at a conclusion with regard to the equation of track sections that will be productive of efficient and satisfactory results.

Mr. Camp:—What Mr. Stein has said, I think, provokes still further discussion, although I agree with him in much that he has said. I think he has been somewhat unfair towards Mr. Stimson, in that he has given him credit for working out only the equation of track mileage. That is only a minor feature of Mr. Stimson's system.

Mr. Stimson has, in addition, worked out unit costs of labor and applied them to his track sections, and with that he has a bonus system. In fact, Mr. Stimson has done what I have never known anyone else to do before him—he has virtually applied a piece work system to track labor. When the railroads went under Government control, two large systems, the Baltimore & Ohio and the Pennsylvania, had that system in force, although the Pennsylvania not as long as the Baltimore & Ohio. As used on the Pennsylvania the system was rather experimental.

I want to say a word about the question of equating track mileage. I believe that if the Committee on Economics of Railway Labor had not tried to split hairs, it could have made some effective recommendations on that matter. I was on the Committee when that subject was being considered, and while we found that one road was equating mileage in one way and another in another way, yet the Committee should have found some way of getting at the fundamental ideas and proposed workable principles. If one insists on rules that are hard and fast, he will not accomplish satisfactory results, but I believe workable principles can be applied to equated track mileage in a way to work out a satisfactory plan.

I believe Mr. Stimson's system of unit costs and paying a bonus to section laborers in accordance with what they accomplish over and above a desirable average of results, is working toward the right object and it appeals to the human element.

To be frank and honest with ourselves, the American people do not want to do manual labor and most of us are trying to get away from it. Country people are running away from the farms, and the wise heads who have so much to say about welfare work and sociology, are trying to devise means of holding people on the farms; and so they are proposing motion pictures, ice cream parlors and various forms of entertainment in the country to get the people back and hold them there. We have housing problems in the large cities, and what does it mean? That we have had a sudden expansion of population during the war and that there are too many people for the houses we have? No, it means that the people from the country have been overcrowding the cities. In the country there are plenty of vacant houses. We have a similar situation on the track—laborers want to shun it. In order to keep the people in the country it is felt that country life must be made more attractive for them.

I am not in entire sympathy with all the plans that have been proposed to make work attractive to the track forces, but I believe Mr. Stimson's system will make track labor more efficient and more attractive to American-born or American-bred men, and I will conclude with this suggestion to the Committee—when you find a good thing, recommend it to the Association and propose that it be placed in the Manual. It is not to be presumed that you can arrive at a system of employing and educating labor in the maintenance of way forces of the companies, full and complete, in one year, but if you find a single principle worthy of recommendation let the Association have the benefit of it.

This Committee has had a life of four years, and some have suggested that it might work on four years more before arriving at conclusions in complete form, and that even then they might not be complete. But why not solve the problem a little at a time? If this matter of encouraging steady labor is a good thing, then recommend it. It has been discussed enough on this floor in past years and talked over until there is nothing further to be said. Let us get that down for one thing and hold to it.

I am not aware that the Committee has investigated the unit cost system that was worked out on the Baltimore & Ohio. I know it has investigated the equating of track mileage, but that is not the distinctive feature of the B. & O. system. I would like to see the Committee investigate the workings of that system on the Baltimore & Ohio and on the Pennsylvania and report on it as a progress report if it could not arrive at any conclusions, but let us have that to begin with.

Mr. R. G. Kenly (Minneapolis & St. Louis) :—Some of our friends come up into Minneapolis or St. Paul and come back and say they spent part of the winter up there, and when they are asked how long they were there they say nine months. There are at least six months of the year in Western Minnesota and the Dakotas when we operate with a section foreman on a six-mile division.

There is so little track work to be done during a large part of the year that it would be difficult to arrive at a method of dividing that work throughout the year so as to maintain our section force. This Committee does not need the sympathy of any man in the Northwest where our labor is highly organized. Some of our Northwestern friends may smile at that, but they are highly organized not to do any work they can help doing, and are highly organized, again, to get all the transportation out of the railroad they possibly can get. I think last year four or five of the Northwestern lines sent seventy-five per cent. more men out on the line by passes than reported on the job and went to work. We had three or four gangs authorized, to work fifty men, and they were sent out daily in batches of fifteen and twenty, before we were able to keep the extra gangs up to twelve or fifteen men. If the Baltimore & Ohio can work out some unit system by which we can do piece work under those conditions we would very much like to have it done.

We certainly owe Mr. Stimson and the Baltimore & Ohio many thanks for the effort they have made to organize their maintenance of way labor to do some of it by the piece-work system. Without desiring to draw particular attention to myself I will say that I equated the mileage on the Lehigh Valley Railroad in 1902 and 1903 on the basis of switches, turnouts, passenger tracks, etc. That was simply a question of equating it so as to place a uniform number of men on the sections. We have a problem in the Northwest that evidently Mr. Stimson does not know anything about at all and this Committee apparently does. I say again, they do not need my sympathy.

Mr. C. A. Morse (Chicago, Rock Island & Pacific) :—I think we all realize that the work of this Committee is something that can do the railroads a lot of good at the present time. We are up against a labor proposition, you can begin at one end or the other or the middle, and there is trouble. I know the work a good many of the members of the Committee are doing and I know they will get something out of it.

I have been at quite a few labor meetings in the last few months where the representative of each railroad had ideas of his own, and no progress was made, because there were as many ideas as individuals. What we need to do is to give the Committee the benefits of any ideas we have, something they can work on and in time solve the question.

There is one point I will refer to. One of the subjects is in regard to training men. On a railroad we have a lot of individual organizations—we have the bridge gangs, water service gangs, track gangs, building gangs and signal gangs, and one of the things the Committee should give consideration to is to try to get the men in charge of these gangs into a habit of planning their work. I have always been impressed with the idea when I see a section gang get on their car that about four out of five when they started had no more idea of what they were going to do than I had. I believe one of the first things to do is to try to get a program for the season's work outside of the ordinary maintenance work, try to get the Roadmaster to plan with the section foreman, and see if you cannot get the section foremen, the bridge foreman and the foreman of each gang which has a regular assigned territory, to have the season's work planned out, so that when they start out on Monday morning, in addition to the regular work, they will accomplish something on that program. I believe we realize that the Roadmaster, section foreman, and Division Engineer as well, who plans his work, gets more out of the amount of material and the expense which he incurs than the man who does not plan. The man who spends his money hit or miss cannot get the results that a man does who plans his work.

We are up against the wage proposition and in all these years of railroading in this country we have considered every man working on the section gang as a common laborer. The man who has been with the road for ten or fifteen years gets the same wages as the Mexican or Italian who is brought in and does not know the name of anything he is to work with. The men who have been with the company a longer time have to do the instructing of these new men.

In this period of reconstruction it would be a great thing if we could recognize the fact that there is such a thing as a skilled trackman, and rate part of our gang as skilled men, and the balance as common labor, at common labor prices, and the men we rate as skilled men, should have higher prices.

My idea is that at least half of the ordinary section gang should be skilled trackmen and the filling in, which is done seasonally, should be done with common labor. In the case of extra gangs probably one-third should be skilled men and the rest common labor. A trackman is as human as the rest of us, and the man that you recognize as more than a common laborer will have greater self-respect and take more interest in his work, when recognized by the company he is working for, as a man that knows something, and is entitled to better than common laborers' pay. One of the ways we will get more interest and greater efficiency in our work is to recognize a certain portion of our trackmen as skilled labor.

Mr. Maurice Coburn (Pennsylvania System) :—I think Mr. Morse's last suggestion is one of the most important we could have and that the Committee should give it very careful attention. Mr. Stein says that the labor leaders are responsible for a good deal of the trouble we have had in the last year or two—they may have been responsible for part of it, but not all of it—we ourselves are responsible for a good deal of the trouble. It has been our practice to hire and fire our men and use them like ties and rails. We must get a different idea if we are to be successful.

There are some other industries that are doing better than we are doing with reference to subject No. (2). Our conditions are such that we ordinarily do not have the courage to inaugurate these things. Mr. Stimson deserves great credit in what he has done, he was a pioneer—we do not agree with all he did, but we are indebted to him for starting something and doing something a little different. Some of the other industries are doing some of these things. Last year we had printed in the Proceedings a few comments by one man who had been doing some of these things very successfully.

For a good many years I asked for the appointment of a Labor Committee and we finally got one. I have felt at times that the Labor Committee might do more than they were doing; perhaps I did not appreciate what they were up against. It is a really encouraging thing to have such an extended discussion as we have had at this time on this subject.

Mr. Stein :—I wish to say just one word more in explanation. If I was understood to have condemned Mr. Stimson's scheme on the Baltimore & Ohio, I want to disclaim any intention of doing so. What I tried to make clear was that in the study of his bonus system made by the Committee of which I was a member, it was impossible for us to come to the conclusion that if we recommended this system or any similar to it, it would receive the endorsement of the Association. That is the exact point I wanted to make.

In regard to the welfare work referred to by Mr. Coburn and the recognition of the human element, I was much interested in what Mr. Morse had to say. I felt that it was exactly in harmony with what I had attempted to say. I wish to say further, in explanation of the statement I made that the labor leaders are responsible for the condition of unrest that exists among our labor element, I have had quite a varied experience in dealing with labor and have been very vitally interested in the labor proposition for the last three and a half years, and have spent most of my time in close association with it. It was upon the basis of this experience that I felt I was justified in making that statement. As a confirmation of the fact that welfare work will not alone hold men loyal to a business organization, I point to the many diversions of welfare work that the United States Steel Corporation has provided for the benefit of its men. All of these beneficial agencies along welfare lines nevertheless failed to have sufficient influence to offset the underground work that the radical labor leaders were doing, and the result was the gigantic steel strike. If these radical labor leaders had not gotten under the skins of the men, this strike would not have occurred, as the rank and file of labor is all right at heart.

When I had my close associations with the men that I was employing from 1907 to 1915, I felt that I was getting along admirably toward producing a state of harmony where I need have no fear as to the results, but in 1916 all of the work that I had done during the preceding years went for naught. It was simply due to the fact that an organizer had gotten into our ranks and disturbed the minds of our men to the point where we could no longer control them, and that they would not listen to us for counsel and advice.

Mr. J. L. Campbell (El Paso & Southwestern) :—Speaking of the human element in this problem, and I believe it is the heart of the problem, Mexican labor is probably as unstable as any other of that class. We are dependent on it for the major part of roadway work and there is still much instability of it. During the past fifteen years we have been improving the living conditions of the Mexican laborers and are getting good results therefrom. There are still some tie shacks on our road, but they are being replaced at a satisfactory rate with good buildings and improved living conditions. In this time there has been improvement in the stability and quality of much of that labor and in its family life. More of the men are remaining with us. In thus giving attention to the human element we have not considered ourselves philanthropists. We did not approach the matter from that standpoint, but we have realized that with the condition of Mexican life as it existed when I went to El Paso, 33 years ago, and as it still exists among the masses in Mexico, we could not hope to have such track labor as we ought to have.

We have developed a number of good Mexican section foremen and it has repeatedly happened that, under the annual inspection, the wives of some of these foremen have won the prize for the best kept section house on the road. We give a variety of prizes in which they are interested, and for which they compete with spirit and benefit. It is not costing us much to do this except the investment in the better class of buildings, which we find fully justified by the results.

Mr. Ford:—The Committee has in previous reports called attention to the defective principle involved and the wasteful practices of intermittent labor, but so far it has not been able to develop a practical remedy or plan that would warrant a definite recommendation to this Association.

From the remarks of one of the speakers in this discussion it is possible that the impression may be conveyed that this Committee is not in favor of equating track sections. If so, this is erroneous. The Committee believes it to be a necessary index, although perhaps not as a conclusive measure, for track maintenance.

Mr. Stimson:—I do not want to be misunderstood in this matter. What I advocate is a system like our own of handling maintenance of way work. It takes the practices which have been used in shop management for a great many years and applies them to track labor. I believe we have demonstrated it can be done successfully. After you have done that you have some way of handling your work so it can be done economically and you will know what you are doing.

I wish to apologize to Mr. Coburn for not answering his letter and to thank Mr. Stein for his kind words. As to Mr. Kenly, my friend from the Northwest, I feel sorry for him.

Mr. Mott Sawyer (Chicago, Milwaukee & St. Paul):—I believe Mr. Stimson and Mr. Willoughby have a different position and a different point of view from men on other lines. Mr. Stimson says he has plenty of men all the time, but about the heaviest burdens that have been put on many maintenance of way officers during the past few years has been to get men enough to do the absolutely necessary things. We do not need a better system of reports or statistics to tell us that the men we are employing do not come within hailing distance of doing a fair day's work and doing it decently. Since we cannot get men enough to do what needs to be done, many of us in the West think that what the railroads have got to do is to attract a better class of men in the maintenance of way department—whether that will be done by a system of bonuses, or by some other system which will tend to gage men's compensation by their production, or come through what Mr. Stimson smilingly calls "welfare work," or by stabilizing labor, is a problem. Many roads cannot do section work throughout the year, and the determination of what can be done to improve the labor situation and get us men enough to do the work efficiently and economically is a very serious matter, and I want to take the opportunity of suggesting that this Committee in putting stress on means of recruiting and retaining labor is doing a very valuable work.

Chairman Johnston:—For the Committee I wish to say, in conclusion, that we have not anything further to offer, and our desire has been achieved in having had this very lengthy discussion. We are especially thankful to Mr. Morse, Mr. Coburn, Mr. Stimson and others for the really constructive suggestions. Also the Committee is endeavoring to become familiar with the conditions in the Northwest, Southwest, South, East, Middle West and New England. We have now a great amount of data and will get some more. We are soft-pedaling on a recommendation, because we think the subject is so important we do not want to get very far from shore until we know we are right. We are not at all discouraged, and this coming year we hope we will be able to prepare a report that will be of real interest next year.

Vice-President Downs:—As the report has no definite recommendations it will be received as information. I want to say that some of the best reports of this Association were not gotten up in one year. The Committee is excused with the thanks of the Association.

DISCUSSION ON ECONOMICS OF RAILWAY OPERATION

(For report, see pp. 723-792.)

Mr. L. S. Rose (Cleveland, Cincinnati, Chicago & St. Louis):—The subjects referred to the Committee are outlined on page 723, Bulletin 234. Mr. Howson will present the matter on subject (1), which will be found in Appendix A.

(Mr. Howson then abstracted the matter in Appendix A, and said):

Mr. E. T. Howson (Railway Age):—The report is one of progress, as we have only just nicely entered upon the subject.

Chairman Rose:—Mr. Brooke will present Appendix B, covering subject (2).

Mr. G. D. Brooke (Baltimore & Ohio):—The report of this Sub-Committee is also one of progress, and while it is really only a beginning of the study of the subject, the Sub-Committee feels that the work can be made some use of by railroad officers in considering problems of increasing the capacity of a railroad.

The report consists of two subjects or parts, the first, shown on page 733, a study of railroad operation with a view of increasing its capacity with its existing facilities. The Sub-Committee has taken the view that the first thing to determine is—"Can the capacity of the railroad be increased without any large expenditure of money for facilities," and in this study an attempt has been made to point out a method of examination along these lines.

The second part of the report entitled, "Notes on the Determination of the Traffic Capacity of Single and Multiple Track Railways," is a discussion of the theoretical capacity of the railroad and it is thought that it has a field of quite practical application. It is the intention of the Sub-Committee to secure data on the operation of various engine districts and apply the methods here outlined with a view to developing them further and develop the scheme which has been started in this report.

Chairman Rose:—The third subject on Track Maintenance will be presented by Prof. C. C. Williams. This subject was divided into three parts. The main subject is, "The Effect of Speed of Trains on Cost of Operation," divided into three parts—part 1, Maintenance; part 2, Cost of Transportation, and part 3, Cost of Motive Power Expenses. Two of the subjects have been reported on by the Committee. We have had some difficulty in finding the right sort of information in connection with the third subject, and we propose finishing it up next year. Prof. Williams will speak about Track Maintenance.

Prof. C. C. Williams (University of Kansas):—There have been many scientific observations on the behavior of track under traffic, and it was the purpose of this Sub-Committee to bring the results of these observations to bear on solving this problem, and to focus upon it whatever light existed in securing quantitative results. There has been a good deal of discussion at the Association meetings and in the press concerning the factors which enter into this problem, and it has been extremely difficult to secure quantitative results.

(Prof. Williams then read the matter on page 760, beginning "Two distinct points of view," etc., down to paragraph at head of page 763. Also abstracts of matter under "Observation of Joint Deformation and Tie Cutting at High and at Low Speed Points.")

Unfortunately the results were too meager to indicate any definite conclusions.

A third method of going at the problem was an analysis of the factors which enter into maintenance and a study of the observations which have been made by various persons concerning the behavior of track under traffic to show what the effect of speed is.

(Prof. Williams then abstracted the matter "Indices of the Effect of Speed on Maintenance," on page 766.)

These tests have been corroborated to a greater or less extent by other observers. These observations were taken as a measure of the tendency of rails to break, and then other observations were made by the Pennsylvania Railroad on the pressures on tie plates, and observations have been made on the lateral thrust on rails, etc.

I may say that the data on which the figures on page 772 were made were of a general nature and consequently should be modified for the greatest usefulness to fit the conditions for the particular road using them.

Chairman Rose:—Mr. Teal will present the report on "The Effect of Speed of Trains on the Cost of Operation," beginning on page 773.

Mr. J. E. Teal (Baltimore & Ohio):—This is also a progress report and I will briefly describe the general methods of attack.

(Mr. Teal abstracted the report.)

Chairman Rose:—We expect to hand most of this back in the form of recommendations, and the Committee would like suggestions and criticisms of these reports in order that we can be sure we are on the right track and go ahead.

The President:—Is there any discussion of the report? This report does not require action for adoption in the Manual, but is before you for discussion. The Chair desires to commend this report to the membership for careful study and coöperative work with the Committee for the coming year. They have undertaken to develop a number of exceedingly important subjects which are going to increase in value as time goes on, especially in connection with the consideration of maintenance programs and the measure of maintenance performance. I hope the good work which this Committee has done will be appreciated and such appreciation shown by an active interest in the subject. It is a matter which interests nearly all of us.

Mr. Maurice Coburn (Pennsylvania):—The first subject is an important contribution to the labor subject we have just been discussing and gives the rank and file some of the fun we have been trying to keep to ourselves.

DISCUSSION ON ECONOMICS OF RAILWAY LOCATION

(For report, see pp. 565-584.)

Mr. C. P. Howard (Interstate Commerce Commission):—The report on revision of the Manual will be presented by Mr. Beahan.

Mr. Willard Beahan (New York Central):—I rise to make report on the revision of the Manual, in the absence of the Chairman of the Sub-Committee, Mr. Lavis.

Your Sub-Committee thought it best to recommend definitions which were simplified as much as possible; these will be found on page 567. In connection with the first proposed definition, we felt that in the problem of location, to take up the question of fuel cost and power and interest was perhaps unwise, and might better be omitted from the Manual. Then, as to the probable cost of operation, consideration should be given to the various and mounting character of traffic, and emphasis should be put on that rather than on cost of fuel.

In the second section we thought it best to define better what we consider the matter of the ruling gradient, especially where starting out of a siding, and the only idea we express is that the gradient should be such that the engine can start its train from any point of departure from that siding.

We also propose to change the words "grade" and "grades" to "gradient" and "gradients," the idea being that a grade may mean the embankment or the cut, and that was somewhat confusing, especially to the younger men; so instead of speaking of the grades, we will speak of the gradient, as being a better engineering term.

We have also recommended that the matter in the Manual coming under the chapter of Location be given a series of sub-headings, and believe it would be better and more comprehensive if shown in that manner.

We also recommend a new formula. This is in addition to the matter now in the Manual and is not a correction.

Chairman Howard:—I move the adoption and insertion in the Manual of the text under Appendix A.

(Motion duly seconded, put to vote and carried.)

Chairman Howard:—Appendix B is a report on "Resistance of Trains Running Between 35 and 75 Miles per Hour." The conclusions recommended for adoption are found on page 577. I move their adoption.

Mr. L. E. Dale (Pennsylvania System):—I inquire if that applies to resistance on straight and level track—the change of resistance with varying speed. That would apply to level track, and would not apply to grade resistance, if I understand it correctly. Could not the conclusions be amended to state that it is straight and level track that is referred to?

Chairman Howard:—The Committee will accept that.

(Mr. Howard's motion was put to vote and carried.)

Chairman Howard:—Mr. Going will present Appendix C, "Economics of Location as Affected by Introduction of Electric Locomotives."

Mr. A. S. Going (Grand Trunk):—Your Committee was supposed to report on the economics of this subject, but the Sub-Committee felt that we should devote most of our attention to the operating features, and you will notice on pages 578, 579 and 580 and part of 581, that we show the advantages and disadvantages of the electrification of our steam railroads, and especially as compared with the modern locomotive, and under the heading "General," on page 581, especially at the top of page 582, I would specially call attention to what we think is fair, where we say, "Steam railroads will generally consider electrification," etc.

Mr. C. F. Loweth (Chicago, Milwaukee & St. Paul):—In Appendix C, in referring to the economics of location as affected by electrical operation, on page 580, the Committee says: "Two or more electric engines coupled together may be operated by a single crew. This possibility of double heading without additional engine crews results in a considerable saving."

Later, under sub-heading, "Rate of Grade," on page 583, the following statement is made: "In heavy service, and especially on mountain grades, the economic value of electric operation may be quite high, as it is possible to add engine units without adding engine crews."

I know of no electric operation where it would be possible or, at least, where it is the practice to double-head freight trains with two electric locomotives with one engine crew, and I doubt the correctness of the conclusions of the Committee.

Is it not possible that the Committee had in mind that many electric locomotives are built in two half-units, each of which may be arranged so as to be operated independently if desired? Three half units are primarily intended to be operated as a unit with one engine crew. An additional unit, however, would certainly require an additional engine crew.

Mr. Going:—Personally I am not able to tell you, but this information is taken from some of the data that is issued by the General Electric Company; in fact, most of the data that we have used in compiling this was information we gleaned from different reports by men connected with the General Electric Company, and these Pittsburgh people.

Mr. Edwin B. Katte (New York Central):—I read the title of this report and it did not occur to me that a report on railway location would contain a dissertation on the relative advantages of steam and electric operation, therefore I regret I have not read it. I find a great deal, at this first glance, to criticize. The explanation from the Chairman of the Sub-Committee that the report is a compilation of information supplied by the General Electric Company might lead to the belief that perhaps the manufacturers of steam locomotives supplied some of the other data, as for instance the statement on page 581. (Mr. Katte read at the top of page 581, commencing with "The breaking of an insulator," and ending with "Section is tied up.")

I do not think such a delay ever occurred, except perhaps on an obscure trolley road. In fourteen years of electric operation on the New York Central there have been broken many insulators, but never has the whole railroad been tied up because of the breaking of one insulator. It might cause a delay of four or five minutes on one track to locate that particular insulator and isolate that feeder or third rail, but no general delay would occur. No railroad depends upon one feeder for its entire system. A little further on the same page I notice a reference to electric operation being more apt to be interfered with by the vagaries of the weather, that lightning is apt to interrupt it. Lightning seldom if ever interrupts electric railways nowadays, and other climatic conditions affect electric operation far less than they do steam operation. The record of the New York Central Electric Division during storms is far better than that of the adjacent steam-operated divisions.

Mr. G. D. Brooke (Baltimore & Ohio):—I have one point that I would like to have cleared up. On page 578 it says: (Mr. Brooke read from the second paragraph on page 578, commencing with "When properly designed" and ending with "under single control.") On page 582 it says: (Mr. Brooke read under Distance on page 582, commencing with "Track Maintenance" and ending with "Electric Motors.") These are two diametrically opposed statements. I would like to know which is correct.

Mr. Going:—In regard to the statement on page 582 I might say that I got that from Mr. McHenry as the result of his experience on the New Haven. Mr. McHenry wrote that sentence himself.

Mr. Brooks:—Can you tell me who wrote the other sentence?

Mr. Going:—I must confess I am a steam railroad Engineer and I do not profess to know very much about electrification. Mr. McHenry assisted me on the economics, for the other part I have used the "Signal Engineer," "Electric Railway Journal," "Railway Age," and all the information I could compile for the last five or six years.

Mr. Katte:—May I suggest that you call upon the Committee on Electricity for such electrical data as you will need for your next report? On the Committee on Electricity there are Engineers who have spent many years in the design, construction and operation of electric railroads and they are entirely at your service and will be glad to coöperate with you.

DISCUSSION ON SHOPS AND LOCOMOTIVE TERMINALS

(For report, see pp. 585-602.)

Mr. F. E. Morrow (Chicago & Western Indiana):—Your Committee has only had this year for the study of the subjects assigned to it. It has been actively engaged in collecting information as to prevailing practice on these subjects, but does not at this time present any definite conclusions as to recommended practice. The Committee have not felt that they have had sufficient time to present mature conclusions.

In Appendix A there is a discussion of the subject, "Design of car shops," it being limited to freight car repair shops, with certain tentative conclusions, and then a series of cuts showing the construction of various shops throughout the country on various railroads.

In Exhibit B we have shown a compilation of certain cuts of the various types and varieties of ash-pits. The Committee is further working on subject (2). This work is progressing, but has not yet reached the stage of compiling a report.

The Committee submits the information shown in appendices A and B simply as information.

The President:—This is the first report of this newly-created Committee, and I think they are to be congratulated for having brought together a great deal of good basic information, which will be built on in coming months. It is a class of work upon which I think we should place a great deal of importance, because it correlates the problems of the Mechanical Department with the Engineering Department. This Committee is coöperating with a similar committee in the Mechanical Division. I am sure they will appreciate constructive suggestions during the coming year in the furtherance of their ambitions.

DISCUSSION ON BUILDINGS

(For report, see pp. 843-888.)

Mr. W. T. Dorrance (New York, New Haven & Hartford):—The subjects assigned to the Committee on Buildings this year were five. A study of the Manual was made, but the Committee has no recommendations to make involving the subject-matter of the Manual. We do, however, expect, when the new Manual is printed, to have the subject-matter arranged in a slightly different form so as to make it more readily available. The Committee has no changes to suggest and the conclusion on this subject merely refers to the editing and rearrangement of the subject-matter now published.

Subject (2), Classification of Buildings, was given considerable study, and the Committee presents as information on this subject the matter contained in Appendix A. There are no conclusions; it is presented as information.

The Committee was not able to do very much work this year in connection with subject (3), devoting most of its time to subjects (2) and (5). In fact, subjects (3) and (4) were not given careful consideration, which enabled us to put most of our time on subject (5), which we felt had to be considered pretty thoroughly in order to get a real start on that subject.

Subject (5) is to report on specifications for buildings for railroad purposes. The Committee secured specifications from various railroads and made a careful study and analysis of the ones they were able to secure and from the data and information collected felt that the proper form for a general specification of this sort was in what might be termed the loose-leaf form, whereby each general subject was given a specification by itself, so as to make possible the combining of any number of these into one specification for such buildings as might be under discussion. We selected sixteen different subjects and were able to prepare specifications for eight of these.

The Committee would like to have the approval of the Association for this general method of the work and would like to submit the eight specifications which we have prepared for discussion, expecting them to lay over for a year before they are offered as final conclusions for insertion in the Manual.

The President:—Do I understand the Committee wants formal expression at this time of the general methods you are following in the preparation of the specifications?

Chairman Dorrance:—The Committee does not ask for any formal action, unless the convention thinks we are on the wrong track. We have gone ahead on our theory of loose-leaf form.

Mr. O. E. Selby (Cleveland, Cincinnati, Chicago & St. Louis):—I notice that in Section 6, Carpentry and Millwork are associated together. I have found that the practice in actual work is to separate these two subjects distinctly; the millwork is sublet usually and is a distinct classification. The carpentry work includes rough lumber and the placing of the millwork; the millwork includes all work that is dressed or framed in the mill before going to the site. I think it will facilitate letting mill contracts if these two subjects are specified separately, and it can be known distinctly in the case of each building just what is included in the term millwork.

The President:—I want to ask, on behalf of the Committee, for a great deal of constructive criticism during the year on this subject. This is a particularly important matter, and the Committee is making an earnest effort and has a good start. Its progress can be helped a great deal if the membership will give constructive criticism by correspondence if not in discussion on the floor.

Chairman Dorrance:—The Committee is presenting no formal conclusions for adoption for this year. I want to add for the Committee to what the President has said. We are very anxious, indeed, to get suggestions on this subject from all the members. It is an exceedingly hard thing to get a specification that will satisfy everyone, and we want to get just as many suggestions as we possibly can.

DISCUSSION ON MASONRY

(For report, see pp. 543-564.)

Mr. J. J. Yates (Central of New Jersey):—The work of the Masonry Committee this year has been largely confined to the work of the "Joint Committee on Specifications for Concrete and Reinforced Concrete," and many of its reports are deferred pending the results of the final specification that is to be issued by that committee. I am pleased to announce that in accordance with the instructions to the Joint Committee, it is proposed to issue a tentative specification to the societies represented on the Joint Committee about May of this year, and I understand it will probably be published in July in our Bulletin. Under the rules of organization discussion is to be open one year, and then it goes back to the Joint Committee for further consideration and preparation of the final specification. We hope that there will be written discussions and when it gets to the floor of the convention, oral discussions on the subject. Our instructions were to conform to the best practice and we are trying to do it, but there are some new things that will be introduced.

The Masonry Committee reports on two subjects, one a progress report, and one for insertion in the Manual. The first report for insertion in the Manual is the "Report on Disintegration of Concrete and Corrosion of Reinforcing Materials in Connection with the Use of Concrete in Sea Water." This subject has been before the Committee for several years and there have been several progress reports made. I will ask Mr. Schall, Chairman of the Sub-Committee, to present the report.

Mr. F. E. Schall (Lehigh Valley) :—In presenting this report of Sub-Committee (2) of the Masonry Committee, it is well to state that we have found it difficult to find a common ground on account of the diversity of results obtained in the use of concrete in sea water.

The Committee presents a number of conclusions, which may be considered a compromise among the whole Masonry Committee.

The precautionary notes in the report were thought necessary for constructing concrete to be used in sea water. The ordinary concrete of to-day, if used in sea water, will not prove satisfactory. It requires the most careful attention to select and prepare the aggregates, grading them to proper sizes. The mixing of the concrete and placing and working it into place must also receive the closest attention, so as to obtain a dense impermeable product.

The report has been printed; there is no reason for going into it any farther, but I will read the conclusions as printed on page 549, Bulletin 233.

(Mr. Schall read the conclusions 1 to 6 on page 549 and said) :

These conclusions should be included in the Manual to take the place of those published on page 294 of the 1915 Manual.

Mr. Chairman, I move that these six conclusions be adopted by the Association and published in the Manual.

(Motion put to vote and carried.)

Chairman Yates :—One other special subject was assigned to the Masonry Committee, that is, "Specification for Concrete Pipe." I am pleased to advise that the tests have been completed by a joint committee and the work of checking the observations will be completed this summer. The report will be presented in time for discussion at the next convention.

The next subject we want to present as information and we would like to have discussion. It is the very important subject, covering investigations of the consistency of concrete. You have before you a leaflet, which I am going to ask Mr. Freeman, the Chairman of the Sub-Committee, to discuss. I might say that I know there has been a heavy demand for this leaflet from many railroads, and I am sure that the Portland Cement Association, who prepared it from a large number of observations and tests, would be pleased to send the leaflet on request.

Mr. J. E. Freeman (Portland Cement Association) :—Mr. President, as this leaflet states, the effect of the quantity of mixing water upon the strength and other properties of the concrete is a matter which has been brought out most forcefully by recent investigations.

The chart which is at the top of the leaflet illustrates the effect upon the strength, indicating how, as the quantity of water in the mixture increases beyond that which has been shown as producing the maximum strength possible, so the strength of the concrete produced decreases. In many cases in ordinary construction, the quantity of water that is used today is probably anywhere from, I should say, 30 to 50 per cent. in excess of the quantity needed for maximum strength.

Now, of course, it is true that a concrete giving the maximum strength indicated on the chart would be rather too stiff to work readily in placing the concrete in structures, but at the same time a great deal can be done towards decreasing the quantity of water, and still have a plastic workable mixture that can be placed in forms without extra effort. As the chart shows, where 30 to 50 per cent. excess of water is used, the potential strength of the concrete is only realized to the extent of 50 per cent.; by reducing the amount of water, which would bring the quantity figure up along the curve to a point between 110 and, say, 125, a strength of the concrete can be realized, which will be 70 to 90 per cent. of the maximum possible.

The use of an excess quantity of water is bad from two standpoints. In the one case it means waste of good concrete material, and in the other case it means a reduced factor of safety in the concrete that goes into the work. For example, we generally count on a 1:2:4 concrete to produce 2,000-pound compressive strength at the end of 28 days, and yet if that concrete is placed in the work with an excess of water, we may not get and generally do not get more than 800 or 1,000-pound compressive strength.

The excess water also means that other properties of the concrete are reduced in somewhat like proportion, for example, the resistance to wear or abrasion. It has been found that where an excess of water is used which is sufficient to reduce the strength of the concrete 50 per cent., the same effect has been produced upon its resistance to wear; in other words, it has half of the resistance to wear which it otherwise would have. It has often seemed to me that if we were required to pay for the quantity of water that was used in the same proportion as we pay for other materials that go into the concrete, we would secure a much better quality of concrete.

However, it is possible to control the quantity of water by means of a simple test which has been developed, called the slump test. That is referred to in Appendix B on page 553. The slump test can be used as a means of determining the slump of concrete that is produced with a given consistency, selected on the basis of the mixture chosen for the work and the aggregates used as the proper consistency for that particular class of work, and then this slump factor can be transferred to the job and used as a control test for the maximum slump permissible. It is not necessarily an exact test. There are naturally some variations in the slump from different samples of concrete, but at the same time it is a good check where we have none at the present time beyond general observation, to see that the quantity of water or that the consistency which has been selected for that particular job is not being exceeded by the use of more water than is really necessary.

This whole matter can be summed up in a few words—put the excess of water on the concrete while it is hardening, rather than in the mixture.

A report which was presented in connection with Masonry Committee report for 1919 showed the results of some tests on the effect of moisture applied to the concrete while hardening and upon the compressive strength and the resistance to abrasion. Some of the tests now presented with this report as information carry this on further, covering a period from one year to seven years. The prior tests reported covered only a period from three days up to four months, but the same result is evident, that the application of moisture to the concrete while hardening has a tremendous effect upon its strength and other properties.

There is a need for further information on other points connected with the manufacture of concrete. We have developed this point as to the effect of quantity of mixing water and the point as to the effect of water applied to the concrete while hardening, but there is also the feature of the actual mixing of the concrete, that needs to be studied more fully—just how the material should be placed together, and the possible effect of certain types of mixers, etc. It is to be hoped that a great deal of investigation will be carried out along that line within the next year or two.

Chairman Yates:—This is offered as information. The Committee has nothing further to present, but would like discussion on this subject.

Mr. A. F. Robinson (Santa Fe):—I am one of the unfortunates who is not willing to accept the so-called slump test. It may be all right, and it doubtless is, but it is like some of those peculiar things which we can make mean almost anything.

I feel a good deal as though the investigations thus far made, and while they were made on proper lines, have at the present time resulted in clouding the results. At the present time we do not know where we are getting, we do not know what we want. It does not seem to me that we ought to arrange our rules for making concrete in such a way that we have got to have a so-called concrete expert on every division of the road. We ought to be able to make our rules so that they are very clear and simple, and so that we can put them into the hands of any intelligent gang foreman and have the work carried out properly and get fine results.

I feel further that insufficient attention has been given the time the mixer is to be run. Some of our friends have started investigations on this subject, but have got switched off onto other lines. They went off on the subject of water and in a certain way discounted the results of the time of running the mixer.

There is another important feature, however, which it does not seem to me the Committee has even touched and that is the care the concrete received after it has been placed. In this section of the country and east of here there is usually a sufficient amount of moisture in the atmosphere to keep and help the cure properly. When we go west of a north and south line, say through Dodge City, Kansas, the quantity of moisture in the atmosphere is much reduced and I doubt if more than 70 per cent. of the concrete built west of that line is near so good as it ought to be, nor so good as we should expect from the materials and workmanship used, provided we could keep the concrete thoroughly wet after the same has been poured and forms removed. This feature is one of the troublesome ones I have to contend with.

I am trying to find a method when making concrete units for pile and slab bridges and for abutments and piers by which when the concrete has been placed in the pier or in the work and the forms removed we can coat it with something that is going to absolutely hold in all the moisture that has been put into the concrete in mixing, thus permitting complete hydration of the cement.

If you look over the concrete in the Western territory you will almost invariably find that it is veined or crazed more or less. The concrete is in such condition that it will not last as long as it ought to and we must find some means of keeping the moisture that belongs in the concrete right through the seasoning process.

I have had several unfortunate cases where we had failures of reinforced concrete girders. When we put in the steel beams to take the load and cut out pieces of the concrete, you could break the chunks off at the corners just like you would a piece of half-dried clay. Afterwards these samples were put into water and left there for a week and we got a fine ring to the pieces. In other words, the hydration of the cement was again started, even after it had stopped for several years. It seems to me the committees could investigate these phases of the matter as well as the others.

Gentlemen, please do not understand from my remarks that I am attempting to ridicule or belittle this slump test and the test submitted by the Bureau of Standards. That is not my purpose. I am with you heart and soul in every kind of an investigation that can make and produce better concrete.

Chairman Yates:—I can submit one experience which will illustrate this matter. We had a structure in sea water, where we wanted the best concrete, and we secured a contractor to do the work in whom we had a good deal of confidence. When the contract was put up to him we told him we wanted every precaution taken and specified that there would be a slump test, and that he was to make the best of concrete. The comparative results were that 6-in. cubes of concrete taken as samples of 1-2-4 concrete as we mix it in ordinary work showed strengths below 2,000 lb., the concrete being made up of the best gravel and sand in our vicinity (washed cowbay gravel and sand). The slump was about 9 in. After a little experimenting we got the slump down to an inch, although we only wanted to keep the slump not to exceed 2 in., the slump test being used as a control test. After the concrete was deposited, cube samples were taken and when tested at the end of 28 days showed strengths of from 3,700 lb. to 4,375 lb. per sq. in.

Now, we found another thing. The weight of the test sample of the wetter concrete was low, 142 lb., and the weight of the dryer concrete of the same material and same mixture was 154 lb. per cu. ft.

As to the mixing time, there has been considerable investigation on that point, but I agree with Mr. Robinson there is much to be learned on this subject. We hope to coöperate with the Concrete Institute in their investigations of mixers this coming year. We do not know enough about mixers.

As for the care of concrete after seasoning, we had some reports last year, but they were not satisfactory. The general care of freshly deposited concrete is a live subject, and we are going ahead and getting further information and hope to have something more definite, but we are not entirely satisfied with the information now before the Joint Committee, and if any of the membership have reliable information as to certain failures of concrete which may be due to improper seasoning, and they will send a written discussion on the subject, we will be only too pleased to put it before the Joint Committee.

DISCUSSION ON ROADWAY

(For report, see pp. 695-722.)

Mr. J. R. W. Ambrose (Toronto Terminals):—There were seven subjects assigned to the Committee, which were handled by sub-committees. This is one of your committees, Mr. President, that believes in standardization, and where there are two or more ways of doing things, we believe that the A.R.E.A. way is the way it should be done.

In the absence of Mr. J. G. Little, the Chairman of the Sub-Committee on the revision of the Manual, I will present that part of the report. We wish, in the first place, to standardize the spelling of the word "Berm," at least for this Association. There is considerable difference in the pronunciation of the next word, "Subsīdence." We propose the accent be placed on the "sī."

The definition for shrinkage was criticized somewhat by Mr. Wendt last year, and through the efforts of Mr. McVay's Committee on Subsidence and Shrinkage, this new definition was formulated. The definition for "settlement" is entirely new, and we wish to delete the table on page 28 of the Manual in connection with the allowance for shrinkage, as it differs somewhat from Mr. McVay's report, which will follow. I move, sir, that this part of the report be approved.

Mr. J. L. Campbell (El Paso & Southwestern):—I would like an explanation of the reason for the redefinition of the word "shrinkage." It seems rather remarkable.

Chairman Ambrose:—The old definition is perfectly true, but the Committee feels in connection with certain work now in progress it needed to be elaborated somewhat and I will ask Mr. McVay to explain that situation.

Mr. C. M. McVay (Kanawha & Michigan):—In the work which was done by this Sub-Committee on instructions (2) and (3) on "subsidence and shrinkage," we found quite a confusion in the use of these words. For instance, the word "shrink" would be used when what was really referred to was "settlement," and we thought it best to outline the shrinkage as applied to materials, so that in this committee-work we could come to some definite comparisons in reaching conclusions.

You will notice in this definition it says "shrinkage as applied to grading material," and that is practically the only way it has been used in this connection.

Mr. Campbell:—The definition as proposed reads as follows (reads definition). Stopping after the word "equilibrium," the definition would not do because the volume of rock excavation in embankment is always greater than it was in excavation, so the words "negative shrinkage is known as swell" are added. The definition as it now stands covers two ideas, the antithesis of each other. It seems to me that it is a violent construction of the word. I raise the question of the necessity for defining so simple a word which always has only one meaning, namely, decrease of volume. This is not true of the word "settlement," which has a variety of meanings. If I were defining shrinkage, I would say shrinkage means decrease of volume.

Chairman Ambrose:—That is perfectly true, Mr. Campbell, but I do not believe that you can apply that definition to the exact purposes to which this is intended to apply. This is shrinkage in connection with grading work, and is precisely what our definition covers. It is true it is contraction of material, but contraction of material is not broad enough to explain exactly what we mean by shrinkage in the construction of an embankment.

As to your criticism regarding the last part of that definition, I feel we might make a separate definition for negative shrinkage. As a matter of fact, that is self-explanatory. If it is a minus condition, we know it is swell. The first part of the definition would hold good even though we had not added that last clause "negative shrinkage is known as swell."

It might be advisable to have a definition for "expansion" in addition to this definition for "shrinkage."

Mr. C. W. Baldridge (Atchison, Topeka & Santa Fe):—I had a good deal the idea Mr. Campbell has in regard to the definitions, and I want to call further attention to the definition of "settlement" given by the Committee; it says: "The term 'settlement' as applied to grading material is the reduction in height of an embankment caused by shrinkage or subsidence."

Then on page 705, at the end of the paragraph carried over from page 704, the Committee states: "Settlement may occur without there being either shrinkage or subsidence, but there can be no shrinkage or subsidence, as herein defined, without settlement." Their statement in this case does not agree with their definition. I believe that we can adopt a better definition than the Committee is offering. I suggest that this be carried over and the Committee ask for further suggestions.

Chairman Ambrose:—The definition for "settlement," I believe, as given here, is absolutely correct. You cannot have either subsidence or shrinkage without settlement. Settlement is simply the reduction in elevation of any kind of an embankment. The Committee, of course, welcomes this criticism. We would like some suggestion as to what the definition should be.

Mr. Baldridge:—I would offer the following as amendments to these definitions:

SHRINKAGE.—Shrinkage is a decrease in the volume of an embankment due to the disintegration of the coarser pieces of material placed in the fill, with a consequent filling up of voids, and compacting of the material in the new location.

SWELL.—Swell is the increase in the volume of material as shown by its measurement before excavation and its measurement in embankment after it has reached a state of equilibrium.

SUBSIDENCE.—Subsidence is the decrease in the height of an embankment due to the compression or displacement of the material upon which the embankment was placed.

SETTLEMENT.—Settlement is a general term covering decrease in height or volume of an embankment due either to shrinkage or subsidence.

Chairman Ambrose:—Mr. President, the Committee did not desire to write a treatise on the subject. The suggestion has been made by our worthy President, that the heading of this definition should be "shrinkage or expansion," then the definition would apply, except we would delete the last sentence.

The President:—We have an unwritten rule that we will not take up the time of the convention in discussing definitions, punctuation, and matters of that kind. The Chair does not want to restrict proper discussion of a matter of this kind, but feels that we should make progress. As the matter stands now, there is a motion before the house, approving this definition as it stands. Bear in mind that if the wording is such that there cannot be any confusion, the question of the exact wording of the definition can be easily disposed of.

(The motion was put to vote and carried.)

Chairman Ambrose:—The second subject is "Subsidence and Shrinkage of Embankments." That was handled by Mr. McVay.

Mr. McVay:—On page 704 there is a mistake in printing. The paragraph next to the bottom of that page, the fourth sentence, the word "settlement" should be changed to "shrink."

On page 705, in the last paragraph in the second line, the word "shrinkage" should be changed to "settlement."

The Sub-Committee and the Committee in general has put in considerable time in going over the information that was received, and submits the conclusions found on page 700.

"Shrinkage" was taken up, and the conclusions are to be found on page 706.

Chairman Ambrose:—I move, sir, that the conclusions be approved and incorporated in the Manual.

Mr. Geo. A. Mountain (Canadian Railway Commission):—I would like to ask the Committee how they come to the conclusion of figuring shrinkage of 10 per cent on earth moved from excavation to embankment?

Mr. McVay:—We had cases cited where the shrinkage would run as high as 40 to 60 per cent; some cases where the shrinkage was 2 and 3 per cent, and in the first place it was necessary to get some definite standard to compare these things, and practically the only comparison that could be made was the quantity in the excavation and the same quantity in the embankment. Quite a lot of the data that is available does not carry that out far enough to give much information, but we found that ten per cent was what would be used generally all over the country in ordinary earth excavation by practically all Engineers in anticipating shrinkage, and we also found that the average of figures taken after the jobs were completed, where the figures were prepared in anything like shape so we could use them, was very close to ten per cent. I am free to say that that appears to be the general practice. Almost every railroad that we got a reply from stated that they were allowing 10 per cent shrinkage.

Mr. J. B. Jenkins (Baltimore & Ohio):—I will ask the Committee if they will accept an amendment to conclusion (1), inserting "of quantities measured in excavation" after "per cent," making it read: "Figure a shrinkage of 10 per cent of quantities measured in excavation on earth removed from excavation to embankment."

The reason I suggest this is that the Interstate Commerce Commission, where it has been applying a shrinkage of 10 per cent had been adding 10 per cent to the shrunken embankment quantities in order to ascertain the quantity of excavation, which results in a shrinkage of 9 per cent instead of 10 per cent.

The President:—Is that a suggestion, or offered in the form of a motion?

Mr. Jenkins:—If it is so desired, I will offer it, but I thought that the Chairman of the Committee could ask the Committee to accede to the amendment.

Mr. McVay:—There has been, as I understand, some discussion about the way this is to be applied, as to whether this yardage is from the source or in the opposite way. We found that in some cases it was applied one way, and in other cases in another, different instances that were brought to our attention, but we did not feel like saying that it must be applied from the source or that it must be applied from the final location. The percentage, I believe, runs about 9.1 one way and approximately 11 the other way. The way it is written here it implies excavation, and that is, I think, the way that it is generally applied by the Chief Engineers of the roads from whom we got replies.

Mr. Jenkins:—I am aware that it was customarily applied to excavation quantities in engineering work in making estimates, but I call attention to the application in the opposite direction, introducing an entirely new custom.

Mr. H. H. Harsh (Baltimore & Ohio):—By looking at the definition that has already been accepted by the Association, I would infer that the application would apply to the original excavation.

Mr. A. M. VanAuken (Chicago, Indianapolis & Louisville):—I do not know as the experience of the rest of you has been the same as mine. There seems to have arisen a serious question as to shrinkage, or what is really a different matter, from loss of material in transporting from the excavation to the embankment. In whatever way it is transported there is a loss. In some methods it is very much greater than in others, and I wondered if it would be desirable to have a clause here following the one under discussion, that this did not include loss in transportation. I do not know whether this is worth while, but with us that has caused quite an argument.

Chairman Ambrose:—The Committee is very glad to have this discussion, and as a matter of fact it was anticipated. If Mr. Jenkins so desires, I will be glad to have him put that in the form of a motion, so it can come before the house officially.

Mr. Jenkins:—Mr. President, I move that the words "of quantities measured in excavation" be inserted after "per cent."

(Motion duly seconded, put to vote and carried.)

Mr. E. A. Frink (Seaboard Air Line):—I move to amend conclusion (1), on page 700, by including the words "in general" after the word "is," so the last sentence will read: "The percentage of subsidence is in general greater under small fills than under larger ones."

My reason for that is that in certain sections of the country, principally along the Coast and Southeast, as far as my experience goes, large swampy sections are overlaid with a heavy mat of decayed or partially decayed marine growth and other vegetation which acts as a raft to a low fill, and we sometimes find a case where this raft is strong enough or has floating power enough to carry not only your fill, but your track and your road. In other cases, of course, it does not do that; but cases sometimes happen where high fills on that same condition will subside 40, 50 and 100 per cent, and I have known of 200 to 300 per cent of normal, and therefore it seems to me worth while to admit that such cases do occur, and simply insert those words.

The President:—The Committee will accept that suggestion.

Chairman Ambrose:—The next subject is "Corrugated Metal Culverts." Mr. Penfield, Chairman of that Sub-Committee, was called away suddenly last night. Although the Committee collected considerable data regarding the use of corrugated metal culverts, they are not recommending the use of them for permanent work, but only as a temporary medium. On page 708 of the Bulletin you see a table showing the results of the use of metal culverts on one of the Southern roads; and then they present a tentative specification. In preparing this they worked in conjunction with the Bureau of Public Roads. They are just putting this up for discussion. They are not recommending it this year, and they wish to have the subject returned to them next year, when they expect to have a finished specification.

"Sealing Bad Cracks in Rock Cuts with a Cement Gun." Mr. C. W. Brown found it impossible to get here. In justice to all the members of the Committee I will say that we have had nearly a full attendance, but several of the members were called away last night on account of labor troubles. Mr. Gilcreast is here representing Mr. Brown, and I will ask him to present the report, Appendix D.

Mr. F. W. Gilcreast (Lehigh & New England):—I will say that we have received considerable information on this subject from a number of roads, and we are also doing some of this work on the road which I represent. It is not far enough along yet to furnish any definite conclusions. About four years ago in a tunnel about 3,900 ft. long, with about 400 ft. of brick arching in different sections, we sealed up all cracks that had accumulated in twenty years' service with cement gun, and that has been absolutely tight ever since then, both to water and affecting causes. Now we are trying to seal up three or four bad places where the water percolates and keeps the track bad—almost impossible to keep a good running track. We simply offer this as information, with the conclusion on page 711 (reading conclusion).

Chairman Ambrose:—This subject is presented to you as information, and the conclusion below is presented to the Committee on Outline of Work for their action.

"Standing Water in Borrow Pits," Appendix E. This subject was handled by Mr. W. C. Curd, Chairman of that Sub-Committee, who will present the report.

Mr. W. C. Curd (Consulting Engineer):—Mr. President, the Committee regrets that it has nothing to present this year. We received a very large number of replies to circulars which were sent out for information, but they contained only opinions and no facts upon which we could base conclusions. There seems to be a confusion existing between the effect of standing water in borrow pits and the water retained in embankments, and we have not been successful yet in getting data on specific locations from which we could report anything definite. We have some information from the Government in regard to the movement of soil moisture, which indicates that it might be brought down to a question of character of soil, and the Bureau of Public Roads is carrying on tests now. We hope to collect further information this coming year and would like to have a little more support from the members of the Association to assist us in coming to some conclusion.

Mr. Mountain:—It seems to me that this question goes further than the stability of an embankment. That, of course, is a very important matter. I note here: "Instances are known where greater benefits have been derived by reinforcing embankments with wider crowns and flatter slopes than by borrow pits drainage." That means, if I get the intention, to leave the borrow pit full of water. That has a deteriorating effect on adjoining land, saturates it and and brings on lawsuits, and is a constant source of worry to Canadian railroads from farmers because of their land being saturated. It seems to me that borrow pits should be drained, both for the stability of the embankment and for the interest of the community at large.

Mr. Curd:—The question of borrow pit drainage is covered in the Manual. The question was presented to the Committee to decide as to the effect of standing water in borrow pits on the stability of embankments. I don't think that anyone denies the fact that troubles have resulted to adjoining land, but the Committee felt that that question was settled, and it could not act upon it. The same suggestion was made, I think, in a reply from some one of the Canadian members.

Chairman Ambrose:—In connection with standing water in borrow pits, I might say that the Committee makes an appeal to you at this time, if the subject is continued, to supply Mr. Curd with the information he asks for. There seems to have been an indifference to the questionnaire which was sent out.

"Drainage of Larger Cuts," which is the last subject, Appendix F, will be presented by Mr. R. B. Robinson, Chairman of that Sub-Committee.

Mr. R. B. Robinson (Union Pacific):—Mr. President, the Sub-Committee on this subject has thought that the drainage requirements for long soft cuts offered a condition which should be avoided in any reasonable way possible, in the first place by not laying the line into such soft locations if it is reasonably possible to avoid it. After it may have been found necessary to lay a line into a condition of that kind, various methods have been used to carry off the water, and the illustrations we have shown, pp. 718 to 722 inclusive, are offered as information, showing how several different railroad lines have worked out their local problems.

We are not attempting to say that any one of these plans shown, or any other one plan would solve every local condition that could arise. The following conclusions, shown on pp. 716 and 717, were arrived at through meetings and correspondence, and are as follows:

(Mr. Robinson read conclusions one, two and three on pp. 716 and 717.)

Chairman Ambrose:—Mr. President, I move that these conclusions one, two and three, be adopted and placed in the Manual.

(Motion duly seconded, put to vote and carried.)

DISCUSSION ON WOOD PRESERVATION

(For report, see pp. 443-480.)

Mr. C. M. Taylor (Central of New Jersey):—The report on Wood Preservation this year is full of information, without any definite recommendations for the Manual. A part of the report that should appeal to each and every Maintenance Engineer is given in Appendix A, on page 446 of Bulletin 233, on Service Test Records. These records have resulted from experimental tracks in most cases, on the Rock Island, St. Louis-San Francisco, Baltimore & Ohio, Santa Fe, the Monon, and the Big Four. In all cases except the Big Four the results are obtained through the insertion of experimental track sections. The first report will be the results obtained on the Rock Island, which will be presented to you by Mr. Ford.

Mr. C. F. Ford (Chicago, Rock Island & Pacific) :—We have selected one section on each Operating Division, which is representative of conditions on the Division, and keep a record of all ties inserted and removed. The ties used on these sections are of the average run and are not selected, as it is desired to keep the conditions as near as possible to the average actual practice. These test sections are checked in the field by a representative of this Department. The service record of treated ties inserted in test sections from 1908 to 1914 will be found on pages 447 to 452 of Bulletin 233.

Chairman Taylor:—Are there any comments to be made on the result of the tests on the Rock Island? You will note that they cover three different treatments, and are giving very satisfactory records.

Mr. Steinmayer, who represents the Frisco on the Committee, is not present. I will call your attention to the report of the Frisco on pages 453 and 454. It is very interesting to note that the white oak, the basis for comparison in most tie work, does not show up as well as a great many people think it should.

The results of the tests on the Baltimore & Ohio will be explained to you by Mr. Angier.

Mr. F. J. Angier (Baltimore & Ohio) :—The tie tests on the Baltimore & Ohio are confined to test tracks. We are not trying to keep a record of several mile lengths of ties, as they are doing on some of the other railroads. Our test tracks are confined to lengths of from 1,000 to 5,000 ties, and we have eight or ten of these. The most interesting test track we have is located at Herring Run, Md., about six miles east of Baltimore. In this track we placed 3,300 red oak ties out of face. They were put in under the same ballast conditions, using screw spikes and tie plates, 300 being untreated and the balance treated in ten different ways. The treatments used were zinc chloride, sodium fluoride, water-gas-tar, coal-tar creosote, and mixtures of coal-tar creosote, water-gas-tar and zinc chloride.

The statement on page 456 of the report may give a wrong understanding. It shows the percentage of ties removed for all causes, and in this test track at Herring Run it shows that 42 per cent of the ties have been removed from a lot of 300 treated with zinc chloride. It is true that 42 per cent have been removed, but not a single tie has been removed for decay. They were removed account of putting in a switch and account of a derailment that occurred on this track within a few months after the ties were installed. I would much prefer to use two columns in these reports, one of them showing the number of ties taken out account of decay and the other for ties taken out account of other causes.

Chairman Taylor:—I might ask Mr. Angier whether the results of the test so far give a definite indication as to the future policy of his road.

Mr. Angier:—This test shows that 63 per cent of the untreated ties have been taken out for all causes, of which 60 per cent were taken out for decay alone, while not a single treated tie of any kind has been taken out. This shows very clearly what a wonderful saving it is in treating our cross-ties.

Chairman Taylor:—The result of the Santa Fe test will be given by Mr. Belcher.

Mr. R. S. Belcher (Atchison, Topeka & Santa Fe):—We have tried to make our test sections on the Santa Fe as nearly representative of the ordinary sections as was possible. In other words, the ties are spotted in, and the only difference between these sections and the ordinary sections is that an individual record of each tie is kept. However, we have some special tests where ties were put in out of face, which are carried on in connection with the A.R.E.A., and annual report made to this Association. Our oldest test of this kind and possibly the most remarkable is that shown on page 459 under the heading "Ottawa Cutoff." This represents about 24,000 ties that were put in in 1906, ordinary hewn pine, loblolly, which, as this report shows, were treated with creosote, and although these ties have been in more than fourteen years, only 357 have come out to date, and none of them have come out on account of decay. The principal reason for those 357 coming out is derailments, and the consequent breakage of the ties.

Chairman Taylor:—The report of the Monon appears on page 464. I will ask Dr. von Schrenk to explain that report.

Dr. Hermann von Schrenk:—I believe that the Monon report speaks for itself. It is simply a progress report of tie insertion, particularly the second table showing the number of ties inserted in the track, and the conditions under which they are being used. There are but few detail figures available.

Chairman Taylor:—The next report will be the Big Four, which is along entirely different lines. It is a history of their treated tie work from the time they started until the end of 1919. In other words, it is the whole story, and I will ask Dr. von Schrenk to explain the report.

(Dr. von Schrenk read page 465, Bulletin 233, and said):

There is a slight correction I wish to call attention to on page 467. There should be a heading inserted in the table on that page, "Removed for Causes Other than Decay," to correspond to the title, "Removed on Account of Decay" on the previous page.

Without going into the details of the interesting phases which have developed through a recent study of the tie record, and the point I wish to call particular attention to, that these figures represent as nearly as possible an actual count of every tie, both treated and untreated, inserted in the Big Four System since 1905. The Big Four adopted the practice of putting a date nail into both treated and untreated ties, the date nail being applied to the ties at the treating plant. As careful a record as possible has been kept of all removals by years, and we hope during the coming year to give further details showing the results of removal by years. You will note that the tie insertions shown on page 465 for the System, have dropped from 365 ties to the mile to 201 in 1919, or a reduction of 164 ties to the mile. I would like to add this additional figure, that for the division on which the highest percentage of treated ties was inserted they dropped down for 1919 181 per cent, in other words, during the year 1919 on the Michigan Central only 181 ties were inserted, making a striking contrast with the previous experience. This record shows in a startling and striking way that the probable life that we are attaining from these early ties, many of which were probably not treated as well as we are doing now, give every indication that every tie in the railroad should be a treated tie.

Chairman Taylor:—That completes the section on Service Test Records. The next portion of the report is shown in Appendix B, "Merits of Water-Gas as a Preservative." This portion of the report will be presented by Mr. Angier.

(Mr. Angier then presented Appendix B.)

Chairman Taylor:—The next subject reported on is "Availability and Use of Sodium Fluoride as a Preservative for Cross-Ties."

(Chairman Taylor then presented this section of the report and said):

Sodium fluoride has certain apparent advantages in the treatment of cross-ties, and the Committee suggests that any railroad maintaining experimental tracks should install a certain number of ties treated with sodium fluoride and maintain records from which conclusions may be drawn; in other words, sodium fluoride presents itself as a possible preservative for cross-ties, and any railroad having experimental tracks would do well to install a thousand or two with sodium fluoride for study.

In the absence of Mr. Ilsley, the Chairman of the Sub-Committee on the subject of the "Protection of Piles in Water Infested by Marine Borers," I will present the Appendix.

The idea in view in this section of the Committee's work was, first, the protecting of those stringers which have been put in untreated, and whose present condition are such that they are threatened with destruction due to the activities of these borers, and, secondly, to devise some method of protection of these structures which were treated with preservative and which were not as carefully treated as the conditions since would indicate they should have been treated, and, thirdly, those conditions which would indicate that due to the very intense activity of the marine borers, the oil used possibly was not strong enough in its toxic qualities to render the piles permanently immune from attack.

Consequently there are three different cases shown of mechanical protection. The one on page 474 is the cast-iron protection on the Louisville & Nashville, with which you are all familiar and which has been reported on before. The second is shown on page 475, the vitrified pipe casing, which is a much cheaper method and seems to be a fairly good protection under certain circumstances. The third case is shown on page 476, and brings up the question of reinforced concrete casings, which can be installed after the piles are in service.

This Sub-Committee reports certain other studies which have been made for the same purpose, covered by gunite and explained on page 478. The Sub-Committee has three definite conclusions given on page 479, which they would like to have approved. They are not for insertion in the Manual, but are conclusions they have arrived at through a study this year.

On subject 8, "Comparative Values of Grades 1, 2 and 3, Creosote Oil and Creosote Coal-Tar Solution," the Committee feels that the report as given last year covers the situation as well as it is able to put in writing, and in connection with subject 9, Accelerated Tests of Grades 1, 2 and 3, Creosote Oil and Creosote Coal-Tar Solution, the Committee has not been able to develop any reliable methods for making any such accelerated tests.

With reference to the conclusions on page 445, Conclusion 2, the Committee felt that the data they have in hand at the present time does not enable them to give you something you can put in the Manual. The Committee does feel, however, as time goes on as a result of these experimental track sections they may have something on the comparative values of Grades 1, 2 and 3, but they also wish to say it is not something that can be decided offhand, because it is interwoven with so many other problems, that it is difficult for the Committee to formulate any definite conclusion that we would dare ask to be put in the Manual. The Committee feels that this subject is one that all future committees should consider, and if at some time they are able to give you something that is worthy of insertion in the Manual, they feel that such will be done.

(In connection with Conclusion No. 3, Chairman Taylor said):

In other words, it was our thought that this Committee could develop something that would determine this matter very quickly, and they suggested accelerated tests to show this differentiation in values, and the Committee is very frank in saying that that is an absolute impossibility, and for that reason they recommend that no further consideration be given to the subject. It is one of those things which cannot be done quickly. It is not like the case of a cement where you can make your quick tests as a preliminary. The Committee suggests these conclusions this year.

The President:—Is there any further discussion of these suggestions? These recommendations do not require endorsing action. They are suggestions which are to be placed before the Committee on Outline of Work.

DISCUSSION ON WOODEN BRIDGES AND TRESTLES

(For report, see pp. 481-542.)

Mr. W. H. Hoyt (Duluth, Missabe & Northern):—The first subject, revision of Manual, was in charge of Mr. Ridgway, but in his absence Mr. Austill will present the matter.

(Mr. Austill presented the matter under "Revision of Manual.")

Chairman Hoyt:—I move that the recommended changes of the Committee be adopted and incorporated in the Manual.

Mr. G. A. Mountain (Canadian Railway Commission):—There is a term used by the Committee in (2) under "Use of guard rails and guard timbers for wooden bridges and trestles." It is recommended that the inner guard rail, *when used,* shall be so spaced, etc. I think it is common practice to use an inner guard rail, and this expression would seem to convey the idea that the Committee does not recommend it entirely.

Chairman Hoyt:—That is in the present Manual, and the question is optional with the Designing Engineer as to whether to use guard timber or not. I am informed that this matter was up at a previous meeting, and a motion to make it standard practice to use an inner guard rail was not approved, and that is the reason the Committee left the clause "when used" in there. Of course, it is possible to bring the matter up at the present time and decide whether it shall remain or not.

Mr. Mountain:—In our practice in Canada it is standard; it has got to be placed.

Chairman Hoyt:—The practice is nearly so in the United States, but there may be a number of cases where it is not so.

(Mr. Hoyt's motion was put to vote and carried.)

Chairman Hoyt:—The second subject assigned to the Committee appears on page 494 in Appendix B, "Specifications and Classification and Grading Rules for Lumber and Timber to be used in the Construction and Maintenance of Way Departments of Railroads." This subject has been before the Committee for the past three years and was submitted last year as information, and this year has been again gone over and a number of revisions and improvements made and is now submitted with a view to final approval for printing as recommended practice. I do not want to take the time to read this all through.

Mr. O. E. Selby (Cleveland, Cincinnati, Chicago & St. Louis):—Is it the intention to insert in the specifications for use these illustrations of defects? It occurs to me that these illustrations are valuable for purposes of instruction, but it hardly is practicable to use them in a commercial specification.

Chairman Hoyt:—It is the intention of the Committee to publish the illustrations. Of course, they cannot be used in a commercial specification, but they are instructive as showing and presenting clearly the defects covered by them. It is the opinion of the Committee that the publication of these illustrations is well worth while.

(Chairman Hoyt then outlined the matter on pp. 504-509, and in relation to "Density Rule for Southern Yellow Pine," on page 509, said):

We have placed in these specifications the density rules as developed by the last specifications of the American Society for Testing Materials, and as further followed out and tested and undoubtedly to be recommended by the Forest Products Laboratory at Madison. This particular feature of the report has been given considerable attention and probably caused more detail work than any other feature of the specifications. We tried to decide on a density clause giving the proportions of summerwood and springwood that would be allowed in the different timbers.

(Chairman Hoyt then abstracted pp. 510-513.)

The President:—On this question of ties, something was said yesterday about the correlation between the recommendations of various committees as to ties and those of the Tie Committee.

Chairman Hoyt:—As we have taken up the question of ties, we only cover ties for wooden bridges and trestles. We do not deal with track ties as such.

The President:—Is there not some conflict, as a matter of fact, between the item "ties and guard rails" on page 513 and any recommendation the Tie Committee has made?

Chairman Hoyt:—The only possible conflict would be on page 527, oak switch ties, and we will reach that in a moment.

(Chairman Hoyt then read the matter on pp. 514-527.)

The question arises as to Switch Ties sawed. It was intended that this clause would apply only to structural oak for bridge purposes. If there seems to be any conflict with the report of the Tie Committee, that particular paragraph can be omitted, but I see no reason why it should be.

Mr. F. R. Layng (Bessemer & Lake Erie):—I think that should be done. These specifications cover wooden bridges and trestles, and should not conflict with the specifications of the Tie Committee. I do not understand why this Committee should bring in specifications on materials applied largely to buildings and other railroad structures, and why they do not confine their specifications strictly to the subject assigned to them

Chairman Hoyt:—I will read the subject assigned to us, "Continue study and report on general specifications and classification and grading rules for timber and lumber for railroad purposes."

Mr. Layng:—I suggest the Board has been a little liberal in their assignment to this particular Committee.

Chairman Hoyt:—I would like that matter to be brought up before the Board.

The President:—I think that is true; it is a matter to be handled by the Board. This suggestion is noted and the Committee on Outline of Work will take cognizance of that.

Chairman Hoyt:—As to the specifications for oak switch ties, if any member wishes to make a motion covering that paragraph, it could be acted on.

The President:—I hardly think that is necessary, unless there is something in the particular paragraph that is objectionable in its text or principle. The question that has been raised in discussion is one for the Board to act on without action on the part of the convention.

(Chairman Hoyt read the matter on pages 527 to 534.)

Mr. Selby:—I am asking for information, because I have not read the specifications thoroughly. I would like to know to what extent the separate specifications for construction oak, for hemlock, and for cypress and for other timbers are independent, and whether they could be taken out and used independently, and to what extent the preliminary definitions and specifications must be taken along with the specifications for the different kinds of timber. Also, are there any heartwood requirements in any of these specifications, except for the No. 1 structural grade yellow pine and Douglas fir?

Chairman Hoyt:—Answering your first question, of course, the Committee, in drawing up these general specifications, found there were certain timbers the manufacture and use of which were so radically different that they could not be included in the general specification and classification of grading rules, principally oak, cypress and hemlock, and that is why a special specification covering these particular timbers was placed in this report. In making up a specification covering any of these timbers, there are certain general clauses that can be taken and so headed in the general specification that they can be applied in a general way, but in getting down to the details concerning oak, cypress and hemlock, it seems necessary to adopt certain specifications covering these particular timbers. As I understand it, your question relates to the matter of drawing up specifications covering particular timbers.

Mr. Selby:—What I want to get at is; in presenting to a manufacturer a specification for structural oak, of course he is not interested in a specification for other kinds of timber. I want to know what paragraphs in this specification, in addition to the one which begins on page 526, for instance, should be given him in order to get in all the requirements.

Chairman Hoyt:—These paragraphs are headed generally in the standard specifications: "Defects of manufacture, applicable to all timber and lumber," and that covers the clauses up to the point where we take up the standard sizes and up to the point where we consider the question of structural grades for bridge and trestle timbers. The Southern yellow pine and Douglas fir specifications are given on page 509. The question of heart requirements is covered practically only in the structural part of the specification under the density rules.

(Chairman Hoyt then read the matter on pp. 536-542 and said):

These specifications are entirely too long to study here in detail.

As I have said, they are the work of the Committee for three years, and we submit them for publication in the Manual as recommended practice.

I move the adoption of the specifications and publication in the Manual as recommended practice.

Mr. Selby:—I ask for information—is the table of Working Stresses Permissible for Structural Timbers, shown on page 542, included in the recommendation for recommended practice?

Chairman Hoyt:—Yes, it is intended to be included. We have a table in the old Manual, and there are only some slight changes in this table from the old table, but it was thought better with these specifications to revise this table to that extent, and I think the only revision is in the structural fir, No. 1, in allowable stress in extreme fiber.

There has been considerable discussion in the Committee on this table, and there has been some criticism, but after it was all boiled down we were unable to come to any conclusion as to how we could improve it at the present time, except with the very few changes we made in the old table, and this table is submitted for publication with the general report.

Mr. J. B. Jenkins (Baltimore & Ohio):—Is the table of unit stresses intended to be part of the specifications?

Chairman Hoyt:—They are not part of the specifications, but part of the report of the Sub-Committee.

Mr. Jenkins:—Are the definitions and description of defects intended to be a part of the specifications?

Chairman Hoyt:—They are a part of the report on specifications and classification of grading rules. Of course, this specification takes in classification and grading rules as well as the specifications covering the timber. In a detail specification all these definitions would not be used, but are a part of the report as elucidating and clearing up the terms used in the specification.

Mr. Jenkins:—Would it not be better to remove the title from the top of page 494 and transfer it to the top of page 504?

Chairman Hoyt:—That might be done.

The President:—That can be considered as a suggestion to the Committee on Manual when the Manual is put in final shape for printing.

Mr. Selby:—It seems to me that it is essential that the definitions of defects, knots and practically all the definitions beginning on page 494 should be included in the specifications. There is no use in prescribing certain things in the definition unless it is definitely known what these things mean.

Chairman Hoyt:—It is my opinion that it is a matter for the individual choice of the Engineer in drawing up his specifications. These specifications are not to be clipped out with a pair of scissors and bound together and be made a specification, but they are a basis from which can be selected and arranged a specification covering the class of timber that it is desired to purchase for use.

I agree with Mr. Selby that you certainly need a clear understanding of the terms in your specification, to have a satisfactory result in the use of it.

Mr. E. A. Frink (Seaboard Air Line):—This Committee has evidently done a great deal of very valuable work. It seems ungracious to throw stones at it, but there are some things about this specification that do not seem to me to be right.

In the first place, it does not seem to me that the table of sizes belong in the specification. They are information, and not properly a part of the specification, and the specification could be largely reduced in bulk if these sizes were printed as information in accordance with our previous practice.

The second point is the density rule for Douglas Fir. That is a new one, and as we adopted the density rule for yellow pine only after thorough consideration and investigation, I can only assume that the Committee has made such an investigation in regard to fir and are satisfied that the rule is equally equitable.

This specification seems to me to be unwieldy and cumbersome. I do not think it should be in one part. I do not see why we should write a specification for oak and fir combined any more than we would write a specification for bridge steel and rail steel combined, and none of us would think of doing that. Why are not the two subjects sufficiently dissimilar to require two separate specifications?

Another thing—why should not the specification for the timber for different kinds of work be approved by the proper committee having that kind of work in charge? While this Committee has done a great deal of constructive work, because I understand this specification is in accordance with the rules of, and practically approved by, the National Lumbermen's Association, and therefore we are reasonably sure we can get what is specified, nevertheless this Committee has written a specification for lumber for buildings and shops and ties, and for other things, over which they have no jurisdiction, and it seems to me that the specifications for lumber for these purposes should be referred to the committees having these subjects under their jurisdiction.

Another point to find fault with is the specification for timber for ties to be treated. I had the honor some four or five years ago of presenting a long treatise on that matter and do not want to burden you with it again, but I think a specification for lumber for treating ought to bring out in unmistakable terms the possibilities of the use of lower grade timber. One of the chief justifications for treating is the ability it gives you to use a cheaper grade of timber and secure equally long life, and sometimes greater life, compared with the more expensive grade.

On the Seaboard Air Line we have at present something over fifteen miles of creosoted trestle timber, over half of which is loblolly pine. All of the stringers and caps are creosoted loblolly pine. We have been carrying on the trestles 12.5-ft. span axle loads as high as 55,000 and some hundred. A recent inspection has not disclosed a single case of a failed cap or split cap or crushed cap or a single failure of any stringer or a single case of deterioration of a stringer, and we have not spent a dollar on these stringers since we applied them in 1910. I think that is good evidence that loblolly pine is good material for that class of work.

These specifications permit the use of loblolly pine, but they do not accentuate it and the natural inference of anyone reading the two short paragraphs in this paper referring to timber for treating, would suppose the proper thing to do would be to order dense pine or fir, all naturally good, for that purpose, and I think we should bring out the point it pays and is economical to use a cheaper grade of timber for treatment.

It would be my recommendation that the report be referred back to the Committee for separation into its component parts in coöperation with the various committees which handle the matters to which the specification applies.

Chairman Hoyt:—There are several points which Mr. Frink brought out which are very interesting, and of course would perhaps require a long discussion to make them clear.

The first subject is the question of sizes. I do not know of a more trouble-causing clause in any of our specifications than the lack of a clear understanding of size. All of us have been up against that problem of buying flooring and ceiling and drop siding, and expect to get a certain size and we found we got something different, depending on the particular mill or the purchasing agent getting the material from the place where he could get it cheapest and then the trouble started.

The lumber dealers have realized that condition the same as we have, and they are working towards standardizing their materials, so there will be a clear understanding of what is meant by siding or ceiling or flooring, especially when certain dimensions are given, and they have considered it very important that any classification should state exactly what was wanted in the matter of sizes, and personally I feel that there is nothing in the specifications that is of more importance than establishing clearly what is intended to be purchased under a certain name, by giving it a definite size. That is my answer on the question of sizes.

As to the density rule for fir, it is true that we have submitted this rule after a study of the rule adopted by the American Society for Testing Materials at its meeting last year. It is their recommendation and has been approved by the Forest Products Laboratory at Madison, Wis., and has been submitted to the Lumber Manufacturers' Association, and I understand verbally that it is satisfactory to them. While it is new, it is being adopted and we have submitted it in our recommendations for form of specification.

Now, as to the question whether the Committee went outside of its jurisdiction in submitting these specifications. God knows they did not intend to do it, because it has been too much work, and right there we get to the root of this question of bulky specifications. Are we to submit separate specifications for every class of timber or lumber to be used on a railroad?

If so, we will run into several volumes of specifications, very similar in their nature to the publications of the American Society for Testing Materials. You can easily see that if we are to draw up detail specifications for tank stock, for bridges, for first, second and third class timber for trestles, and for the various other structures on a railroad, we will run into an almost unlimited number of specifications, all complete in themselves, which it is true you can turn to, and have a guide for use in purchasing material, but if you are going to do that, gentlemen, we will have, as I say, a very large volume of specifications, and in my opinion it is going to load up our publications with an unnecessarily large amount of matter. The idea of the Board in assigning this topic to the Committee was to condense these specifications into one compact body, from which could be taken and drawn specifications covering the various items they desired. That is what we have attempted to do. If it is the desire of the Association that separate specifications should be submitted for all the various uses to which timber and lumber is to be put, then I would recommend that such specifications be drawn up by the committee which had charge of that particular item, or at the best a special committee be arranged to draw up such specifications.

As to the question of wood treatment, I will ask Mr. Hansen to discuss that, as he is in charge of that part of the work.

Mr. H. J. Hansen (Chicago, Milwaukee & St. Paul):—Mr. Frink has objected to the specification for timber to be treated, principally on account of the fact that he does not think these specifications bring out the fact that we can use a lower grade of timber if the timber is to be treated.

In drawing up these specifications the Committee got all the information we were able to get on this subject, and discussed it from various angles, and at first drew up only the first paragraph, page 514, but recognizing Mr. Frink's stand in the matter we added the second paragraph reading, "Many varieties of timber can be used, if treated, that would not be satisfactory to use in the untreated state on account of being subject to rapid decay if they are not treated."

That was presented last year for information. There is room for discussion whether we should use lower grades of timber or not in trestles. On our road it has been the experience where we use loblolly pine the caps and stringers crush under our loads, starting at seven or eight years, and in fourteen or fifteen years these members are destroyed because the timbers are not strong enough. They do not rot, but they have to be replaced. I think it is up to the judgment of the Engineers using the timber to say whether it is good enough or not. So far as the decaying part goes the deterioration of the timber can be protected against by treatment.

Mr. J. R. W. Ambrose (Toronto Terminals Railway):—I think the Committee deserves a great deal of credit for the wealth of material and information they have given us in the report, but it must not be forgotten that the object of this Association is to prepare specifications and so-called standards of such a character that the roads can make use of them, and we want them used universally, but these specifications as they stand are so voluminous that I doubt very much if a road would print these as their standard specification, and cover such a large field when they perhaps only want to use it in connection with one sub-division.

As I see it, it is quite possible for the Committee to take the information, which is very complete, and sub-divide it into general conditions which apply more or less to all the sub-divisions, and then amplify the condition by a short specification, which will take care of each individual subject, and I agree with Mr. Frink that they would be more acceptable in that form than in such a voluminous form as that in which they are now given.

Mr. Selby:—The Big Four has had in use for a good many years specifications for timbers and lumber for the Maintenance of Way Department that are fully as voluminous—possibly more so—as the one presented by this Committee. They are published in a pamphlet form, and all kinds of timber are covered, and timbers for all uses in that department are specified. The specifications are numbered, and in making requisition and orders for timber and lumber we simply refer to the specification number. The general instructions and definitions are all included and at the top of each page in the specification there is a reference to the fact that the general instructions and definitions must be considered in connection with the particular specification. That has worked out nicely and there has been no trouble on account of the voluminous nature of the specifications.

Mr. Ambrose:—I am glad that Mr. Selby has spoken as he has, because he has supported exactly what I recommended. It is a volume of separate specifications. Each one is individual in itself, and the general conditions which precede these specific specifications are also what I have in mind. That does not apply to the specifications we have here.

Chairman Hoyt:—It is true that this question which is being discussed is really basic. This report is not made to cover a detail specification that can be taken and printed in book form to cover the purchase of all forms of timber and material, but is a basis from which such specifications can be drawn.

You will find if we reduce it to comply with your requests we will arrive at this condition that this report will be considered very brief, and that the specifications as suggested by the last gentleman will require a very large amount of material to cover. There will be twice or three times as much material as in the present report. This set of specifications has been brought up to date and it is intended to be basic, from which can be built just such specifications as Mr. Selby stated he is using, and it seems to me as a recommendation of this Association specifications of this kind should be basic, for each individual company undoubtedly has certain conditions which they may require to be complied with, certain timbers in their districts and certain timbers for bridges and other structures, and it will be, in my opinion, very hard for this Association to publish specifications which could be taken and used verbatim by all the railroads in the United States on account of the variations in local conditions, and this specification was laid out to be basic for use in drawing up detail specifications as required.

Mr. J. L. Campbell (El Paso & Southwestern) :—These specifications cover the subject quite completely and put the whole matter in condensed form, and inasmuch as the Manual is going to be reprinted at an early date, if these specifications are referred back for the revisions suggested, the specifications subsequently so produced would not appear in the new edition of the Manual, and would appear in one of the supplements, and it would perhaps be another five years before we had the subject as admirably set forth in the Manual as this report presents it.

I would therefore be in favor of adopting the recommendation of the Committee and letting these specifications covering the whole subject-matter appear in the Manual, and then the sub-divisions can be worked into the specifications, for different railroad uses, and is a matter which can be taken care of later.

Mr. Frink:—I dislike to differ with Mr. Campbell, but I think he gave a poor reason for putting the specifications in the Manual. I have previously said, I think, that we have too many things in the Manual, and do not see the philosophy in adding one more. I think that is a reason against printing it in the Manual rather than in favor of it. I did not mean to accuse the Committee of going outside their province. It simply occured to me that the separate committees might better prepare some specifications for the material which their work requires.

One word more. The specifications Mr. Selby spoke of seems to be exactly in line with what I think we ought to have—separate specifications for the different kinds of timber assembled, if you will, in one publication, so that no one will have any difficulty in knowing what you require when you order material.

One word about Chairman Hoyt's reference to the specifications. It seems to me there may be some misunderstanding as to what is meant by a specification. A Purchasing Agent's idea of a specification is a bill of material, so many pieces and of such sizes. The same idea prevails among the smaller manufacturers, and if you have ever been in commercial work, when you draw them a bill of material for a contract job, it is referred to as a specification—so many pieces of hardware, and this, that and the other thing. That is called a specification, but that is not what we mean. What we mean by a specification is something that describes the quality of the products we want to get, and that is the reason I said I do not think the bill of sizes applies in the specification.

Mr. H. A. Lloyd (Erie) :—I agree with Mr. Campbell for the reason that we all need a guide from which to make our specifications. We had an experience on the Erie in trying to coördinate a dozen or fifteen manufacturers' associations specifications and had a hard time to do it, and in fact we have not done it. We would like a specification to guide us.

Mr. Ambrose:—Regarding the idea of putting it in the Manual in order to have the information, we will have all the information in the Proceedings whether it goes in the Manual or not. I feel that this subject is fully covered—all of the data is here, everything that is necessary. It is no reflection on the work of the Committee should it not go into the Manual at this time—as a matter of fact it is really a matter of collecting and editing this information and sub-dividing it under its distinct heads.

Mr. Lloyd:—It makes all the difference in the world as to whether it is in the Manual and recommended by the Association, as against being placed in the Proceedings for information, as I see it.

Mr. W. E. Hawley (Duluth, Missabe & Northern):—I would like to offer one little comment in relation to the new material contained in this report, with reference to the material that is already in the Manual. In the Manual we have two sections, one under Committee VII—on Wooden Bridges and Trestles, pages 219 to 236, or 17 pages of material. Under another committee, which was a Special Committee on Grading of Lumber, we have pages 591 to 652, or 61 pages, making a total in the old Manual of 78 pages of material. This report which is being offered now requires for printing in its present type size 47 pages; in other words, it is a material reduction in the volume of material which will be put in the Manual, if it is adopted for publication in the Manual as recommended. Mr. Fritch tells me it will require a little heavier setting, which will probably increase it six pages or thereabouts in size, making about 53 pages of material in the new Manual.

The Committee has worked, as far as I can understand it, under instructions of the Board of Direction that they were to work on the basis of a composite specification rather than to bring in a series of specifications, and in this way bring about a reduction in the amount of material which is to be put in the Manual. By adopting it at this time for insertion in the Manual, we will secure the benefit in permanent form, with the backing of the Association, and also will secure the benefit of having put on record something that we can argue with the manufacturers of lumber, and will give us a greater ability to purchase what we want in the way of uniform material for bridge building.

Chairman Hoyt:—I simply want to say in closing my part of this report, that the matter of uniform sizes, which was one of the hard nuts to crack, that we have submitted here, received the endorsement of the largest number of consumers that have ever gotten together in a particular matter. They held a meeting in Chicago last year representing practically all of the retail lumber dealers of the country. This question was thoroughly gone over, and they favored and approved standard uniform sizes. To make anything of that kind effective it requires the backing of the consumers everywhere, and that is the reason that we inserted and are in favor of definite uniform sizes for lumber.

I want to say if it is the desire of the Association at some future time or at any time to develop individual specifications for individual or particular pieces of work, this Committee is at hand to do any such work willingly under any instructions that may be given it.

The President:—Before taking action on the motion, it is only fair for the Chair to state that a ruling was called for from him this morning, regarding the right to amend a motion, which would have the effect of referring this report back, and the ruling made may be subject to a different interpretation. In the absence of the copy of the Rules of Order, I am not able to give the interpretation correctly, but it is fair to say that if there should be a majority of the opinion that that specification should be revised, a negative vote puts the matter in that shape. An affirmative vote adopts the specifications as they stand. If there should be a negative vote, then it would be within the power of the Board of Direction to order the Committee to reconsider and revise in any definite manner as to arrangement that the Board might designate.

Mr. Ambrose:—Mr. President, I would like to ask the Chairman of the Committee if he thinks it would be at all possible to select the individual specifications immediately, so that they can go into the Manual as such. There is no additional information needed. They have everything that is necessary and it is simply a matter of editing.

Chairman Hoyt:—I would say in regard to that that if individual specifications are to be drawn—take, for instance, tank stock, an individual specification for tank stock should be drawn up under the Committee on Water Service, and that would require probably three or four individual specifications; and while it would be within the province, perhaps, or the ability of this Committee to develop such specifications, it would have to be done in conjunction with the other committees handling or using that particular class of material.

These specifications are basic. They are the basis upon which can be drawn and built a specification for individual classes of lumber or material for any class of railroad work.

Mr. B. H. Mann (Missouri Pacific):—I think this is a very important discussion as to useable material, but I do not like to see this Committee singled out as a sample. It seems to me preparation work has got to be done among the members of the Association very largely before we decide just how we are to change our specifications to suit the consumers, and put them in shape for the railroads so that the railroad will use them.

The Board of Direction and the Association membership really will finally decide what form the specifications should take in the Manual.

(The pending motion was put to vote and carried.)

Chairman Hoyt:—Mr. President, there is one other report that this Committee offers for a progress report. This Sub-Committee's report is submitted in Appendix A on page 485. I would ask Mr. VanAuken to explain the features of the report as far as the work has progressed at the present time.

Mr. A. M. VanAuken (Chicago, Indianapolis & Louisville) :—Our report, as you will see, is only a progress report. It is a composite report. There were five members on our Sub-Committee, and there were five opinions on nearly every subject that came up. We have tried to work out some of the bigger questions in this problem, and we place the results before you.

The first question raised by those replying to our questionnaire, or by about one-third of them, was as to it being worth while to formulate standard plans for wooden trestles, as wood suitable for trestle timber would soon be unobtainable. Our figures on page 485 look to be a little contradictory at first, but if you consider the basis of them they will harmonize. The Forestry Bureau gives a quantity materially less than that named by the National Lumber Manufacturers' Association. In the matter of Douglas Fir this is due to the figures of the Forestry Bureau being some three years more recent than the others and in yellow pine the Forestry Bureau, beside being later figures, also exclude all except old pine, never cut over.

On the question of stresses we find ourselves unable to design a trestle in conformity with the table of stresses given in the Manual or the one in Bulletin 225. We believe both these tables to be useless in trestle design. In the matter of more concise definition of timber the latter table is an improvement, but in the stresses permitted it appears entirely too conservative. Referring to the tests which the Forestry Bureau refer to as being the basis for the table we find there the recommended safety factors, by the use of which factors we gain approximately the figures shown in the table in Bulletin 225.

These safety factors when compared with those in the Manual are as follows:

	Manual	*Forestry Bureau*
Allowable stress in extreme fiber.................	6	5
Allowable horizontal shear stress..................	4	8
Allowable compression stress parallel to grain.....	4	3
Allowable compression stress across the grain.....	4	1½

It will be noted that the Forestry Bureau has reduced the safety factor in all stresses save horizontal shear, where it has been exactly doubled. We do not believe this is justified in railroad practice, especially in the composite chords of two or more stringers. No designers follow this extreme in practice. Data obtained from 34 railroads using yellow-pine stringers and 28 railroads using Douglas fir stringers as well as the practice of the Highway Division of five states shows that the bending stress in these tables is exceeded over 20 per cent. and the horizontal shear is doubled.* Acting upon the theory that continued practice in actual service is a safer guide than theoretical deductions from experimental tests, we are submitting designs which violate both tables of stresses, and we ask you to express your views on our acts.

*To make clear the point here made this data is added, which was not read in the Convention.

Loads in Pounds, Per Square Inch.	Table in Bulletin No. 225.	Table in Manual.	Highway Practice as Represented by Specifications Used by Five States.		Railroad Practice as Represented by Railroads Reporting to Committee, 34 Using Yellow Pine and 28 Using Douglas Fir Stringers.		
			O'sborn, 3 States.	Cooper, Ameri-can Bridge Co., 1 each.	Aver-age.	Maxi-mum.	Mini-mum.
Bending, allowable stress in extreme fiber—							
Dense Pine..........	1400	1300	1600	1200	1600	2000	1300
Douglas Fir..........	1400	1200	1500	1200	1600	2000	1200
Cypress	1100	900			1400		
Bending, longitudinal shear—							
Dense Pine..........	125	120	200	200	200	230	180
Douglas Fir..........	100	110	160	160	190	220	150
Cypress	100				200		
Compression, "short column"—							
Dense Pine..........	1100	1000	1000	1000			
Douglas Fir..........	1100	900	1000	1000			
Cypress	1100	830					
Compression, across grain—							
Dense Pine..........	250	260	350	350	240	280	180
Douglas Fir..........	250	310	350	350	230	260	180
Cypress	250	170			240		

The two tables are submitted as information and are self-explanatory. We invite discussion of each of them and suggestion on points brought out.

We also invite discussion upon the length of panel we have assumed. Our work will be more useful in just the degree that it is adaptable to varying conditions of different localities.

We should like to have discussion as to our proper loading of piles. Also, our length of cap. Is our twelve feet in length necessary? Do we recommend too long a cap?

In the recommendation for guard timbers we have simply taken the 6x8 timber and deducted the amount cut away in the dap.

We corresponded with the mills and the Forestry Bureau about sizes. A good many of them did not give us very much of an answer, but the Forestry Bureau sent us a pamphlet and gave the sizes of standing timber in yellow pine, which indicates that 26-ft. stringers, 16 in. the largest size which could be sawed out of a very considerable portion of the standing yellow pine. Larger than that it does not seem to be available to any considerable extent; and the manufacturers rather dodged any answer about larger sticks than 16 in. for stringers.

To get a standard trestle, we found from the replies—I made a rough estimate of the amount of wooden trestles on each of these roads, and we found that a very considerable majority use yellow pine stringers as yet; consequently it was necessary that we should consider conditions. We could not adopt a set of standard plans that would eliminate the larger portion of the railroads.

As we were limited to a 16-in. stringer by the supplies available to the larger portion, we attempted to agree on the loading. We had to pass that up to the main Committee, with the result that you see on page 485. We had a large number of plans sent to us, and they are abstracted on pages 486 and 487. We were very much assisted in the work by Mr. Hawley, who prepared the tables on the following two pages. Most of the details of these tables are brought out in the text which follows.

The principal reason for adopting E-45 as the lightest loading was the fact that practically every road is liable to haul over it two heavy coal cars coupled, and that is practically an E-50 load, but due to conditions we all understand is no more severe on a structure than an engine load of E-45, and due to that we felt it was useless to consider less than E-45. The following tables are a development of that: With a 16-in. stringer we could not carry these loads on a longer span than 12 ft., or a very small fraction over that, and the recommendations below fall in line with that.

With these introductory remarks, this subject is with you.

Chairman Hoyt:—This is offered for information and discussion. We would appreciate having the membership study this matter during the coming year, that they may offer us as much advice as possibie. We have already developed some plans in our studies, but it is going to require more study and perhaps will require revision of them to study out individually by themselves.

Mr. Frink:—Mr. President, some of you may remember that I objected very strongly last year to the loading adopted, and I think there is much more justification for the loading on trestles than there would be on bridges, because the margin of overstrain is not nearly as large. It does not seem to me, however, that we ought to use standard loading of E-45, 55 and 65 for timber trestles used in the same track with steel bridges, with a standard of E-60. It seems to me as though the loading of the trestle ought to correspond with the bridge that has to carry the same load. I think the Committee would do well to revise those loadings to agree with steel bridge specifications.

I question the statement of the Committee on page 492 about paying for even feet, for stringers are usuallly—in fact, I may say universally, ordered in double panel lengths, so that there is no objection to buying panel lengths in even feet. I do not say I advocate that. I am suggesting it for the consideration of the Committee.

I also question the statement of the Committee about the use of 16-in. stringers instead of perhaps 14. While it is perfectly possible to get 16-in. stringers from our Southern mills, yet it has been my experience that you pay more per thousand feet for 16 in. than you do for 14 in., and more for 14 in. than you do for 12 in. Therefore, I think some method should be allowed to have the road use whatever size of stringers best suits its practice, and which they can get to the best advantage. The road I represent has used 14-in. stringers for years and is using them now.

Chairman Hoyt:—The discussion that has been brought out by Mr. Frink is just exactly what we want. The more data and the more information of that sort that we can get, the better we will be satisfied.

DISCUSSION ON YARDS AND TERMINALS

(For report, see pp. 889-900.)

Mr. B. H. Mann (Missouri Pacific):—The report of this Committee is in Bulletin 235, page 889. We will take it up as shown on page 890 under "Conclusions." The first two conclusions call for action by the Association. The following conclusions are submitted as information. On the first subject, there are no changes in the Manual, as recommended last year by this Committee.

Conclusion (1) will be handled by Mr. Hastings, Chairman of the Sub-Committee.

Mr. E. M. Hastings (Richmond, Fredericksburg & Potomac):—Sub-Committee (4) was charged with the work of making a final report, if practicable, on typical situation plans for passenger stations, and the methods of their operation. The Committee, however, feels that this is a subject covering such large work, and a work which is constantly in the process of development, that it was not thought advisable to make a final report; consequently we followed out the idea of reporting passenger terminals of interest that have been recently constructed, which has been the idea followed out by this Committee heretofore.

We present as information for your consideration this year the plans of the Union Passenger Terminal at St. Paul, built by the St. Paul Union Depot Company, and also the plans and photographs of the Richmond, Va., Terminal, which was constructed a few years ago and has been in operation about two years. We ask you to study these two situations, as they present some very unique ideas, particularly that of the Richmond Station, which is in the nature of a perfect loop, all trains moving through the station in the same direction.

We present to the Association for approval and publication in the Manual a typical track layout of a dead-end passenger station, which was published in the Proceedings of the Association in 1911. This has been slightly revised. Also a typical track layout for a through passenger station published some time ago. These two plans, slightly revised, are now presented to the Association for adoption and inclusion in the Manual.

Also types of ladders particularly applicable to passenger stations, which ladders were originally prepared by Mr. S. S. Roberts, and were presented to the Association and printed as information in 1917. These types of ladders have been slightly revised, and we now present them for inclusion in the Manual. They are type numbers 20 to 26, and they have been printed in the Bulletin immediately following this Appendix B, on page 898.

Chairman Mann:—Mr. President, I move that these situation plans be adopted and published in the Manual.

(Motion duly seconded, put to vote and carried.)

Chairman Mann:—Conclusion (2), covering subject (8), Appendix A, will be presented by Mr. D. B. Johnston.

Mr. D. B. Johnston (Pennsylvania System):—Unfortunately the report of the Sub-Committee does not appear in the Bulletin. It is not long, and if it is satisfactory I will read it.

(Mr. Johnston read the report of the Sub-Committee.)

Chairman Mann:—I move the adoption of the conclusions for insertion in the Manual.

(Motion duly seconded, put to vote and carried.)

Chairman Mann:—Subject (3) will be presented by Mr. H. T. Douglas, Jr., Chairman of the Sub-Committee.

(Mr. Douglas presented Appendix A.)

Chairman Mann:—The next subject to be presented is the matter found in Appendix C, which will be presented by Mr. J. B. Hunley in the absence of Sub-Committee Chairman Baldwin, who is busy with Board of Direction work.

Mr. J. B. Hunley (Cleveland, Cincinnati, Chicago & St. Louis):—The Committee really did more work than might be imagined from reading the report in Appendix C. We decided first that grain-weighing scales could not be considered along with the others, and at that time we started to adopt a specification for a portable type of scales, both of the self-contained and built-in type, and the motor-truck scales. We found a good many complications. In the first place the manufacturers, while they manufacture railroad scales and many other classes of scales, the railroads are small consumers. We realize we had better, if possible, recommend certain sizes and capacity of scales which would meet practically all conditions and a questionnaire was sent to all the railroads. We found that they were using various sizes and capacities, and while we could have adopted certain of these sizes and capacities, because the manufacturers were making them at that time, we realized that the situation might bring out different classes of scales, and the manufacturers naturally objected to scrapping the old patterns and designs, so that that matter has taken a good deal of time.

We found there was not very much information with regard to motor-truck scales, that is, as to the weight of motor trucks, but a great deal of information was collected. After we got the information we found we sometimes could not always agree with the manufacturers, and many times the Committee could not agree. We hope to have a tentative specification to submit at the next convention. I understand that the American Railway Association has adopted a specification for grain-weighing scales recently.

Chairman Mann:—The next subject is instruction (2) and the Board of Direction instructed that the Committee submit a complete report, but it has not been possible to do that. Mr. Montzheimer will give the details.

Mr. A. Montzheimer (Elgin, Joliet & Eastern):—Last year, it will be remembered, that this Committee made a progress report on the unit operation of railway terminals in large cities. It was hoped that we could make a final report on that subject this year, as well as revise the catechism on the operation of terminals as a statement of principles. On account of the change from government operation to private operation, it was impossible for us to make a final report on this subject, and we would like to have the matter carried over another year, with the hope that we can make the final report at that time.

DISCUSSION ON RULES AND ORGANIZATION

(For report, see pp. 793-841.)

Mr. W. C. Barrett (Lehigh Valley):—The Committee was given four subjects on which to make a study and report.

Inasmuch as the action to be taken on subjects (2) and (3) will determine what action will be taken on subject (1), they will be presented first. Mr. Harsh will outline the matter under subject (2).

(Mr. Harsh briefly outlined the matter in Appendix A.)

Chairman Barrett:—I move the adoption of conclusion 2, on page 795.

(Motion duly seconded, put to vote and carried.)

Chairman Barrett:—While I believe this is the first time subject (3) has been presented formally to the Association for approval, it has been before the Committee and the Association for a number of years, so that in presenting the "Manual of Rules for the Guidance of Employees of the Maintenance of Way Department," the Committee is not presenting an entirely new subject. Mr. Barnhart will present this part of the report.

(Mr. Barnhart briefly abstracted Appendix B.)

Chairman Barrett:—I move the adoption of conclusion 3.

Mr. C. W. Baldridge (Atchison, Topeka & Santa Fe):—I believe I will have to take exception to Rule No. 1 to start with. I do not believe it should be the duty of any employee to provide himself with a book of rules. The rules should be altered to read that the employing officer shall provide each new employee with a book of rules and that the employee then should familiarize himself with the rules.

I also notice in reading over the report of this Committee, commencing on page 825, Conduct of Work, in a great many cases it duplicates the work of other committees already in the Manual, and in a few cases conflicts with such work, and I will offer a motion that this portion beginning at the middle of page 825 to the bottom of page 837 be referred back to the Committee, with instructions to coördinate the matter on the conduct of work with the work of the other committees, and that the report be brought in next year. I believe we will find a good many conflicts in our Manual if we put this in without checking it up against the work of other committees. I believe there is a serious conflict with the work of the Committee on Ballast.

Mr. H. L. Ripley (New York, New Haven & Hartford):—I second the motion and endorse what Mr. Baldridge has said, without any intent to criticize the work of the Committee. As he has already pointed out, there is conflict in this section on conduct of work with the work of the Ballast Committee, and the recommendations that were made and adopted by the Association. I think these things should be reconciled in some way by a conference of the two committees, or the acceptance by this Association of the wording of the Ballast Committee or the acceptance of the wording of this Committee, so that the matter should not cover instructions relating to the same point different in character and perhaps in conflict.

Chairman Barrett:—The Committee went very carefully over everything that was in the Manual, and so far as we could ascertain, there was no conflict with any other committee's report. We tried not to put anything in our report which would conflict. I really believe that the matter we have submitted here will not conflict with the work of the Ballast Committee.

Mr. Ripley:—Am I to understand that you have compared the matter you are presenting here with the matter presented the day before yesterday by the Ballast Committee and there is no conflict?

Chairman Barrett:—I compared it as fully as I could, with the amount of time at my disposal.

Mr. Ripley:—I do not care to contend the point at all, but it seems to me, as a natural method of proceeding, that these rules should be arranged by a conference of the members of the different standing committees, so that there should be no conflict. I am sure as far as the Ballast Committee is concerned, they will be glad to accept it as it is. If there is no conflict there is nothing to say about it.

Chairman Barrett:—There was no conflict with the matter already printed in the Manual, and, as I said, I went over the Ballast Committee report as carefully as I could, and I do not think there is any conflict sufficient to warrant any extended discussion. This Committee wants to work in harmony with the Ballast Committee and any other committee, and if this report were deferred until next year, it would not be possible, of course, to compare the new work of every committee, and that is why, as I explained before, we went over the Manual very carefully and made our report agree with what was in the Manual.

Mr. Maurice Coburn (Pennsylvania System):—I agree with Mr. Baldridge's motion. There are one or two other portions which should have some consideration. The instructions about "Line and Surface" seem to me misleading. Under "joint bars" it reads "Rail joints should be as simple and of as few parts as possible to be effective."

These instructions, as I understand it, are for the trackmen with relation to the actual operation and are not for such items as that. I rather believe there is some duplication about nutlocks. In the general instructions, in the beginning, after our discussion about labor yesterday, we might say something about the duties of the foremen and the minor officers toward the employees, making it a little more human.

Mr. A. S. Baldwin (Illinois Central):—I think it would be a mistake to refer these rules back to the Committee. A great deal of excellent work has been done on them; what they are intended for is to be used as a general compendium of rules for maintenance of way departments. It would not be possible for this Committee to get up a set of rules that would agree with everything that might be done in the convention after they came in. These rules will be adapted to the special conditions of every railroad, and it will be understood that they are for general use and will be very helpful. I do not think a time would ever come when the Committee could get up a compendium of rules which would answer for all companies and all conditions, or that would be acceptable to every member of the convention in session. These rules, however, constitute the groundwork that may be adapted to the use of any company.

I believe it should be the duty of the superior officer to supply the men with a copy of the rules, but the employee should not be able to offer as an excuse that he did not carry out the rules because he had not been supplied with a copy of them. I think it should be one of the employee's first duties to supply himself with a copy of the rules, although I believe it should likewise be the duty of the superior officer who is responsible to see that he is so supplied.

The points these gentlemen have raised are good, but I believe we want a set of rules in the Manual, and my belief is that a great deal of work has been done, and very well done, on these rules, and they will be very useful in general to the railroad companies.

Mr. J. B. Carothers (Baltimore & Ohio):—On behalf of the Committee, I wish to say that the first question that was brought up about the employee providing himself with a book of rules, that is not our thought, we copied that from the American Railway Association Standard Code. They have been practicing that for a good many years. I do not believe it is necessary to raise that question at this time.

With reference to the other question, we were unfortunate in being placed in the afternoon of the last day when all the other reports were in. If we had been in first, the Ballast Committee might have had to revise their report, but I have no objection to some of the questions that are raised, in fact, there are not being as many stated as I expected.

I am very much in favor of having these rules adopted. I am the Chairman of the Sub-Committee on the revision of the Manual, and next year I may recommend a change in some of the words and items that have been suggested here, but I think it should go into the Manual this year, as we have been trying for twelve years to place a book of rules in the Manual for the guidance of employees of the Maintenance of Way Department.

Mr. Ripley:—Having been very thoroughly answered, if it is permissible, I will withdraw my second to the substitute motion.

Mr. Coburn:—How would it do to publish these rules coupled with the statement that these are a guide for the preparation of rules?

The President:—I think there is no middle ground—they must be adopted for the Manual or must go into the Proceedings. Anything going into the Proceedings as a progress report may be considered as a tentative recommendation of good practice.

Mr. C. F. Loweth (Chicago, Milwaukee & St. Paul):—These rules appear to contain a good many duplications. For instance, on pages 818 and 819, the rules for Bridge and Building Foremen and Mason Foremen are identical, and those for Painter Foremen are identical with those in the preceding two groups, excepting Rule 168. It would seem that Rule 168 would be as applicable to Bridge and Building and Masonry Foremen as to Painter Foremen. On many roads, Bridge and Building Foremen are at times Painter Foremen and are in charge of water station and other work for which there is a still further duplication of rules. A similar duplication of rules runs through the whole portion of this report.

It would seem desirable to recast these rules so as to avoid this, and the result would be a more concise code of rules and instructions, more readily referred to, thus making them more efficient for the purpose intended.

Chairman Barrett:—The Committee was cognizant of the fact that in preparing rules for these different foremen they would be more or less the same in their reading. We thought it proper to make the rules correspond to one another, so that they would of necessity be in somewhat the same form, and while there is, perhaps, as indicated, some repetitions, these rules were intended as the groundwork for perhaps very much more extended rules that particular railroads would want, and we thought each one should be complete in itself. For that reason the Committee submitted the rules in the form in which they did.

Mr. Baldridge:—I will call attention to Rule 274 with reference to broken rails. The rule is very good as far as it goes, but it does not go quite far enough, in that a broken rail, under present-day conditions, should be removed from the track as soon as possible. The Committee has finished this rule by saying: "The broken ends of the rail should be connected by joint bars, the rail drilled, and the joint bars full bolted, after which the resumption of traffic may be permitted." But they do not go on to say that the rail should be taken out of the track at the earliest practical moment.

With transverse fissure failures of rails which are occurring all over the country, this becomes important, because where one transverse fissure occurs in a rail, there are almost always several others sufficiently developed to cause the rail to break again at any time.

We had a case of this kind on the Santa Fe, in which a broken rail was reported and the Section Foreman went out to look after it. Because there was no rail at the immediate point, he proceeded to drill and joint the rail. He then procured another rail and took it to the point where the broken rail was in track, but as it was near quitting time, he decided that he would wait until next morning to put the rail in track. The defective rail broke again under a passenger train, before the section gang reached the place the next morning, resulting in the train being derailed.

I think we should add a little more to this rule, and provide that a broken rail must not be left in track longer than is necessary.

Chairman Barrett:—The Committee accepts the criticism and will ask permission to add to that paragraph to make it read like this: "After which the resumption of traffic may be permitted with reduced speed. The rail should, however, be removed from the track as quickly as possible."

Mr. Coburn:—Will the Committee be willing to omit paragraph 275?

Chairman Barrett:—We will eliminate Rule 275.

I move the adoption of the report as amended.

(Motion duly seconded, put to vote and carried.)

I will ask Mr. Carrothers to present subject (1).

Mr. Carothers:—The revision of the Manual has been taken care of by the adoption of the other portions of the report, and we have nothing further to offer.

I move the adoption of conclusion (1) on page 795.

(Motion duly seconded, put to vote and carried.)

Chairman Barrett:—Subject (4) is covered in Appendix C. I am sorry that Mr. Coombs is not here to present the report, but we are fortunate in having Mr. Gaines, Vice-Chairman of the Sub-Committee, and he will present the report.

(Mr. Gaines presented an abstract of the report.)

Chairman Barrett:—I move the adoption of conclusion 4.

Mr. Coburn:—It seems to me that paragraph 8 on page 839—"There must be interchange of ideas and information between all types of executives," should have added to it, "and with the rank and file as far as possible," or something else to convey that idea. Many of the executives do not interest themselves in working with the rank and file.

Chairman Barrett:—The Committee will accept that suggestion.

(Motion to adopt conclusion 4 put to vote and carried.)

DISCUSSION ON RECORDS AND ACCOUNTS

(For report, see pp. 901-924.)

Mr. H. M. Stout (Northern Pacific):—The work of the past year has been handled without sub-committees, except one which was carried over from last year's work. The Committee, on subject (2), Cost-keeping

Methods and Statistical Records, continued its work, but it has not been able to complete it.

Toward the end of the season's work we organized for carrying on the new subjects assigned to the Committee. The first subject was carried out by the whole Committee and you will find the changes on page 904.

This form which is being proposed now to be substituted for the one previously submitted and published in the Manual follows the practice which we have adopted of having forms as far as possible printed on one side only. Any descriptive matter of instructions to be shown on the face of the form.

I move the approval of the Committee's recommendations for changes in the form and that the matter submitted in Appendix A be substituted for similar matter now in the Manual.

(Motion seconded, put to vote and carried.)

Chairman Stout:—With reference to subject (2), as stated, the sub-committee which has been handling this subject has continued its work, but does not have the matter in shape for presentation at this time, so that no conclusions are offered.

We will pass to subject (3). Last year you will recall there were some eight or nine blanks submitted, some of them directly in accordance with the requirements of the Order itself, and some of them designed to furnish supporting data. This year we are submitting three additional forms, and these will be found on pages 910, 911 and 912.

Mr. H. L. Ripley (New York, New Haven & Hartford):—Since the first days of December I have been spending much of my time in connection with this matter, which has to do with the I.C.C. Order No. 3. It may be the intention of the Committee to present these forms and collect certain data, but I believe there will be a circular issued soon by the I.C.C. to cover that subject. It may not be known to the Committee that new forms have been prepared illustrating what is required under that Order of the Commission. The joint standing committee composed of three representatives of the carriers and two or three representatives of the Bureau of Valuation have been appointed to consider this matter, and I would question the expediency and perhaps the propriety at this time of adopting this Appendix B for inclusion in the Manual.

Mr. O. E. Selby (Cleveland, Cincinnati, Chicago & St. Louis):—I want to call attention to the Register of Authorities for Expenditure. It carries under the third column a D.C.E. reference. That refers to the period of Federal control and is not necessary now.

Chairman Stout:—The column carrying the D.C.E. reference is only inserted there to carry projects which are not yet closed out, some of which were initiated under government control. It is not the intention to perpetuate that. As soon as we get entirely away from that period the D.C.E. reference will automatically drop out.

In answer to Mr. Ripley's suggestion. We recognize that at this time Order No. 3 may be considered as being in a somewhat tentative condition, but the order has been served and its terms must be complied with until they are amended. We feel that these forms meet the requirements of Order No. 3, and since no limit as to the amount of information to be shown on the set of forms was specified by the I.C.C., Bureau of Valuation, considerable leeway is given for additional information. They specify only the minimum amount of information required. Therefore we think we are justified in presenting the forms at this time.

Mr. Ripley:—I really feel I would be embarrassed rather than helped by the adoption of this Appendix B as it is presented; still what the Chairman has said is true. There was prepared and handed to the Secretary of the President's Conference Committee a new set of forms arranged in considerable detail and differing substantially from the old forms, and I may say if it had not been for the intervention of the carrier's committee, these forms would probably be before you in mandatory form. We asked for an opportunity to suggest modifications in these forms. I do not know how much consideration the Committee has given to it, but we spent weeks on this thing, and these forms do not go far enough. I would like to make the suggestion that this Appendix B be received as information, rather than for adoption and printing in the Manual.

The President:—The Committee desires to change its recommendation and that this subject be continued; that neutralizes the motion made for adoption. The motion for adoption has been withdrawn by the mover.

Chairman Stout:—Subject (4) is under consideration and no conclusions are presented at this time. Subject (5) is also under consideration and definite conclusions have not been prepared. In Appendix C in connection with that study will be found a very valuable bibliography covering the subject assigned. This has been prepared in large part by the Bureau of Railway Economics, and we feel we are fortunate in getting their assistance in this manner.

This matter is presented as information.

DISCUSSION ON CONSERVATION OF NATURAL RESOURCES

(For report, see pp. 925-940.)

Mr. W. F. Ogle (Chicago, Rock Island & Pacific):—The first subject, "Make thorough examination of the subject-matter in the Manual, and submit definite recommendations for changes," your Committee had no recommendations to make with regard to what had previously been published in the Manual, as we consider it in very good form now. That report, which was on the prevention of the spread of forest and field fires, was gone into very thoroughly last year and a very complete report made at that time. We are very glad to know that many of the roads operating through the timbered countries had requested a great many copies of these rules for distribution.

Subject (2), "Reclamation of Materials." Under Appendix A we have shown a few examples of how reclamation of materials can be practiced. I think it is needless to say that most Engineers to-day realize that there is a great saving to be made through reclamation of materials, but the field is so large that it is really up to the individual to practice it in a manner best suited to his own railroad; for instance, the reclaiming of some article on one railroad may be a paying proposition while the same article, reclaimed on another railroad, may not, due to local conditions and volume reclaimed.

Subject (3), "Tree Planting and Reforestation." Under Appendix B we have given a few remarks. This is such an old subject and has been gone over so often that there is little left to be said. I think the thing that we, as Engineers, should do is to encourage proper legislation regulating tree planting and reforestation. There is such a long wait for the individual before he can realize any return that he is not interested, this is also more or less true with railroads; it is, therefore, a subject to be handled by either State or Federal Governments or both.

Subject (4), "Conservation of Human Life and Energy Among Engineering Employees." Under Appendix C we have attempted to show under several headings a few of the methods which should be followed in the conservation of human life and energy. This is also a large subject and there are many ways in which human life and energy can be protected.

I think a great many of the railroads to-day are realizing the necessity of better housing and living conditions for their employees. Here we are overlapping somewhat the work of the Committee on Economics of Railway Labor.

Subject (5), "Report on Progress of Conservation in Canada." Under Appendix D we have shown some of the progress in reforestation and conservation in Canada, which is very similar to conditions in the States.

I move you, Mr. President, the adoption of this report as progress.

Prof. S. N. Williams:—Mr. President, in the way of comment on the report I would like to explain that in accordance with the fourth direction of the Board, I attended the meeting of the Association of Railway Surgeons; their action, papers and discussions were entirely in reference to the surgical side of the subject, and they did not take up anything which would give us information of advantage to present at this time.

I wish to express my profound regret over the death of Mr. Sattley, a member of the previous Committee. With other members of this organization I attended the funeral out at Austin not many weeks ago, and could not but be impressed with the fact that had Mr. Sattley been allowed to live or been able to live longer, it would have been a source of great gratification to his children and grandchildren. I trust you will excuse my perennial reference to the importance of the subject of the greatest possible care of your health, life and energy for the sake of your loved ones.

It is also a matter of extreme regret to me that during the past year Mr. L. J. Putnam, the Chief Engineer of the Chicago & Northwestern Railway, was carried off by death, which came in the effort to save his own son from drowning.

There are many instances which might be mentioned that are occurring all the time, which you read of in the papers and with which we become familiar; and yet it seems to me that the conservation of life, health and energy is one of those things which we should at all times keep in mind, and try to assist in preventing the colossal destruction of human life which is now in progress throughout the world.

INDEX

E

F

G

H

S