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PROCEEDINGS

OF THE

SEVENTH ANNUAL CONVENTION

OF THE

American Railway Engineering and Maintenance of Way Association

HELD AT THE

AUDITORIUM HOTEL, CHICAGO, ILLINOIS

March 20, 21 and 22, 1906

VOLUME 7

PUBLISHED UNDER DIRECTION OF THE COMMITTEE
ON PUBLICATIONS

1906

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PROCEEDINGS

This Association is not responsible, as a body, for the opinions or views expressed by individual members.

TUESDAY, MARCH 20, 1906.

MORNING SESSION.

The meeting was called to order by the President, Mr. H. G. Kelley, at 9:30 a. m.

The President:—The first business in order is the reading of the Minutes of the last annual meeting. As these Minutes have been printed and furnished to each member of the Association, it is unnecessary to read them, and unless there is objection, they will stand approved.

The next business is the President's annual address.

PRESIDENT'S ADDRESS.

In addressing the Association at this its seventh annual convention I shall endeavor to confine my remarks to a brief review of the work of the past year and suggestions for the present.

The reports of the Secretary and Treasurer for the fiscal year will be especially gratifying to the members, showing a sound financial condition, and even with the unusual expenditures upon the publications, and especially the Manual of Recommended Practice, a material increase in the surplus will be shown. The growth of the Association during the seven years of its existence has been remarkable. Launched as an experiment, the early years of our Association's life were hazardous ones; but the wise and conservative policy of those distinguished members, who, as officers, guided the first efforts of the Association, together with the cordial co-operation of the members, have placed this Association upon the highest plane of honor and usefulness. It now remains with us to continue to the best of our ability the work so admirably begun.

The Association has recently been honored by receiving from the Chief Executive of the nation an invitation to be officially represented upon a National Advisory Board on Fuels and Structural Materials, such representation to be performed by the President of the Association and his successors in office, and in addition two of the members, Mr. J. Kruttschnitt and Mr. Hunter McDonald, Past-President of the Association, have also been invited to become members. The work of the Advisory Board is destined to become of national importance, its field of work and investigation embracing all materials of construction and fuels. The Association is now represented officially upon the Joint Committee on Concrete and Reinforced Concrete, and the Committee on Rail is co-operating with the Rail Committee of the American Society of Civil Engineers.

It is especially gratifying to note the interest in the work of the Association evinced by managing officials, many of whom have become identified with it and have taken active part in committee work. This fact emphasizes the principle upon which we have proceeded in the past, that our work must be marked with conservatism and our recommendations adopted only after the most thorough consideration of all points involved. It is better to refer back to a committee for further consideration any subject which is not entirely clear or satisfactory, rather than to pass it hastily and have it remain as an official expression against which just criticism might be made.

The volume of important subjects to be considered at our annual convention has increased to such an extent that it has been considered necessary to eliminate the consideration of definitions of terms from discussion at the meetings, and confine the work to more important subjects. A circular to this effect was sent out early in the year, and members desiring to criticize or discuss definitions appearing in the reports are requested to do so by correspondence with the respective chairmen of committees, and such definitions as cannot be agreed upon will be taken up by letter-ballot during the year. It is believed by this method that a more accurate rendering of definitions will be secured. In the general discussion of the subject matter of the committee reports the chair desires to urge upon the members a free expression of their opinions, either for or against the various particular items contained therein, for it is only by such free and open interchange of thought that the sum of our knowledge may be increased and the underlying principles of a subject be differentiated from local or particular conditions.

Some apparently conflicting specifications are in reality the adaptation of a general principle to meet conditions existing in particular localities. The economic construction grade line for a railroad in a Southern state would not necessarily be the correct one for a railroad in 50 degrees north latitude, and as our Association now contains members from all quarters of the world, a general and free recital of experience will add materially to the wealth of knowledge contained in our publications.

When it is considered that to the members of this Association is entrusted the expenditure of millions of dollars capital annually, and the maintenance of the permanent way by which the transportation of persons and property may be handled with safety and economy, the responsibility resting upon us as an Association and as individuals may be realized.

Great credit is due to the various committees for the excellent reports presented at this meeting. These reports represent an amount of effort and time taken from busy lives, purely as an unselfish contribution to the general fund of our knowledge.

Some inconvenience has been felt for lack of proper facilities for committee meetings in Chicago, and the Board has authorized the Secretary to secure an additional room for use as a library and for committee meetings, where the necessary quiet and privacy may be enjoyed.

You will be asked by the Roadway Committee for advice upon the proper wording of an overhaul clause for use in grading contracts, and it is hoped that some determination may be reached upon this important subject.

The Tie Committee has recommended a standard size for ties, which may conflict with the practice of many roads. The Committee on Ballasting has submitted for your approval ballast cross-sections for single and double track. The Committee on Buildings makes important recommendations on the construction and ventilation of roundhouses. The Committee on Masonry has prepared specifications for stone masonry and for a classification of masonry. The other committees have presented, respectively, specifications for standard right-of-way fences, specifications for signaling and interlocking, office records, and rules for the government of employés in the maintenance of way department, conclusions as to hump yards, specifications for steel railroad bridges, and a statistical report classifying railway districts according to freight and passenger car mileage and speed of trains.

The Track Committee makes a valuable suggestion that a special committee be appointed to confer with a like committee of the American Master Mechanics' Association to consider the proper increase in gage for different degrees of curvature and varying lengths of wheel base.

In the past, time and interest have been lost awaiting the announcement of the personnel of committees; the Board has, therefore, decided to announce the appointments at this meeting, in order that members may become acquainted and make plans for work and meetings during the early summer and autumn. These lists may require some correction, and the Board of Direction will be pleased to give due consideration to the personal preferences of members if they will notify the Secretary of their choice of committee work. It has not been possible in all cases to assign members to the committees upon which they would prefer to serve, but the list has been prepared as closely as possible from the expressed preference of the members which have been received by the Board.

The year 1905-1906 has marked the first publication of the first volume of the Manual of Recommended Practice, an event to which the Association has looked forward for several years. The comments of the technical press and of individuals have been favorable, and the demand for the volume gratifying, and we believe that the volume will take its place in our libraries as a standard work of reference.

The recent progress toward the partial electrification of steam roads indicates that the new conditions arising will in the immediate future require the attention of the members of this Association. It is opening up a new and broad field for original thought and work.

In conclusion, I desire to express the appreciation of the Board of Direction for the hearty support and interest given by the various chairmen and members of committees, and trust that the new year will show the same upward progress that has marked the passage of the years we have left behind. [Applause.]

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

Secretary L. C. Fritch read the following report:

REPORT OF THE SECRETARY AND TREASURER.

To the Members of the Association:

The following report is respectfully submitted:

FINANCIAL STATEMENT.

Balance cash on hand last annual report		$8,559 01
Receipts during the year	$11,406 23	
Expenditures during the year	10,017 38	
Balance to credit	$1,388 85	1,388 85
Balance cash on hand date of this report		$9,948 76

Expenditures in detail:

Stationery and printing	$ 6,159 02
Postage and exchange	597 70
Salaries	1,800 00
Clerical services	364 65
Office supplies	86 60
Rents	360 00
Expressage on Proceedings, etc.	233 05
Light	18 92
Telephone and telegrams	54 23
Committee expenses	76 90
Annual meeting expenses	216 31
Entrance fees returned	50 00
Total expenditures	$10,017 38

MEMBERSHIP.

Membership last annual report			463
Members admitted during the year		102	
Withdrawals	9		
Dropped for non-payment of dues	27		
Death	1		
	37	37	
Gain		65	65
Membership date of this report			528

The President:—The next business in order is the reports of the standing committees. Before taking up the reports of the various committees, the chair desires to call the attention of the members to the necessity of announcing their names and the name of the road with which they are connected when they first rise, in order that the reporter may be enabled to record the names properly.

The first report is that of the Committee on Uniform Rules, Organization, Titles, Code, etc. In the absence of the chairman of the Committee, Mr. G. H. Webb, Chief Engineer of the Michigan Central Railroad, vice-chairman, will present the report. (See report, pp. 19-22; discussion, pp. 23-27.)

The President:—The next report is that of the Committee on Ties. In the absence of the chairman, Mr. W. W. Curtis, the vice-chairman of the Committee, will present the report. (See report, pp. 29-64; discussion, pp. 65-82.)

AFTERNOON SESSION.

The President:—The report of the Committee on Ballasting is the first business in order this afternoon. The chairman of the Committee, Mr. John V. Hanna, will present the report. (See report, pp. 83-89; discussion, pp. 90-127.)

The President:—The next report is that of the Committee on Yards and Terminals. In the absence of the chairman, Mr. E. E. R. Tratman, vice-chairman, will present the report of the Committee. (See report, pp. 129-167; discussion, pp. 168-182.)

The President:—The work outlined for to-day's session has been finished a little earlier than we contemplated. To-night we will consider the report of the Committee on Iron and Steel Structures. This is an important report, and the Committee would appreciate a large attendance at to-night's session. It is desired to have the report acted upon as final, in order that it can be incorporated in the Manual of Recommended Practice.

EVENING SESSION.

The President:—Mr. J. P. Snow, chairman of the Committee on Iron and Steel Structures, will present the report. (See report, pp. 183-217; discussion, pp. 218-264.)

WEDNESDAY, MARCH 21, 1906.

MORNING SESSION.

The President:—The first business this morning is the report of the Committee on Records, Reports and Accounts. Mr. Edwin F. Wendt, chairman, will present the report. (See report, pp. 265-317; discussion, pp. 318-329.)

The President:—The next report is that of the Committee on Classification of Track. Mr. Chas. S. Churchill, chairman, will present the report. (See report, pp. 331, 332; discussion, pp. 333-340.)

The President:—The next report is that of the Committee on Roadway. Mr. H. J. Slifer, the chairman, will make a preliminary statement. (See report, pp. 341-442; discussion, pp. 443-449.)

AFTERNOON SESSION.

The President:—The first business this afternoon is the consideration of the report of the Committee on Signs, Fences, Crossings and Cattle-Guards. Mr. W. D. Williams, Chief Engineer of the Cincinnati Northern, chairman of the Committee, will present the report. (See report, pp. 451-472; discussion, pp. 473-480.).

The President:—The report of the Committee on Signaling and Interlocking will be the next business before the convention. The chairman of the Committee, Mr. Chas. A. Dunham, will make a preliminary statement. (See report, pp. 481-532; discussion, pp. 533-548.)

The President:—The next business is the report of the Committee on Rail. Mr. Wm. R. Webster, chairman, will present the report of the Committee. (See report, pp. 549-556; discussion, pp. 557-577.)

The President:—Before we adjourn, the chair would announce the appointment of the following members as tellers to canvass the votes for officers: Messrs. Garrett Davis, C. W. Pifer, F. L. Nicholson.

The chair would also call the attention of the chairmen and vice-chairmen of the new committees to the desirability of holding informal meetings before final adjournment for the purpose of getting acquainted and making plans for future meetings and work. The noon recess is suggested as a good opportunity, and if any committee chairman desires to call his committee together for a brief conference and will hand the Secretary a notice to that effect, giving time and place for such meeting, it will be read in open session.

THURSDAY, MARCH 22, 1906.

MORNING SESSION.

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

Before taking up the report of the Committee, the chair would like to again call attention to the announcement made in the opening address on Tuesday, that, on invitation of President Roosevelt, the American Railway Engineering and Maintenance of Way Association is officially represented by three of its members on the National Advisory Board on Fuels and Structural Materials.

During the past year, and at the present time, investigations of these subjects are being conducted under the direction of the United States Geological Survey at St. Louis. The members are also aware that our Committee on Masonry has a sub-committee on concrete and reinforced concrete, which, jointly with similar committees of the American Society of Civil Engineers, the American Society for Testing Materials, and the Association of American Portland Cement Manufacturers, is co-operating with the Geological Survey in these investigations, especially as regards concrete and reinforced concrete, and is depending largely, if not entirely, on the results of these investigations, which will enable it to formulate a report.

The Congress of the United States has now under consideration an appropriation of $350,000 for the continuance of this work, and of this amount $100,000 is to be devoted to structural materials, that is, cement mortars and concrete. The appropriation will form an item in the sundry civil appropriation bill, which will be reported to the House of Representatives about the latter part of the coming month.

Your sub-committee on Masonry is deeply concerned in the passage of this appropriation; indeed, its whole future work is dependent upon securing this appropriation. It is very desirable, therefore, that every member of this Association communicate with the member of Congress from his respective district, and urge upon him the importance of this appropriation.

We will now consider the report of the Masonry Committee, and will hear the preliminary statement of the chairman, Mr. E. C. Brown. (See report, pp. 579-601; discussion, pp. 605-624.)

The President:—The Committee on Records, Reports and Accounts asks the unanimous consent of the convention to strike out the words "bridges, trestles and culverts," and substitute the word "structures," in order that the conclusion may include bridges, trestles, culverts, signals, etc.

The President:—We will next take up the report of the Committee on Buildings. Mr. A. R. Raymer, chairman, will present the report. (See report, pp. 625-631; discussion, pp. 633-640.)

The President:—We will now call on the Committee on Economics of Railway Location to present a progress report.

Mr. W. McNab (Grand Trunk):—The Committee on Economics of Railway Location have simply to report progress. It is at work on the particular lines of investigation that have been relegated to it, and its first Bulletin will be issued as early as the matter that is now in hand is gotten in concrete form.

The President:—The chair will ask the Secretary to read the names of the new committees for the current year. (See list, pp. 754-764.)

The President:—The next business in order is the consideration of the report of the Track Committee. Mr. Garrett Davis, chairman, will present the report of the Committee. (See report, pp. 641-656; discussion, pp. 657-666.)

The President:—The next report is that of the Committee on Water Service. Mr. G. M. Davidson, the chairman of the Committee, will make a preliminary statement. (See report, pp. 667-676; discussion, pp. 677-680.)

The President:—We will now take up the report of the Committee on Wooden Bridges and Trestles. In the absence of the chairman, the vice-chairman, Prof. H. S. Jacoby, of Cornell University, will present the report. (See report, pp. 681-713; discussion, pp. 714-725.)

The President:—This concludes the consideration of the reports of standing committees.

The chair desires to offer the following resolution for the consideration of the convention:

"Resolved, That the thanks of the Association be extended to the Committee of Arrangements for the efficient manner in which they have performed their duties."

No doubt all present at the annual dinner last night and also throughout the convention will fully appreciate the work of this Committee.

(The resolution was adopted.)

The President:—The Committee of Arrangements offer the following resolution:

"The Committee of Arrangements requests that the Board of Direction consider the subject of the adoption of an official badge for the Association, and that consideration be given to the design of the pin presented by this Committee to the President at the annual dinner last night."

(The resolution was adopted.)

The President:—The Secretary will now announce the result of the election.

The Secretary:—The report of the tellers to canvass the ballots for officers is as follows:

Total number of votes, 257.

Vice-President (two years):

Walter G. Berg	256
S. B. Fisher	1

Secretary:

E. H. Fritch	256
L. C. Fritch	1

Treasurer:

W. S. Dawley	257

Two Directors (three years each):

W. C. Cushing	255
J. P. Snow	252
J. B. Dickson	2
F. E. Turneaure	1
D. W. Lum	1
C. F. W. Felt	1
J. H. Wallace	1

The President:—You have heard the report of the tellers. The gentlemen receiving the highest number of votes are declared elected.

Before adjourning, the chair desires to congratulate the Association upon the attendance at this convention, which has been the largest in the history of the Association. Over two hundred members were present during the convention.

The meeting now stands adjourned for one year.

The next annual convention will be held at the Auditorium Hotel, Chicago, Ill., March 19, 20 and 21, 1907.

E. H. FRITCH, *Secretary.*

COMMITTEE

REPORTS AND DISCUSSIONS

REPORT OF COMMITTEE NO. XII.—ON UNIFORM RULES, ORGANIZATION, TITLES, ETC.

To the Members of the American Railway Engineering and Maintenance of Way Association:

The report of your Committee presented in 1902 recommended a plan of organization, which, in discussion, developed a wide diversity of opinion with no definite conclusion.

The Committee appointed in 1904, before taking the subject in hand, unanimously concluded it would be inadvisable to attempt to formulate any rules for a uniform plan of organization above certain positions, and in so far as uniform organization was concerned they would stop with the office of Supervisor, leaving the roads to formulate such an organization beyond that point as might best serve their conditions. It is considered by your Committee that uniform rules are practicable in so far as they might be made to pertain to general conditions, but could not be made of general application if rules should be established including methods and recommended practices. The Committee, having proceeded on the line of formulation of as many rules for general application and recommendation as possible, submitted a report in 1905, which was received as a report of progress.

Your Committee resubmits the rules referred to, with the request that the Association give an expression as to whether the Committee is proceeding on the right lines, in order that the future work may be useful.

The Committee has in contemplation the formulation of rules covering the following points: Protection in case of obstruction of track; condition of under, over and grade crossings and proper protection of same; reporting neglect of any department whereby train movements would be jeopardized; personal attention to renewal or extraordinary work.

Also the formulation of rules for the government of "Supervisors of Structures" and "Supervisors of Signals."

GENERAL RULES FOR THE GOVERNMENT OF EMPLOYÉS
OF THE
MAINTENANCE OF WAY DEPARTMENT.

....RAIL ROAD / WAY

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 employés, 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.

Employés, in accepting employment, assume its risks.

*All employes in the Maintenance of Way Department must do all in their power to prevent accidents, even though in so doing they may occasionally have to perform someone else's duty.

GENERAL RULES.

(1) The Maintenance of Way Department on each division is in charge of ....(To be filled in by each road.).......... who will receive instructions from and report to..........(To be filled in by each road.)..........

(2) It will be subdivided under the following heads:

SUPERVISORS OF TRACK.
SUPERVISORS OF STRUCTURES.
SUPERVISORS OF SIGNALS.

(3) Supervisors of Track to report to and receive instructions from the ....(To be filled in by each road.)..........

(4) Supervisors of Track are responsible for the safe condition and proper maintenance of the track and roadway. They must inform themselves of the condition of structures, make temporary repairs of such defects as may endanger or delay the movement of trains; and promptly report defective condition to.............................

*See amendment, page 22.

(5) They shall employ, in the discharge of their work, such men as are necessary for carrying out the duties for which they are responsible.

(6) They must know that all foremen are provided with all rules, circulars, forms, and special instructions pertaining to their duties and that they fully understand and comply with the same.

(7) They must know that all foremen are supplied with tools and material necessary for the efficient performance of their duties and must see that they are properly cared for and used.

(8) In the execution of the work under their charge, they must conform to the prescribed standards and plans.

(9) They will have immediate supervision of all work train service for the maintenance of track on their division, and will employ such service only when authorized by the ....(Title.).......... doing work by other means as far as practicable and economical.

(10) In cases of obstruction or damage to track or roadbed, they will go promptly to the spot with the force, tools and materials necessary to effect clearance and repairs.

*(11) They must investigate and report on form No. ... all accidents occurring in their districts, which may be attributable to track, roadbed or structures.

(12) They will see that no encroachment upon or occupancy of any portion of the Company's right-of-way is permitted, except by authority of the ....(Title.)..........

(13) They will permit no experimental trials of applicances or devices not standard with the Company, or give out information of the results of any trial, except by proper authority.

(14) They will keep general oversight of all work performed in their district by contractors or others who do not come under their direct charge, and see that nothing is done by them that will interfere with the safety of track or movement of trains.

Respectfully submitted,

R. H. Aishton, General Manager, Chicago & Northwestern Railway, Chicago, Ill., *Chairman.*

G. H. Webb, Chief Engineer, Michigan Central Railroad, Detroit, Mich., *Vice-Chairman.*

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*See amendment, page 22.

J. H. Abbott, Bridge Engineer, Spokane International Railroad, Spokane, Wash.

A. S. Baldwin, Chief Engineer, Illinois Central Railroad, Chicago, Ill.

Robert Bell, Superintendent, Pennsylvania Railroad, Buffalo, N. Y.

C. N. Kalk, Chief Engineer, Wisconsin Central Railway, Milwaukee, Wis.

E. L. Peckham, Vice-President and General Manager, Denver, Enid & Gulf Railroad, Enid, Okla.

H. G. Prout, Vice-President and General Manager, Union Switch & Signal Co., Swissvale, Pa.

R. O. Rote, Principal Assistant Engineer, Lake Shore & Michigan Southern Railway, Cleveland, O.

H. J. Simmons, General Manager, El Paso & Southwestern Railway, El Paso, Texas.

Committee.

AMENDMENTS.

Employés in the Maintenance of Way Department must do all in their power to prevent accidents, even though in so doing they may occasionally have to perform some one else's duty.

Insert heading above Rule 3: "Rules Governing Supervisors of Track."

Rule 11: They must investigate and report on form No....all accidents occurring in their district which may be attributable to or result in damage to track, roadbed or structures.

DISCUSSION.

The President:—In the absence of the chairman, the vice-chairman, Mr. G. H. Webb, Chief Engineer of the Michigan Central, will present the report of the Committee.

Mr. G. H. Webb (Michigan Central):—Your Committee concluded it would be inadvisable to attempt to formulate rules for a uniform plan of organization above certain positions, and would not go above the office of Supervisor, leaving each road to formulate such an organization beyond that point as might best suit their conditions. The Committee considered that it was practicable to formulate rules pertaining to general conditions, but that they could not be made applicable if rules were established including methods and recommended practices. The Committee would like to have the rules discussed, in order that we may ascertain whether the work is proceeding along the right lines.

The President:—The chair would state that the general rules for the government of employés of the Maintenance of Way Department will be found on pages 100 and 101 of Bulletin 71. For the information of the members the chair wishes to say that the "General Notice," at the head of the rules, is taken from the standard code of the American Railway Association. Mr. Johnston, are you prepared to open the discussion on the rules submitted?

Mr. A. W. Johnston (New York, Chicago & St. Louis):—It seems to me, in view of the method previously pursued at these meetings, and as I presume some of the members have not read the rules carefully, the Secretary might, as usual, read the rules and then the gentlemen who desire to comment upon them as we go along can do so. Personally, I have no extended criticism to make. I think the Committee, in view of the scope which they chose for themselves in dealing with the rules, have done very well. It is not an easy matter, as they well say, to outline general rules covering an extensive department. I think we had better go on as we have before and consider these rules seriatim.

The President:—The Secretary will take up the rules in order, and as they are read, if there is no objection, he will proceed, and then a general vote can be taken at the close. In regard to such clauses as are commented upon, special action will be taken.

The Secretary:—"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 employés, 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. Employés, in accepting employment, assume its risks. All employés in the Maintenance of Way Department must do all in their power to prevent accidents, even though in so doing they may occasionally have to perform someone else's duty."

Mr. C. H. Ewing (Philadelphia & Reading):—The word "All," at the beginning of the paragraph in the section headed "General Notice," appears to be superfluous. The rule preceding it begins with "Employés." I suggest that the word "All" in the last paragraph be eliminated.

The President:—If there is no objection, the word "All" will be eliminated.

The Secretary:—"General Rules.—(1) The Maintenance of Way Department on each division is in charge of...................., who will receive instructions from and report to................

"(2) It will be subdivided under the following heads: Supervisors of Track; Supervisors of Structures, and Supervisors of Signals.

"(3) Supervisors of Track to report to and receive instructions from the...................

"(4) Supervisors of Track are responsible for the safe condition and proper maintenance of the track and roadway. They must inform themselves of the condition of structures, make temporary repairs of such defects as may endanger or delay the movement of trains; and promptly report defective condition to ....

"(5) They shall employ, in the discharge of their work, such men as are necessary for carrying out the duties for which they are responsible.

"(6) They must know that all foremen are provided with all rules, circulars, forms, and special instructions pertaining to their duties, and that they fully understand and comply with the same.

"(7) They must know that all foremen are supplied with tools and material necessary for the efficient performance of their duties, and must see that they are properly cared for and used.

"(8) In the execution of the work under their charge they must conform to the prescribed standards and plans.

"(9) They will have immediate supervision of all work train service for the maintenance of track on their division, and will employ such service only when authorized by the.........., doing work by other means as far as practicable and economical.

"(10) In cases of obstruction or damage to track or roadbed they will go promptly to the spot with the force, tools and materials necessary to effect clearance and repairs.

"(11) They must investigate and report on form No. ... all accidents occurring in their district, which may be attributable to track, roadbed or structures.

"(12) They will see that no encroachment upon or occupancy of any portion of the company's right-of-way is permitted, except by authority of the.....................

"(13) They will permit no experimental trials of appliances or devices not standard with the company, or give out information of the results of any trial, except by proper authority.

"(14) They will keep general oversight of all work performed in their district by contractors or others who do not come under their direct charge, and see that nothing is done by them that will interfere with the safety of track or movement of trains."

The President:—The Committee desires an expression from the Association as to whether they are proceeding upon the right lines, in so far as the organization is concerned, and also of the rules submitted. The chair would also ask if there are any suggestions for additional rules.

Mr. I. O. Walker (Nashville, Chattanooga & St. Louis):—In paragraph 11 it is provided that "They must investigate and report," etc. It seems to me that this department should also report on the result of accidents whether they are due to the failure of the track, roadbed or structures, or not. For example, a broken axle might tear a bridge to pieces, and naturally a report from the operating department, which has supervision of rolling stock, should follow. The Committee could modify that somewhat as follows: "They must investigate and report on form No. ... all accidents occurring in their district which may be attributable to or result in damage to track, roadbed or structures."

Mr. Johnston:—I second the suggestion of Mr. Walker. In my own practice we make it obligatory upon the employés of each department to exchange reports which affect the efficiency of the department, so far as accidents are concerned. Even though it might not appear on the surface that a broken axle, or a broken wheel, or a broken axle-box, or a broken truck affected the track, we find it advantageous to require an exchange of such reports and make the department head responsible for its exchange of such reports with other departments.

The President:—The Committee accepts the suggestion of Mr. Walker as seconded by Mr. Johnston.

Mr. Ewing:—I want to question the general makeup of the rules. Under the head of "General Rules," I notice there are specific duties outlined for the Supervisors of Track. My suggestion would be that the general rules should be defined under one head, and that the rules for the Supervisors of Track, Supervisors of Structures, etc., cover the specific rules of those men.

Mr. John V. Hanna (St. Louis & San Francisco):—I think the point just made is well taken, and that under the head of "General Rules" we should include everything which is applicable to all branches of the Maintenance of Way Department, and then under separate heads the specific duties that apply to the different branches.

The President:—Do you make the suggestion in the form of a motion, Mr. Ewing?

Mr. Ewing:—Yes, I would make a motion that the general rules contain such matter as is applicable to the heads of all departments, and that the specific duties of each head of department be outlined under a separate heading.

(The motion was seconded and carried.)

The President:—The chair desires to call attention to the effect of the motion. At first it was thought it would require a redrafting of the entire set of rules as printed, and that therefore the effect of the motion would be to refer the entire report back to the Committee, but as the rules given in the report pertain only to Supervisors of Track, it will simply be necessary to insert above Rule 3 a heading "Rules Governing Supervisors of Track." Rules Governing Supervisors of Structures, etc., could come in on a subsequent report. The report can therefore be acted on as a whole or by individual sections.

Mr. Edwin F. Wendt (Pittsburg & Lake Erie):—The Committee requests that the Association give an expression as to whether it is proceeding on the right lines, in order that the future work to be done by it may be useful. I want to say that in general I think the Committee is proceeding upon right lines. Members who have attended these meetings for the past five or six years will recall what difficulty this Committee had in discovering a line of work which would be generally useful to the Association. For several years no report was submitted by the Committee, and the report now presented is, I believe, the second they have submitted. The Committee has begun at the bottom of the organization, instead of the top, and it is their intention, according to their statement, to work from the bottom up. This, I think, is proper, and the report now before us is certainly a step forward and one that will be beneficial to the members of the Association. I would therefore say that in a general way the Committee has taken the right step, and I hope that they will follow this up next year with specific rules for the other heads of departments—Supervisors of Structures and Supervisors of Signals.

The President:—The chair would suggest, Mr. Wendt, that you make that in the form of a motion, so that it will be a matter of record that the Committee is proceeding upon the right lines.

Mr. Wendt:—I make the motion that it is the sense of this convention that the Committee is proceeding upon proper lines. Personally, I would like to supplement that motion and move that the report be adopted and printed in the Manual of Recommended Practice. In my judgment, as far as it goes, the report is fairly complete. No doubt from time to time additional rules will be introduced under the heading of "Supervisors of Track," but in accordance with our practice, the Manual is supplemented from year to year.

(The motion was seconded and carried.)

Prof. W. D. Pence (Purdue University):—I presume it is understood that the words "Rules Governing Supervisors of Track" will be inserted above Rule 3.

The President:—Yes, that is the understanding.

Mr. Richard Mather (Erie):—I would suggest that Rules 5, 6, 7, 8 and 13 be placed under the general rules.

The President:—The convention has heard the remarks of Mr. Mather that rules 5, 6, 7, 8 and 13 be placed under the general rules.

Mr. Hanna:—Also rules 9 and 10.

The President:—Would not rules 9 and 10 come under the duties of the Supervisor of Track and not under the general rules?

Mr. Hanna:—I think not. It says, they shall have supervision of the work train service.

The President:—In the maintenance of track.

Mr. Hanna:—How about the work trains?

The President:—That would come under the specific rules, as the chair understands it, for Supervisors of Structures.

Mr. Hanna:—How about rule 10?

Mr. Webb:—The idea of the Committee was to hold the Supervisor of Track responsible for the policing. It is his duty to police the road, no matter whether it affects signals or any other property. We expect him to see that everything is all right. In all organizations that I know anything about the Supervisor is responsible for the policing of the roadway, and we wish to hold the Supervisor responsible for it. That is the reason we phrased the clause as we did.

Mr. Johnston:—I can see no special objection to allowing these rules to stand as they are and if we have connected with the rules applying to use of signals those applying to other departments, no harm can be done. We want to have the gentleman in charge of a special department see all the rules which affect his work.

The President:—The discussion is somewhat out of order, as the report has been accepted. Unless there is other objection, the Committee will be dismissed with the thanks of the Association.

Mr. W. M. Camp (Railway and Engineering Review):—Before the Committee is relieved, I wish to ask whether it would not be proper to add another heading under paragraph 2—"Water Service." The Atchison, Topeka & Santa Fe Railway, the Illinois Central Railroad, the Missouri Pacific Railway, the St. Louis & San Francisco Railroad, and some other roads have general officers in charge of water service.

The President:—The Committee state they will take cognizance of the suggestion in their work during the coming year.

REPORT OF COMMITTEE NO. III.—ON TIES.

To the Members of the American Railway Engineering and Maintenance of Way Association:

The report of this Committee, printed in Bulletin No. 60, February, 1905, was read by title at the last annual convention, but not discussed. The Committee recommended in that report the adoption of certain definitions; that the specification for ties, as amended, be adopted; that the rules for tie records be adopted; that the method of stamping, in addition to the use of the dating nail, be adopted; and also that ties treated with mineral salts be seasoned from four to six weeks before being laid in track.

During the present year the Committee has held two meetings, besides one joint meeting with the Track Committee, acting on the instructions of the Board of Direction to confer with the latter committee as to tie spacing and size of ties for various conditions.

An effort was made to secure from the members of the Tie and Track Committees their views upon the possibility of expressing in a formula the most desirable length of ties, and spacing thereof, for three types of track—ballasted track for heavy traffic; ballasted track for light traffic, and unballasted track. It was suggested that the proper factors in such a formula would be the engine axle load, the weight of rail, the allowable bearing pressure of the rail on the tie, and of the tie on the roadbed. Three axle loads, and also three weights of rail were suggested; the weight of rail being intended to accord with the usual present practice as to proportion to the axle loads. Several replies were received to this request, but the consensus of opinion was that it was impossible to express by formula any rule which would have any value. One member of the Committee presented a letter in which he attempted to determine the proper spacing, on the theory that the bending moment in the various rails under their axle loads should be the same. This letter is printed as an appendix to the report as being a suggestive study.

The Committee carefully considered the data on the subject of the size of ties in use on the railroads of the country, as embodied in their previous report (Bulletin No. 60), and concluded, in view of the increasing length of spikes being used, to recommend that the standard thickness of tie be made 7 in. and in view of the great scarcity of tie timber in this country, with the corresponding increased cost, that the length of tie should preferably be 8 ft. Consequently it is recommended that the standard tie be 7 in. by 8 in. by 8 ft.

The specifications for ties are resubmitted with the corrections, as embodied in our report (Bulletin No. 60), and with the following changes in addition: The word "Cypress," under the heading of "Woods to be used untreated," has been qualified by putting in parenthesis immediately thereafter, "Except White Cypress." From the table of dimensions classes F. and G. have been eliminated, F. being for a tie 6 by 7 in. and G. for a tie 6 by 6 in. The marginal references have been corrected as follows: "Piling Ties" to read, "Piling Untreated Ties," and a new paragraph has been inserted covering "Piling Treated Ties." A provision in the paragraph relating to "Piling Untreated Ties" has been added to the effect that they must be marked with the date when piled, as well as with the owner's name.

The definitions for "Heart Tie," "Half-Round Tie," "Face," and "Cross-Tie," which have not been acted upon by the Association, are resubmitted. A definition for "Sawed Tie" is presented and previous definitions adopted by the Association for "Score Marks" and "Doty Tie" are amended.

The Committee was directed to submit rules for marking ties, and also to resubmit specifications for dating nail. In the previous report instructions for marking the ties by the use of dating nails were submitted. In the instructions given for keeping and reporting tie records, it is recommended that, in addition to the use of the dating nails, all ties be stamped at both ends. Embodied in our specification for dating nail, the dimensions of these nails are given. The Committee is not at all sure that the specification for dating nail is sufficient; it is quite questionable in our judgment as to the possibility of the steel nail giving satisfactory service. In previous reports attention has been called to the very short life of galvanized nails in some instances, and the Committee has endeavored to ascertain the cause. It will be a great misfortune if nails which are placed in the ties for the purpose of identifying them ten years hence should fail to have as long a life as the tie. One member of the Committee reports as to the practice on the Pennsylvania Lines:

"Until within a year ago the dating nails used by this company were made of copper. It was found that these copper nails were being pulled out of the ties by boys and others, presumably on account of their intrinsic value, and we have for the last year, or year and a half, been using galvanized wire for our dating nails. The material in these dating nails is steel; we have not so far specified the amount of carbon—the less carbon, the less corrosion, as a rule. I would therefore suggest that we specify that iron be used for dating nails instead of steel.

"It is a well-known fact that the Western Union Telegraph Company's wire has a considerably longer life than our galvanized fence wire. Under extremely unfavorable conditions this telegraph wire lasts from 8 to 10 years, and under ordinary conditions obtaining along railroads it lasts about 30 years. This very long life is in my judgment due not only to the quality of galvanizing, but, without doubt, mostly to the fact that the wire is made out of iron.

"We have on one of our western lines a telegraph wire, which was put up in 1856, and is still in service, and in fairly good condition. This was originally a No. 9 wire, and is at present very little decreased in size. I am told that this is an iron wire which was boiled in oil before being put up.

"It may be advisable to make some experiments with iron wire boiled in oil and iron wire galvanized, and with steel wire boiled in oil and steel wire galvanized, with a view of determining the life under unfavorable conditions"

The Committee at one meeting voted to specify the amount of carbon which the steel nails should contain, but concluded that this is inexpedient, and believes, before attempting to specify what is necessary, further efforts be made to determine what the facts are. The specification for dating nail as amended is resubmitted, believing that while it may need correction, it will insure uniformity of size if adopted.

The rules offered in Bulletin No. 60 for the keeping of tie records are resubmitted herewith.

In previous reports the results of the use of treated ties on various roads have been given, and as this is all accessible it is unnecessary to repeat it. Nothing has developed during the past year to change the conclusions as to the value of treatment. Whatever new evidence has been found has been simply confirmatory of the favorable conclusions of previous years. There has been no large increase in the number of ties treated during the past year. There can be no question but that the more general adoption of treatment would inure largely to the benefit of the railroads. Unfortunately the policy of many roads is to refuse to consider the matter when the price of ties is weak, because of the temporary cheapening of the supply; and to refuse to embark in it when the price of ties is high, because then it is impossible to contract for a supply of ties except at the higher prices. There has been a report made during the month of December, 1905, on the ties laid in the experimental track of the Gulf, Colorado & Santa Fe in Texas. These ties have been reported on by this Committee in previous years, and by reference thereto the number of ties of each kind, and details as to treatment cr non-treatment can be secured. It will be remembered these ties were treated and laid under the direction of the Bureau of Plant Industry of the Department of Agriculture of the United States. This latest report is too much in detail to be reproduced, but the general results are to demonstrate the value of the zinc-chloride and zinc-creosote methods. The benefit of the treatment is shown more on certain species than on others; for instance, of the 91 red oak ties laid in track without treatment, 82 have already been removed, while of the 9 still in track two show decay. All of the red oak ties treated by the zinc-chloride, the Wellhouse and the zinc-creosote (two-injection) processes, are in good condition. Of the 49 tamarack ties laid, four-fifths were removed in February, 1905, because of rottenness. The ties of the same species, treated by the methods mentioned above, are all in good condition. The same comment applies to the loblolly pine ties, of which the 100 untreated were all removed in May, 1904, being rotten. The ties treated by the usual methods are in good condition. Of 42 ties immersed for 48 hours in Beaumont crude oil, 40 were removed in September, 1904, being rotten. Of 100 immersed in Spirittine, 80 had been removed up to Sptember, 1904. Of the 93 untreated long-leaf pine ties, 85 were removed in November, 1904. Of 100 short-leaf pine ties untreated, 55 had been removed up to February, 1905, being rotten, while of those still in track only 13 are reported as being in good condition. Of 101 hemlock ties, untreated, all were removed in September, 1904, being rotten. Of 100 beech ties, 97 have been removed, being rotten. In all of the above cases the ties treated by the zinc-chloride, the Wellhouse and zinc-creosote (two-injection) processes have given good results, except in the case of certain ties treated with the zinc-creosote, which were badly overheated in steaming, and which have gone to pieces therefrom. The ties treated by the Hassellman process have given in general unsatisfactory results. The ties which have shown the best results by this treatment have been the white oak and the long-leaf pine, both of which are supposed to give good results without treatment. It will be remembered that it is claimed these ties given the Hassellman treatment were not properly treated. What bearing this may have on the results is unknown. The only ties treated with Spirittine, besides the loblolly previously mentioned, were 100 long-leaf pines, of which 7 show decay, one is badly split, while the rest are in good condition.

The Committee has thought it desirable to attempt the preparation of general specifications covering the various kinds of treatment, and submit these specifications for the consideration of the Association. It is not asked that they be adopted, as it is believed it will be wiser to have them thoroughly considered and discussed before this is done. The Committee has not written specifications for all forms of treatment, confining themselves to those regarding which they have some knowledge, and which were neither secret or patented. In some respects the Committee recognizes the specifications could be made more complete. It has been our effort, however, to write a specification which shall be reasonable, and which we can reasonably hope may be generally adopted. As an appendix two letters are printed—one from a member of the Committee who was unable to be present at the last meeting, containing some criticisms and suggestions, and another from Mr. J. Kruttschnitt.

CONCLUSIONS.

Your Committee submits the following conclusions:

(1) That the specifications for ties, as amended, be approved.

(2) That the definitions submitted herewith be adopted.

(3) That the specifications for dating nail be approved.

(4) That the rules for tie records be approved.

(5) That the standard tie be 7 in. by 8 in. by 8 ft.

(6) That the specifications for tie treatment be discussed and referred back to the Committee for further consideration.

Respectfully submitted,

E. B. Cushing, General Superintendent, La. & Texas Lines, Sou. Pac. Co., New Orleans, La., *Chairman.*

W. W. Curtis, Consulting Engineer, Chicago, Ill., *Vice-Chairman.*

E. G. Ericson, Principal Assistant Engineer, N. W. System, Pennsylvania Lines, Pittsburg, Pa.

E. O. Faulkner, Manager Tie and Timber Dept., Santa Fe Railway System, Topeka, Kan.

C. F. W. Felt, Chief Engineer, G., C. & S. Fe Ry., Galveston, Texas.

E. E. Hart, Chief Engineer, New York, Chicago & St. Louis Railway, Cleveland, O.

V. K. Hendricks, Division Engineer, Baltimore & Ohio R. R., Baltimore.

J. C. Nelson, Division Engineer, Alabama Great Southern Railway, Birmingham, Ala.

S. M. Rowe, Consulting Engineer, Chicago, Ill.

H. R. Safford, Assistant Chief Engineer, Illinois Central R. R., Chicago.

Dr. Hermann Von Schrenk, Pathologist, Dept. of Agriculture, St. Louis.

Committee.

SPECIFICATIONS FOR TIES.

RECOMMENDED STANDARD SPECIFICATIONS.

s to sed ated.

The following woods may be used for tie timber without any preservative treatment:

White Oak family.
Long-leaf strict heart yellow pine.
Cypress, excepting the white cypress.
Redwood.
White Cedar.
Chestnut.
Catalpa.
Locust, excepting the honey locust.
Walnut.
Black Cherry.

s to eated.

The following woods shall preferably not be used for tie timber without a preservative treatment approved by the purchaser:

Red Oak family.
Beech.
Elm.
Maple.
Gum.
Loblolly, short-leaf, lodgepole, Western yellow pine, Norway, North Carolina pine and other sap pines.
Red Fir.
Spruce.
Hemlock.
Tamarack.

rial Manu- re.

All ties must be well and smoothly hewed or sawed out of straight, growing timber of specified dimensions and out of wind, sawed ends, with straight and parallel faces, the minimum width of either face to be not less than that given in the table of dimensions. All ties must have bark entirely removed before being delivered on the company's ground. Ties shall be free from splits, shakes, loose or decayed knots or any other imperfections which may impair their strength or durability.

DIMENSIONS.

Dimensions.

Except in pole ties with rounded sides, or in half-round ties, none shall be less than eight (8) in. width of face, and in no tie shall the thickness be less than six (6) in. A variation in size will be permitted of one-half (½) in. over in thickness, two (2) in. over in width and one (1) in. over in length.

Allowable Variation.

In pole ties with rounded sides and half-round ties, the width of face may be less than that given in the table of dimensions below, but the least area of cross-section shall be not less than the area corresponding to the tabular dimensions, and in no case shall the width of face be less than six (6) in.

TABLE OF DIMENSIONS.

Class.	Thickness by Width of Face.	Length.		
	Inches.	Feet.	Feet.	Feet.
A	7 x 10	8	8½	9
B	7 x 9	8	8½	9
C	7 x 8	8	8½	9
D	6 x 9	8	8½	9
E	6 x 8	8	8½	9

Piling Untreated Ties.

Ties which are to be delivered along the right-of-way of the railroad must be piled at station yards or at points between stations designated in the contract, not less than ten (10) ft. from the nearest rail; each pile to be of either 25 or 50 ties, built with two ties on the ground and above in alternate courses of 7 and 2, except the top, which shall be placed to

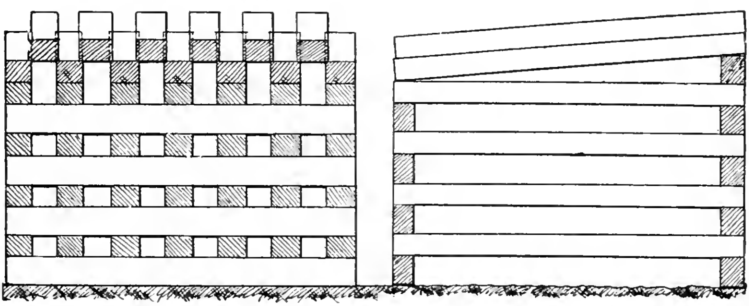


FIG. 1.—PILING DIAGRAM FOR FIFTY TIES.

form a watershed, as shown in diagram. Each pile must be plainly marked with the owner's name and date when piled. Three feet of space must be left between piles to allow easy inspection. Sawed ties must be piled separately from hewed ties.

All rejected ties must be removed from the company's right-of-way within ten days after notice is given.

Ties treated with a water solution, like zinc-chloride, particularly Red Oak and Beech ties, must be piled in close piles on well drained ground, to prevent checking.

Ties shall be cut, as far as possible, in the winter period; that is, from October to March.

DEFINITIONS.

CROSS-TIE.—That transverse member of a railway track which supports the rails and by means of which they are retained in position.

SAWED TIE.—A tie having both faces and sides sawed.

HALF-ROUND TIE.—A slabbed tie which has greater width on lower than on top face.

HEART TIE.—A tie which shows sapwood on one or two corners only and which sapwood does not measure more than one inch on either corner, on lines drawn diagonally across the end of tie.

DOTY TIE.—A tie which is affected by fungous disease.

SCORE MARKS.—Marks made by the ax as an aid in hewing.

FACE.—The upper or lower plane surface of a tie.

SPECIFICATIONS FOR DATING NAIL.

Materia

The nail shall be ¼-in. in diameter, 2½ in. in length, with head ⅝-in. in diameter, having stamped therein two figures designating the year; the figures to be ⅜-in. in length and depressed into the head $\frac{1}{16}$-in., made of iron or steel, galvanized with a coating of zinc, evenly and uniformly applied, so that it will adhere firmly to the surface of the steel.

Test.

Any specimen shall be capable of withstanding the following test: The sample shall be immersed in a standard solution of copper sulphate for one minute and then removed, immediately washed in water thoroughly, and wiped dry. This process shall be repeated. If after the fourth immersion there is a copper-colored deposit on the sample or the zinc has been removed, the lot from which the sample was taken shall be rejected.

Chemic

The standard solution of copper sulphate shall consist of a solution of 34.5 parts of crystallized copper sulphate in 100 parts of water. This solution will have a specific gravity of 1.185 at 70 degrees Fahrenheit. While a sample is being tested, the temperature of the standard solution shall at no time be less than 60 degrees Fahrenheit nor more than 70 degrees Fahrenheit.

RULES FOR TIE RECORDS.

Section foremen will be provided with daily record blanks having space for each day of the month to record the number of treated ties put into track that day and the number taken out the same day, the latter being according to the cause necessitating their removal, whether rotten, broken, burned or rail cut. They must also show the year in which these ties were treated as indicated by the stamp and by the dating nail. The section foreman must make these records each day, and at the end of each month the daily record must be forwarded to the proper superior officer. If no treated ties have been taken out or put into track during the month, section foremen must so note on report.

Treated ties already in track, but taken up and relaid on another part of the same section, need not be inserted on this report as ties taken out or put in.

Section foremen must see that a dating nail is driven in the upper side of every treated tie when it is first laid in the track, about ten inches inside of the rail, and on the line side of the track. The tie shall be laid with the end having the year stamp on it on the line side of the track. A supply of these nails must be carried on the hand-car whenever any ties are to be laid, and dating nail must be driven the same day the tie is put in.

Foremen must be especially careful to see that neither they nor their men injure or destroy the marks or nails intended to identify the ties.

At the end of each year all dating nails for that year remaining on hand and unused must be returned to the storekeeper, and requisition made for a new supply stamped with the following year.

It is recommended that, in addition to the use of the dating nail, each tie be stamped at the treating plant, before treatment, with the year; and, preferably, be stamped on both ends.

SPECIFICATIONS FOR TIE TREATMENT.

GENERAL REQUIREMENTS.

No ties shall be treated earlier than 90 days after cutting and piling in open spaces to season, if of pine; or 120 days if of oak; and for other timbers for such period as is necessary to bring them to a corresponding degree of seasoning. If this is done prior to receipt at the treating works, ties may be loaded direct from the cars to the trains; otherwise they must be unloaded on the ground, stacked in piles eight (8) ft. square, with two ties only in bottom layer and two and seven in every alternate layer, except the top one, which shall be laid close with an extra tie under one end to form a rain shed. The outside ties in each layer shall be placed on edge to provide an air space above each layer. The piles shall be placed ten (10) ft. centers in one direction and nine (9) ft. centers in the other direction. When so stacked, ties shall be allowed to season for a time at least sufficient to make up the 90 and 120 days required, or other time necessary to thoroughly air season. Ties treated in the same run shall be as nearly as possible uniform in kind and degree of seasoning. No ties should be put into the cylinder which do not conform to the requirements of the tie specifications as to shakes, checks, etc. All ties which show signs of checking should be provided with some means for preventing further checking, either by means of "S" irons, bolts, or other device, in order to prevent further checking during and after treatment, which would be liable to render the tie worthless. Where ties are to be adzed or bored for subsequent insertion of tie-plates or screw spikes, such adzing and boring should in all cases be done before treatment.

When in condition to treat, the ties shall be placed in the cylinders, the door closed and live steam admitted at such rate as to secure 20 lbs. of steam pressure within 30 to 50 minutes, as shown by gage connected to the cylinder. This pressure shall be maintained for periods varying from one to five hours, depending upon the character of the timber and its condition; but the pressure as indicated on the gage shall at no time be allowed to exceed 20 lbs. Where the timber is absolutely air-seasoned and it is possible to secure the desired penetration without steaming, this may be omitted entirely, subject to the approval of the purchaser. During the time of steaming a vent shall be kept open in the bottom of the cylinder or in the drain therefrom to permit the escape of air and the condensed water in the cylinder.

When the steaming is completed the steam shall be blown off, and a vacuum of not less than 24 in. of mercury produced, if the works are located at sea level, or a corresponding degree of vacuum produced at higher altitude.*

ZINC CHLORIDE TREATMENT.

This vacuum shall be maintained for at least one-half hour, at the expiration of which time zinc chloride shall be admitted without otherwise breaking the vacuum; a pressure of 100 lbs. per sq. in. applied, and maintained until the desired absorption is obtained. The amount of solution injected shall be equivalent to ½-lb. of dry soluble zinc chloride per cubic foot of timber. The solution shall be as weak as can be used, and still obtain the desired absorption of zinc chloride, and shall not be stronger than 5 per cent. The solution shall be heated to a temperature of not less than 140 degrees before admission to the cylinder. If the cylinders are provided with steam coils, steam pressure shall be maintained in these coils during treatment.

The zinc chloride used shall be as free from any impurities of any kind as is practicable, being slightly basic, absolutely free from free acid, containing not more than $\frac{25}{1000}$ of 1 per cent. of iron. The amount of chloride specified to be injected shall be of soluble zinc chloride only. The amount of solution absorbed shall be determined by calculation based on the gage readings of the tank holding the supply of solution. The strength of the zinc-chloride solution must be carefully controlled from time to time by hydrometer readings. Borings should be taken from time to time from at least six ties treated in the same run, and a determination of the actual zinc chloride according to the standard method should be made. The holes made in taking these borings to be plugged tightly and completely with creosoted plugs.

ZINC TANNIN TREATMENT.

This vacuum shall be maintained for at least one-half hour, at the expiration of which time zinc chloride shall be admitted without otherwise breaking the vacuum; a pressure of 100 lbs. per sq. in. applied, and maintained until the desired absorption is obtained. The amount of solution injected shall be equivalent to ½-lb. of dry soluble zinc chloride per cubic foot of timber. The solution shall be as weak as can be used and still obtain the desired absorption of zinc chloride, and shall

*The General Requirements above apply to each of the following treatments. If used in specifications for the purchase of ties or for treatment, these paragraphs should be followed only by the particular treatment required.

not be stronger than 5 per cent. The solution shall be heated to a temperature of not less than 140 degrees before admission to the cylinder. If the cylinders are provided with steam coils, steam shall be maintained in these coils during the entire treatment.

After the required amount of zinc chloride has been injected this solution shall be run off and the ties allowed to drain for 15 minutes. The chloride draining off shall be blown or run off, and a 2 per cent. solution of tannic acid, made by mixing $6\frac{2}{3}$ lbs. of 30 per cent. extract of tannin with 100 lbs. of water, run in, and a pressure of 100 lbs. produced and maintained one-half hour. This shall then be run off, a 1 per cent. solution of glue (made by dissolving $2\frac{1}{10}$ lbs. of glue containing 50 per cent. gelatine, in 100 lbs. water) shall be admitted to the cylinder and a pressure of 100 lbs. produced and maintained for one-half hour. Care shall be taken to maintain the solution containing the glue and tannic acid up to their original strength in these elements.

The zinc chloride used shall be as free from all impurities of any kind as is practicable, being slightly basic, absolutely free from free acid, containing not more than $\frac{35}{1000}$ of 1 per cent. iron. The amount of chloride specified to be injected shall be of soluble zinc chloride only. The amount of solution absorbed shall be determined by calculation based on the gage readings of the tanks holding the supply of solution. The strength of the zinc-chloride solution must be carefully controlled from time to time by hydrometer readings. Borings should be taken from time to time from at least six ties treated in the same run, and a determination of the actual zinc chloride according to the standard method should be made. The holes made in taking these borings to be plugged tightly and completely with creosoted plugs.

CREOSOTING.

This vacuum shall be maintained for at least one-half hour, at the expiration of which time dead oil of coal tar shall be admitted without otherwise breaking the vacuum; a pressure of 100 lbs. per sq. in. applied, and maintained until the desired absorption is obtained. The amount of dead oil to be injected shall be that provided for in the contract for ties; suggested to be 10 lbs. per cubic ft. The dead oil shall be heated to a temperature of not less than 140 degrees before admission to the cylinder. All cylinders must be provided with sufficient steam coils to fully maintain this temperature during injection, steam pressure being maintained in these coils also during vacuum. The dead oil shall comply with the standard specifications therefor, as determined by standard methods of analysis. The amount of oil absorbed shall be determined by calculation based upon gage readings taken before the introduction of the oil into the cylinder and after forcing back the oil after treatment.

All oil shall be analyzed when received at the works; these samples being taken in the manner prescribed by the specifications for oil. At least once during each week samples of oil shall be taken from the cylinders during the treatment and analyzed to determine if the water in the oil exceeds the limit in the specifications. If so, a correspondingly greater amount shall be injected. If this amount of water exceeds 10 per cent., steps shall be taken before it is used to remove the water, so as to bring the oil within the limits of the specifications.

WELLHOUSE TREATMENT.

This vacuum shall be maintained for at least one-half hour, at the expiration of which time zinc chloride containing $\frac{1}{2}$ of 1 per cent. of glue shall be admitted without otherwise breaking the vacuum; a pressure of 100 lbs. per sq. in. applied, and maintained until the desired absorption is obtained. The amount of solution injected shall be equivalent to $\frac{1}{2}$-lb. of dry soluble zinc chloride per cubic foot of timber. The solution of zinc chloride shall be as weak as can be used, and still obtain the desired absorption of zinc chloride, and shall not be stronger than 5 per cent. The solution shall be heated to a temperature of not less than 140 degrees before admission to the cylinder. If the cylinders are provided with steam coils, steam pressure shall be maintained in these coils during the entire treatment.

After the required amount of zinc chloride and glue has been injected, this solution shall be run off and ties allowed to drain for 15 minutes. The chloride and glue draining off shall be blown or run off and a $\frac{1}{2}$ of 1 per cent. solution of tannic acid run in, and a pressure of 100 lbs. produced and maintained $1\frac{1}{2}$ hours. Care shall be taken to maintain the solution containing the glue and tannic acid up to their original strength in these elements.

The zinc chloride used shall be as free from any impurities of any kind as is practicable, being slightly basic, absolutely free from free acid, containing not more than $\frac{25}{1000}$ of 1 per cent. of iron. The amount of chloride specified to be injected shall be of soluble zinc chloride only. The amount of solution absorbed shall be determined by calculation based on the gage readings of the tanks holding the supply of solution. The strength of the zinc-chloride solution must be carefully controlled from time to time by hydrometer readings. Borings should be taken from time to time from at least six ties treated in the same run, and a determination of the actual zinc-chloride according to the standard method should be made. The holes made in taking these borings to be plugged tightly and completely with creosoted plugs.

TWO-INJECTION ZINC CREOSOTE.

This vacuum shall be maintained for at least one-half hour, at the expiration of which time zinc chloride shall be admitted without otherwise breaking the vacuum: pressure applied and maintained until the desired absorption is obtained. The amount of solution injected shall be equivalent to $\frac{3}{10}$-lb. of dry soluble zinc chloride per cubic foot of timber. The solution shall be as weak as can be used, and still obtain the desired absorption of zinc chloride, and shall not be stronger than 5 per cent. The solution shall be heated to a temperature of not less than 140 degrees before admission to the cylinder.

The solution of zinc chloride shall then be run out, and dead oil of coal tar immediately admitted to the cylinder, pressure applied of 100 lbs. per sq. in., and oil injected into the ties to the average amount of 3 lbs. of oil per cubic foot of timber. The oil shall be heated to a temperature of not less than 140 degrees before admission to the cylinder. All cylinders must be provided with sufficient steam coils to fully maintain this temperature during injection, and steam shall be maintained in the coils also during injection of the zinc chloride and during vacuum. The dead oil shall comply with the standard specifications therefor, as determined by standard methods of analysis. The amount of oil absorbed shall be determined by calculation based upon gage readings taken before the introduction of the oil into the cylinder, and after forcing back the oil after treatment.

All oil shall be analyzed when received at the works; these samples being taken in the manner prescribed by the specifications for oil. At least once during each week samples of oil shall be taken from the cylinders during treatment and analyzed to determine if the water in the oil exceeds the limit in the specifications. If so, a correspondingly greater amount shall be injected. If this amount of water exceeds 10 per cent., steps shall be taken before it is used to remove the water, so as to bring the oil within the limits of the specifications.

APPENDIX.

Mr. J. Kruttschnitt (Union Pacific and Southern Pacific—by letter):—I have read over with some care the proposed specifications for treating timber with zinc chloride and dead oil of coal tar, and the following suggestions occur to me:

I think some stress should be laid on the fact that no one method of treatment can be prescribed that will suit all kinds of timber, different woods require entirely different treatments, as is evidenced by the fact that we are not able to adopt a standard treatment that will do for all of *our* lines; for instance, for the Wyoming mountain or lodgepole pine, and for the Louisiana and Texas yellow pines, we prescribe 90 days for air-seasoning and find that this reduces the time of treatment and is in every way beneficial, while on the Pacific Coast it is found that the Douglas fir, which we use to a great extent for tie timber, takes the treatment best without seasoning.

We doubt whether bolts, "S" irons, or other devices will be of any benefit to prevent ties that are badly checked from checking further. We think the specifications should be rigidly enforced, and would not attempt to treat badly shaken or checked ties.

All machine work to be done on timber should, without doubt, be done before treatment.

We have found it best at all of our works to apply a vacuum before admitting live steam. We think it promotes the seasoning of the timber by removal of the fermentable sap, the retention of which serves to promote decay.

We raise the steam pressure to 25 lbs., but prefer to specify the temperature above which the timber shall not be heated rather than the steam pressure.

We have found with Pacific Coast timbers that they are not injured if the (upper grade of) temperature be limited to 280 degrees Fahrenheit, and the Eastern yellow pines are not injured if the temperature be limited to 250 degrees Fahrenheit.

We use a pressure of 125 lbs. to 145 lbs. per sq. in. for forcing the chloride into the ties.

We use only one-half the amount of dry chloride per cubic foot (our specifications call for ¼-lb.) that the Committee recommends, and we never allow the solution to go as high as 5 per cent. Our standard solution is 1.7 per cent., and we do not permit it to rise above 2.5 per cent. as a maximum.

While the heating of the solution is all right, we see no reason in burnettizing why the cylinders should be provided with steam coils. It is an added expense, and an added device to rust out and be corroded by the chloride of zinc.

Creosoting.—The amount of creosote per cubic foot of tie seems to us ample. While we do not use this treatment for ties, we have used it extensively for trestle timbers and bridge ties and have never had any trouble with timber impregnated with this amount of oil. We heat the oil rather higher than the Committee recommends before admission, using a temperature of from 170 to 180 degrees Fahrenheit.

The method of measuring the solution absorbed, by gage readings on the tank holding the stock supply of the solution, is fallacious, unless the coefficient of the measuring tank is obtained for correction. The apparent injection of both zinc chloride and creosote may be simply evidence of compression of bubbles of air, gas, etc., in the timber.

I quote clauses of our specifications bearing on this subject:

"At regular intervals of about 30 days during operation and whenever there is a change in the character of the timber to be treated, make a coefficient for the measuring tank as follows:

"When injecting, pump from the measuring tank into the retort the exact net number of inches theoretically required for the timber, without coefficient of any kind; let off pressure from bottom of retort through a pipe into and over top of measuring tank; note exact inches returned; subtract this from the theoretical number of inches. This gives the inches remaining in the retort. Then the ratio of 100 times the inches flowing back to the inches remaining gives the percentage to be added, in every case, to the theoretical inches required. Example:

60 in. required theoretically;
12 in. flowed back;
—
48 in. remaining; then $\frac{100 \times 12}{48} = 25$ per cent., the coefficient required.

This coefficient is the addition to be made to the theoretical amount to be pumped from the measuring tank into the timber.

"This must be corrected at intervals not exceeding two days (preferably each day at noon) by taking stock of material used in a given interval and the amount of timber treated in the same interval. These pounds of preservative material divided by the cubic feet of timber treated should correspond to the amount of preservative per cubic foot desired."

In creosoting, the individualities of the timbers treated must be consulted. The method given in the proposed specifications is that long in use in the East, but it is absolutely inapplicable to Douglas fir.

With Douglas fir, our standard method of treatment is to run the trucks into the cylinder, close the door, fill with creosote (120 degrees to 140 degrees Fahrenheit), open up the vents and allow the vapors to pass out under atmospheric pressure through the condenser, which is only for use in measuring the rate of vaporization and recovering a certain amount of light oil which is carried over mechanically during the process. When the timber is properly dried, fill the tanks with creosote, close the vents, and put on pressure, injecting oil from the measuring tank.

At our works in Texas we use the method outlined by the Committee, heating the oil up to 170 or 180 degrees Fahrenheit before admission.

A standard analysis for the oil is much to be desired, but we do not know that there is one.

Mr. E. O. Faulkner (Santa Fe—by letter):—In regard to the proposed specifications governing method of piling ties before treatment, as also the several different forms of the treatment itself—it seems to me the Committee is undertaking quite a task in attempting to frame specific rules governing these matters in such a wide territory as that covered by the Association, and they probably will not be followed excepting where they agree with local conditions or practice.

Take the question of piling ties to start with; we have given some attention to this matter, and for that reason fully realize its importance, but find that for the climate and woods of Eastern Texas, where the rainfall is heavy, and at certain seasons of the year the atmosphere very warm and humid, the form most suitable there is not suited to the climate and woods of the Rocky Mountain region. In East Texas our ties are hauled to the right-of-way, inspected and brought into the Somerville storage yard as quickly as possible after making, and there piled on the 1x8 plan, so as to give the best opportunity for quickly drying out and for the rain to fall off. We tried the same plan in New Mexico, but found the hot sun and dry air seasoned the outside of the ties so fast that they checked badly, so we make piles 7x7, with the outside ones on edge where the shape will permit, just as suggested. In the case of cypress ties, we pile them as solid and close as possible in order to hold the water or sap in the wood. As to the time of drying; this, too, depends somewhat on local conditions. Accompanying this letter are some blue prints of ties we have been testing for piling and length of time in seasoning before and after treatment (Burnettized) at Bellemont, Ariz. On Fig. 6 the difference is shown between the time of seasoning in the summer months as compared with the winter, where ties cut in June had lost 33.1 per cent. of their weight in the first 30 days and in the next 90 the total additional loss in weight was only 1.6 per cent. In Figs. 7 and 8 I do not think we got absolutely green ties. Now compare these with Fig. 5 for ties cut in December, and it will be seen that they were held six months before the loss in weight equaled 30 days in Fig. 6, and, further, that until the warm spring days, practically no decrease in weight occurred after the first month. The prints have not been carried past October, but there is sufficient on them to show the different conditions that govern in this country of ours, and, in my opinion, each one must work out his own salvation, as we are trying to do. It is not much trouble or expense to make these tests, and they beat working in the dark. I think if the Committee will urge and encourage the officials of roads in different parts of the country to do a little investigation on their own account, it may in the end produce better, if not quicker, results than trying to get them to adopt something which may not fully suit their conditions, and concerning which they really do not appreciate the importance.

Before discussing the various treatments, let me say there is one feature the Committee has not touched upon, that I think is equally, if not more, important, than the seasoning ahead of treatment, and that is the seasoning after treatment where a water solution is used. If we expect the best results out of treated inferior woods, we must give them a fair show, and this is not done in putting them in the track just as soon as they are received after treatment, when they have probably 70 or more pounds of water in each tie; and when some of this water will squirt out as the spike is driven. What can one expect from a soft pine tie under such conditions but rail-cutting, loose and damaged spikes and unsatisfactory service? A year ago one of the leading roads in the West wrote our people in Chicago that they noticed their treated ties were corroding spikes, and asked for our experience; the matter was referred to me, and after full investigation I reported that, in my opinion, where the ties were allowed to properly dry out before insertion, the damage from corrosion was scarcely noticeable, but where the contrary was the case, then some corrosion took place; but, even then, nothing like so serious as to give concern. The doctors said that for certain chemical reasons this could not be, but as I produced both corroded spikes and tie-plates, I heard no more about it. Now that so many roads are using Burnettized or Wellhouse ties, special attention should be called to the necessity of seasoning after treatment, even if more ties are ordered to admit of this, as I believe it would pay good interest on the investment.

Now as to treatments; as the Committee knows, we are adopting the Rueping process at Somerville, while continuing Burnettizing in New Mexico and Arizona. We use half a pound of dry zinc-chloride to the cubic foot; the Southern Pacific uses a quarter of a pound; the Union Pacific four-tenths; the Great Northern, I believe, something over a pound. I hardly think these roads will change their methods simply because the Committee says half a pound is the correct quantity. If the Committee is going into this subject, I would suggest that it be in the nature of a recommendation rather than as an absolute proposition, as being more likely to produce results, but if it does not, then the Committee is in a better position than otherwise. Twenty pounds steam pressure is provided for; where cylinders are well jacketed, this may be sufficient, but where they are not, I think allowance should be made for local conditions, outside temperature, etc. From one to five hours' steaming is laid down, depending upon the character of the timber and its conditions; would this be sufficient in the case of Oregon fir? I do not know, and have asked the Government officials if they have any tests on Pacific Coast timbers, but they say not. The period covers the time of our steaming, as we pile the timber long enough for good seasoning beforehand; but, as I said before, I have also shown there are portions of the year where 90 days does not accomplish much. The Committee also stipulates that the solution should be heated to 140 degrees; is there any special significance in this temperature, or is it simply such as might be expected to accomplish results? It is possible in some of the oldest plants there are no heating coils in the cylinders, neither thermometer flanges, nor sap drums, and I believe the Committee should recommend that in any new plants hereafter put up these appliances should certainly be provided; it would probably be done in any case, and this would emphasize the importance.

Creosoting Treatments: One hundred pounds pressure is required; this is seldom necessary in the case of loblolly pine with 10-lb. treatment, as the wood will take up almost that quantity under the vacuum; it would be better to say the pressure must be continuous and such as will give the desired absorption. I also think the timber should stay in the cylinder long enough after treatment to take care of the drip, and that the final gage reading should not be taken until after this has been forced back. I would not allow anything like ten per cent. water in the oil before having steps taken to reduce it; I believe with proper appliances it is quite possible to keep it out, and for this purpose would require a sap drum under the cylinder to take care of any water or condensation at the end of steaming and vacuum periods. I think the working temperature of 140 degrees is too low and that it should be at least 175. I saw a sample of oil sent in by a treating plant for analysis, which showed that it began to solidify at 153, it being fully liquid at 160; I know this is an extreme case, but I think 140 is too low. Again, in creosote, where the treatment is in weight per cubic foot and the tank gage shows gallons, the weight of the oil per gallon is an important feature, especially as creosote expands, so that a gallon at a low temperature weighs more than it would at a higher temperature; sometimes more than half a pound difference, which, on a 10-lb. treatment, equals five per cent. In our commercial treatment we therefore require the temperature of the oil to be taken at time of forcing it into wood, and after forcing back; then strike an average of the two in case there is any appreciable difference.

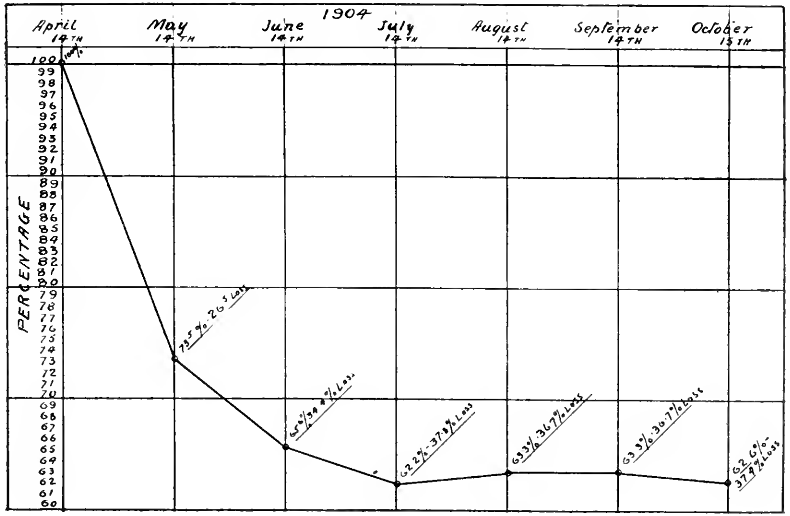


FIG. 1-A—BEFORE TREATMENT.

Diagram showing loss in weight of 7x8x8 sawed ties piled at Bellemont, Arizona, for seasoning. Wood—Mountain pine, piled 1x11, April cut. Heavy rains almost every day during August and up to middle of September.

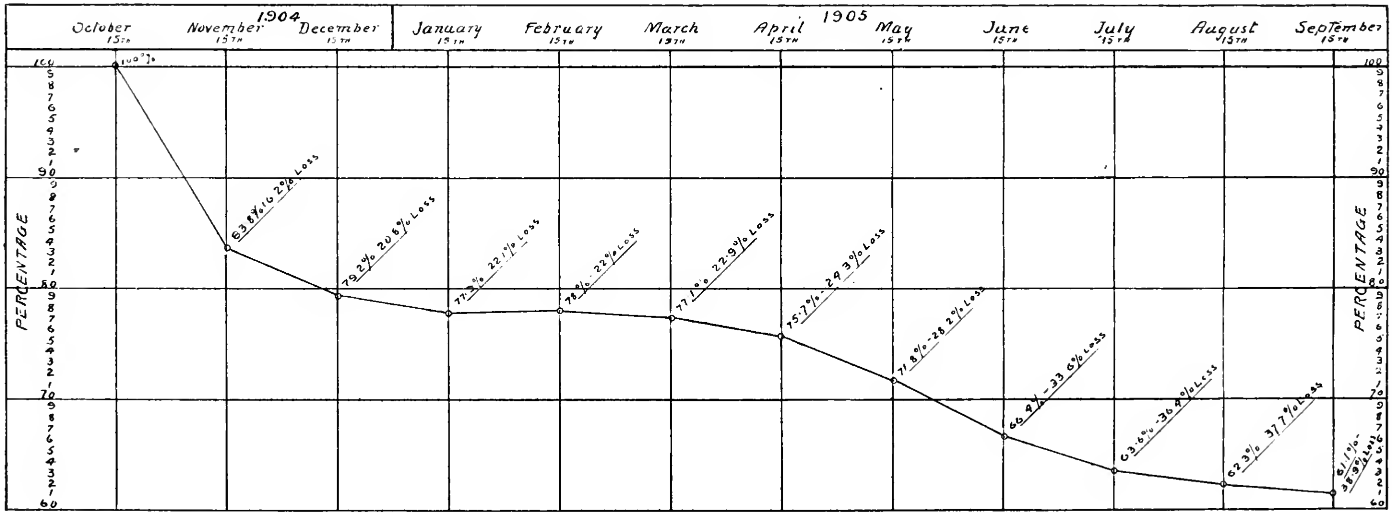


FIG. 1-B—AFTER TREATMENT.

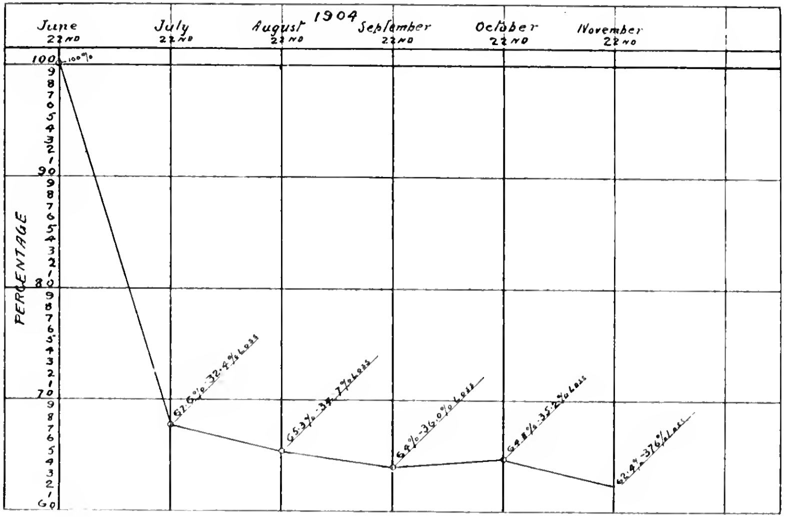


FIG. 2-A—BEFORE TTEATMENT.

Diagram showing loss in weight of 7x8x8 sawed ties piled at Bellemont, Arizona, for seasoning. Wood—Mountain pine, piled 1x11, June cut, taken out of same car as Fig. 3.

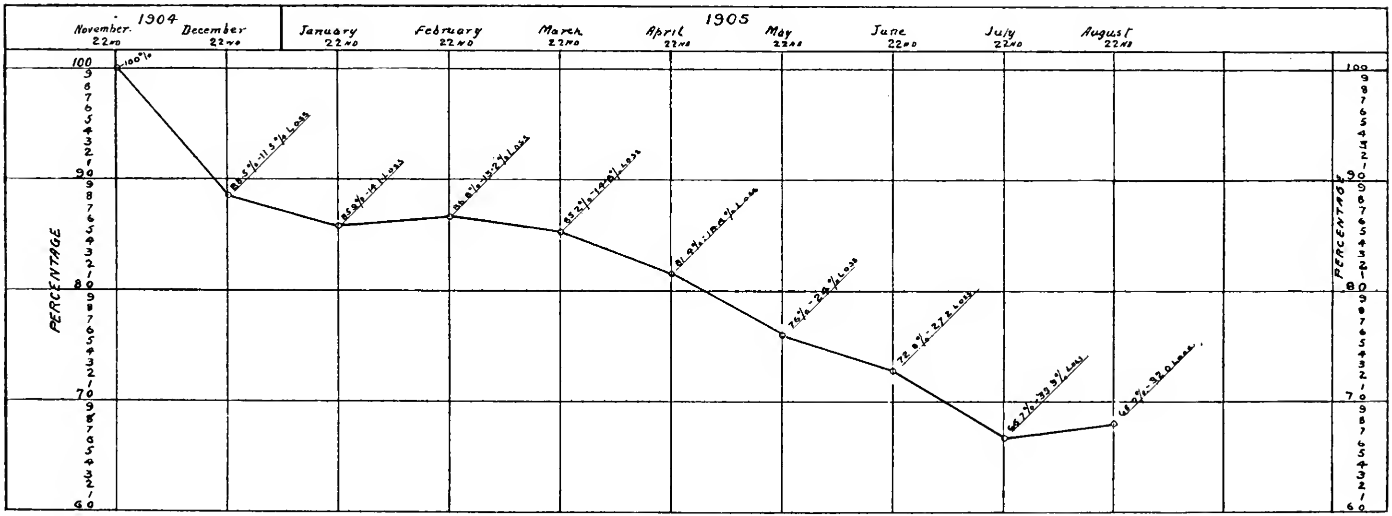


FIG. 2-B—AFTER TREATMENT.

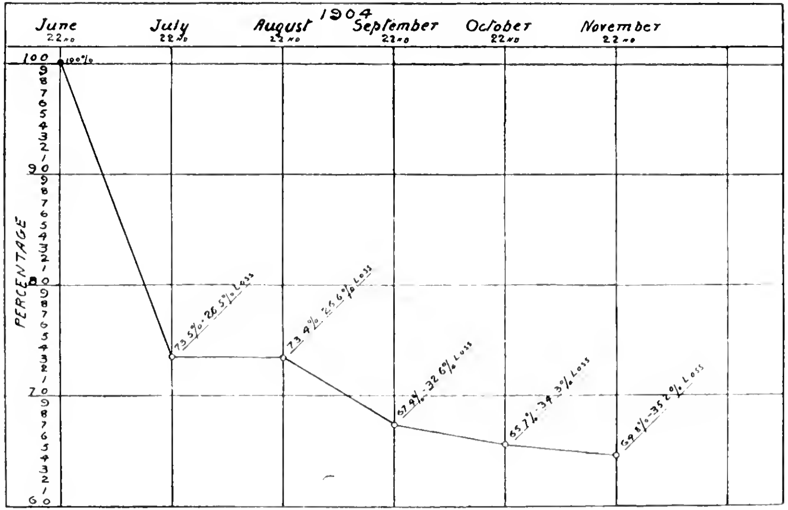


FIG. 3-A—BEFORE TREATMENT.

Diagram showing loss in weight of 7x8x8 sawed ties piled at Bellemont, Arizona, for seasoning. Wood—Mountain pine, piled 12x12, edged; June cut, taken out of same car as Fig. 2. Showers nearly every day from latter part of July to middle of September.

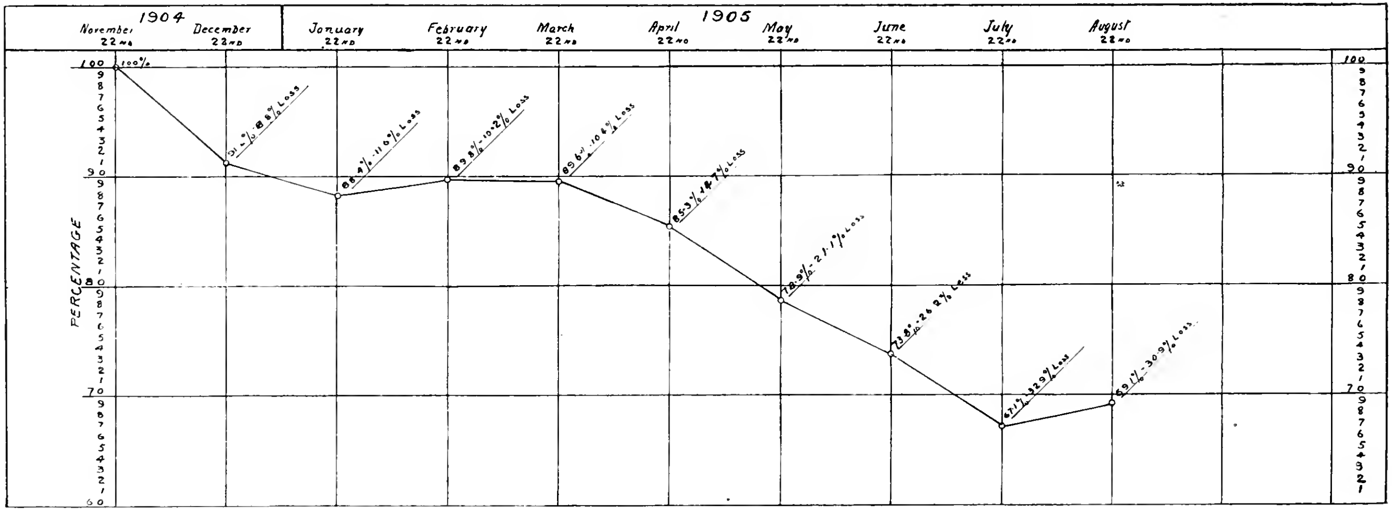


FIG. 3-B—AFTER TREATMENT.

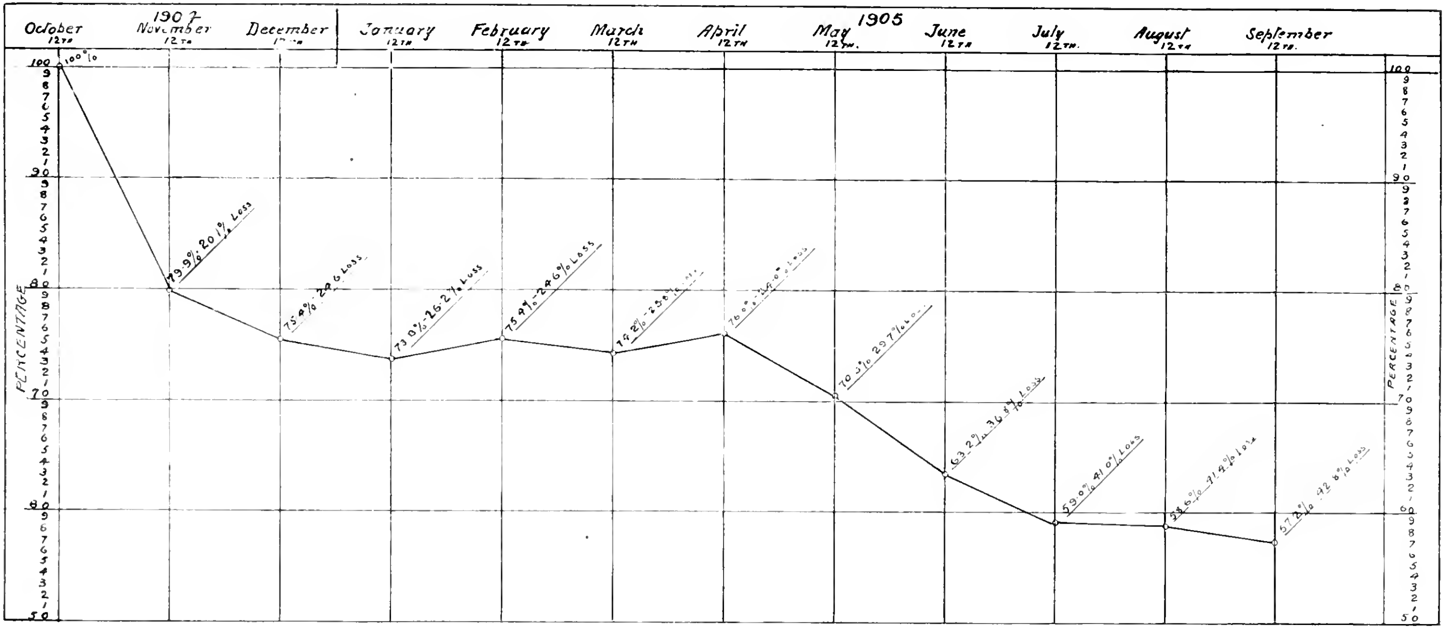


FIG. 4-A—Fifty hewn mountain pine ties, seasoned in yard three months; drained five hours after treatment, and before weighing. Weight: before treatment, 2,642 lbs.; after treatment, 5,015 lbs.; increase in weight, 90 per cent.; 18 ties piled 2x7.

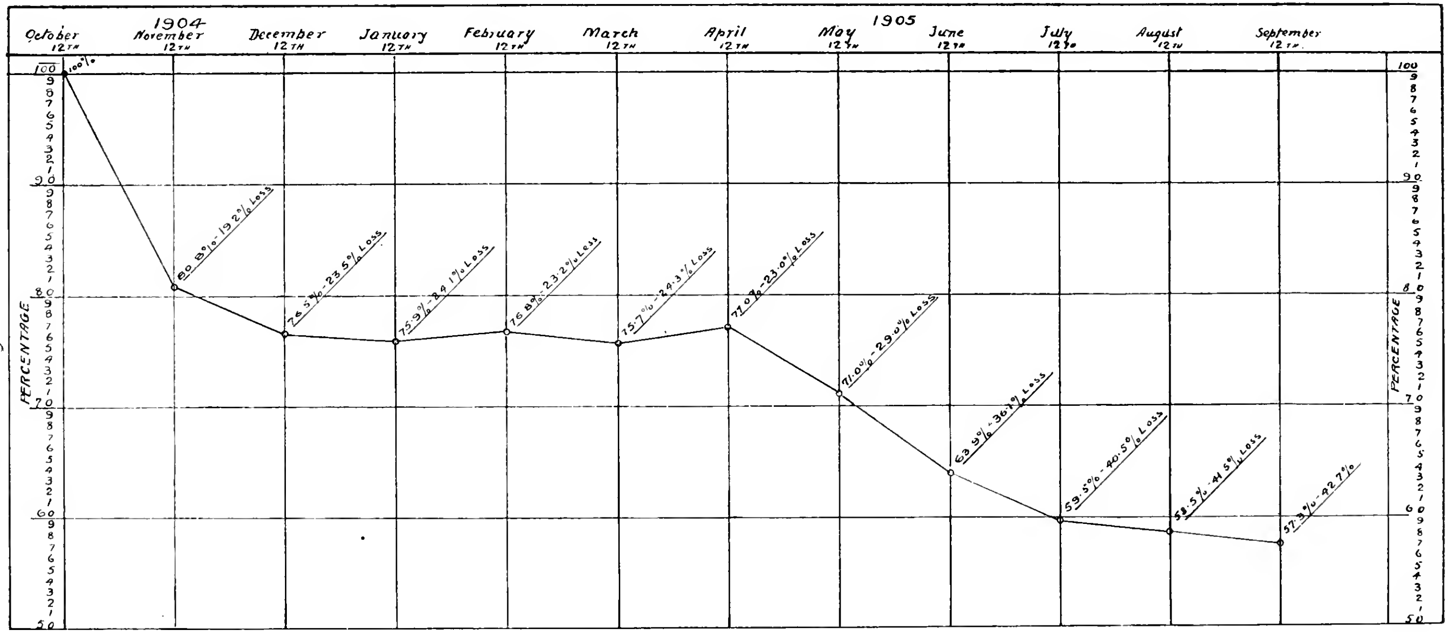


FIG. 4-B—Weight: before treatment, 2,848 lbs.; after treatment, 5,454 lbs.; increase in weight, 91.5 per cent.; 20 ties piled 7x7 edged.

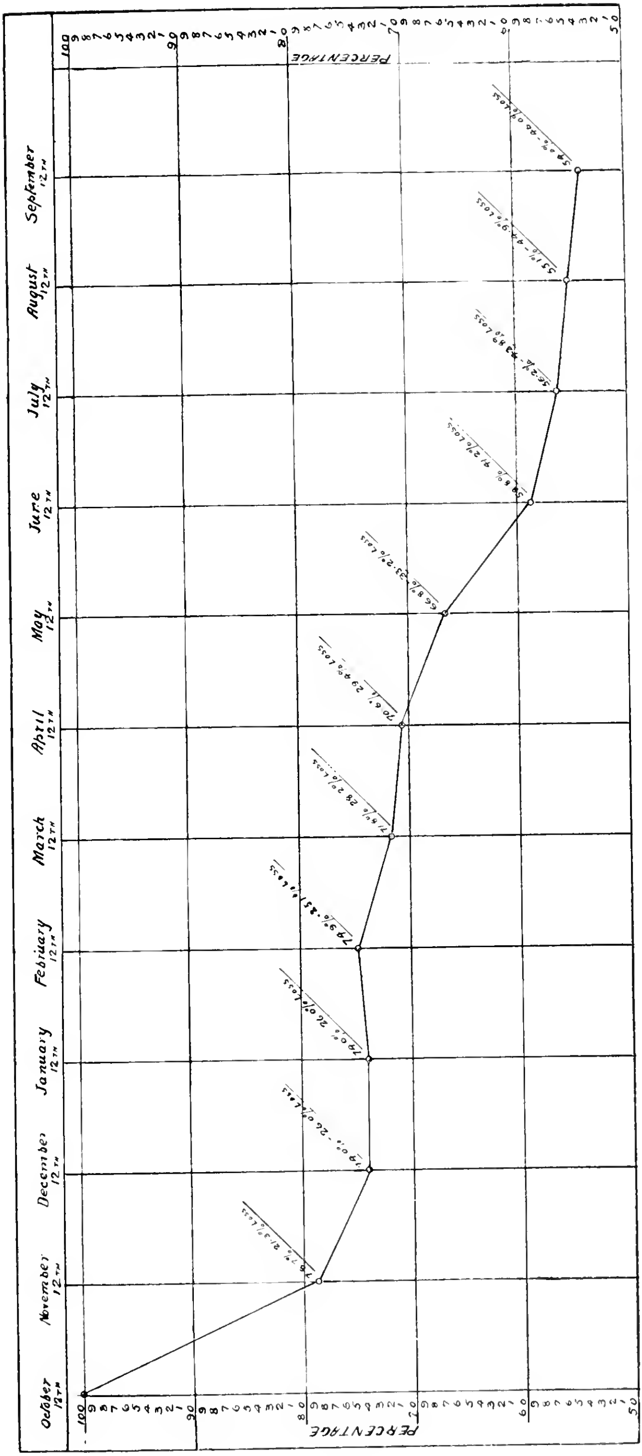


FIG. 4-C—Weight: before treatment, 1,440 lbs.; after treatment, 2,776 lbs.; increase in weight, 91 per cent.; 12 ties piled triangular.

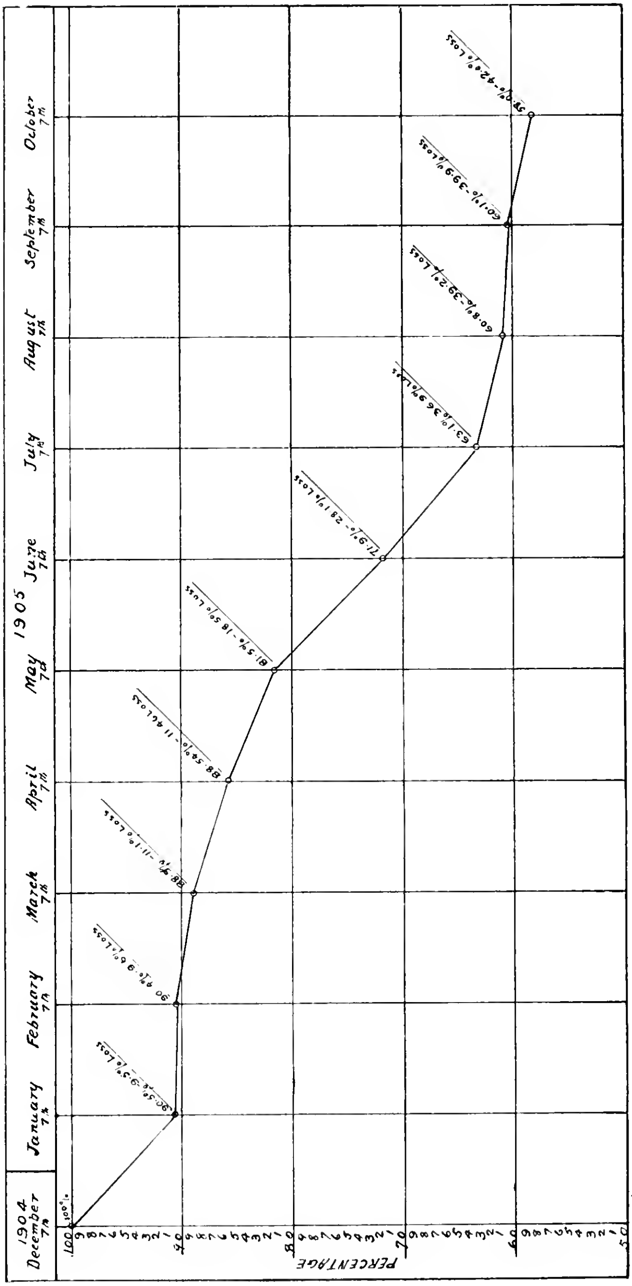


Fig. 5—Fifty hewn mountain pine ties, made November 28, 1904; received and weighed December 7, 1904. Weight, 11,925 lbs.; piled 8x8 edged.

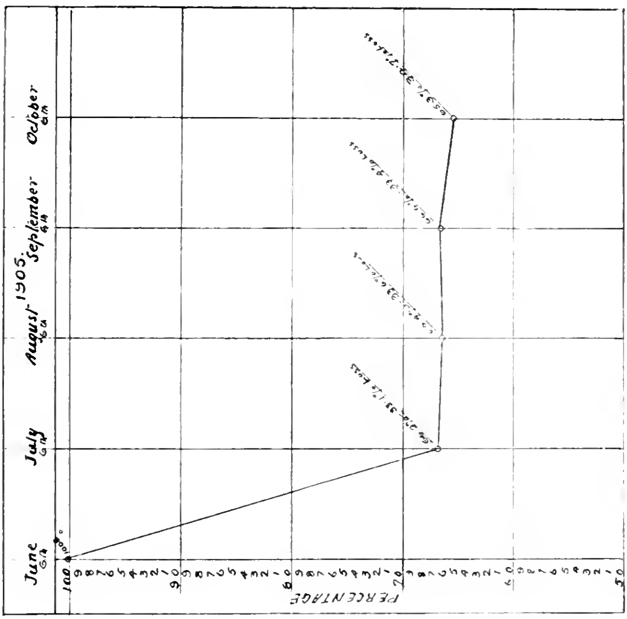


Fig. 6—Fifty hewn native pine ties, made June 2, 1905; unloaded and weighed June 6, 1905. Weight, 11,914 lbs.; piled 7x7.

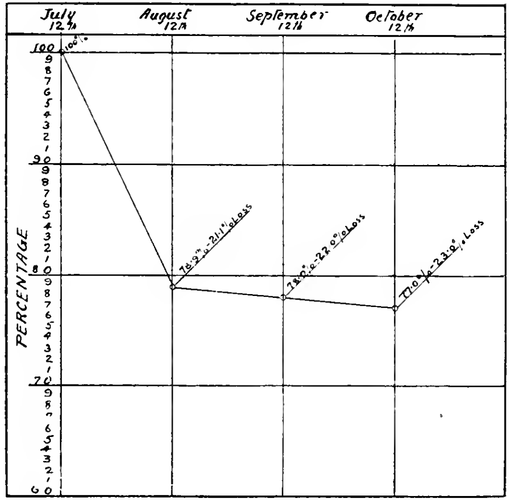


FIG. 7—Fifty hewn native ties; loaded July 8, 1905; received and weighed July 12, 1905. Weight, 9,352 lbs.; piled 7x7. (Sent in as green ties.)

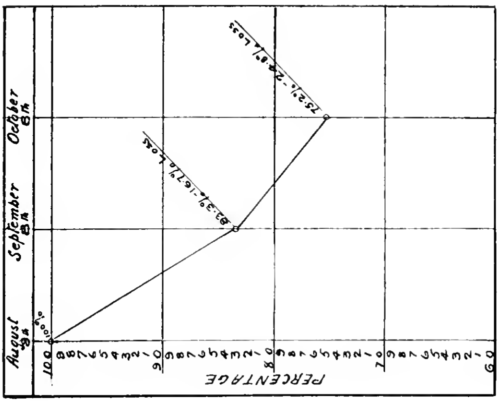


Fig. 8—Fifty hewn native ties, loaded August 3, 1905; received and weighed August 8, 1905. Weight, 11,184 lbs.; piled 7x7. (Shipped green.)

Mr. H. R. Safford (Illinois Central—by letter):—I have given the subject of proper size and spacing of track ties very careful consideration and endeavored to find some formula or basis for determining the proper spacing of ties, with due consideration to the various types of ballast, wheel load and the economical maintenance of good line and surface.

Unforunately, no data seems to exist to show the supporting power of ballast per unit of area, neither is there much definite data to show the economical spacing of ties, as far as actual track maintenance is concerned, although this has been a very much discussed subject among railroad people, and I think we will, therefore, have to take the practice of a long period of time upon our high-class tracks as a basis, and assume a certain number of ties per rail, on good well-drained ballast, as a proper condition, taking as this basis the average practice of the more important railroads.

An investigation which the Committee made last year developed that the general practice was about eighteen 6x8x8 ties to the 30-ft. rail, which means a spacing of 20 in. between tie centers. This spacing may be a trifle greater than some of the heavy tonnage railroads are using, but it will be recalled that our investigation showed this size of tie and spacing was being used on some of the heavy tonnage roads. I think we can safely assume, therefore, that the above is a safe basis for analysis to arrive at some comparative figures. The three features to be considered in this analysis, are:

(1) Proper width of tie for bearing surface under the rail.
(2) Supporting strength of roadbed.
(3) Proper spacing for economical tamping.

The first feature is admissible of considerable discussion, but into it is brought the crushing and breaking strength of the various types of wood, and this introduces so many values into the problem, as far as strength only is concerned, that it would be hardly possible to consider this, and we are forced to rely upon common practice and assume the 6x8 tie is sufficiently strong—as I believe it has always proved to be—for our heaviest wheel load. I think we can assume that we could stand even a narrower tie with safety, but the tendency is to increase, rather than decrease, the width, up to the point where thorough tamping would be difficult.

The second feature, that of supporting strength of roadbed, is readily determined, and it will be found that with from 8 to 12 in. of ballast, and assuming the ballast is tamped for a distance of 18 in. on either side of the rail and distributes the load at an angle of 45 degrees to the roadbed below, that a maximum load of 15 tons per wheel would cause a maximum load on the roadbed of 1.10 tons per sq. ft. This is a low unit for supporting strength of good clay and loam, but on account of the inferior character of material frequently found in the roadbed, we are obliged, of course, to assume a very low value for bearing strength. It can be assumed that track surfaced on dirt above the natural roadbed would transmit the load to the roadbed through the dirt upon which the tie is tamped in about the same manner that it would be transmitted through the ballast, and the character of ballast can, therefore, be eliminated, and for the purpose of this discussion be considered only as a means of keeping good line and surface with the least cost, and causing a rapid drainage of water falling thereon.

The third feature, that of proper spacing for economical tamping, is one that has considerable bearing, and yet its value does not vary with the different character of rail and roadbed, as it is largely a matter of convenience in handling tools and getting the entire surface of the tie tamped, and the necessity for tie spacing, as far as this feature is concerned, is the same for all character of ballast and all sizes of rail. It would seem, therefore, that we must, in order to eliminate as many factors as possible, come down to the consideration of rail section and wheel load, and for the purpose of comparison I have worked up the spacing on the following basis, assuming three different characters of railroads, as discussed at previous meetings, viz.:

(1) Maximum axle load, 18 tons on 56-lb. rail.
(2) Maximum axle load, 22 tons on 65-lb. rail.
(3) Maximum axle load, 30 tons on 85-lb. rail.

Taking the matter of fiber stress of the rail; it is found that, upon the assumption that the spacing of 18 ties to the rail is correct for Class 3, the spacing for the other two classes would be 23 ties for Class 1 and 20 ties for Class 2, or $14\frac{5}{16}$-in. and $17\frac{1}{2}$-in. centers. This shows up one of two things: either that we are using too many ties per rail for our high-class track or not using enough for our low-class track. Without considering any other features, this comparison should be correct, but into the discussion must be introduced the question of cost of maintenance, or, briefly, section force and speed of trains and the character of track to be maintained as far as line and surface is concerned.

It is, of course, not the experience of any of us that the tie spacing computed on the above basis is necessary, and little value would seem to be attached to such a result, because we know that we do maintain low-grade track on 18 and 19 ties per 30-ft. rail. The result, therefore, has largely shown us that, while for uniform speed conditions, and other conditions entering into economical maintenance, we should maintain a different spacing, and that we could safely reduce the number of ties per rail under our heavy tonnage, it would not seem desirable to do so. The result does show us that we have been working on the safe side on our tie spacing for our high-grade track, and it would seem as though we could safely recommend a reduction of ties per unit of length for such track and establish more nearly a relationship between the various classes of track, as shown by results above determined.

I am inclined to think that even with the inferior character of track, that it might represent a saving to get a tie spacing of 20 ties per 30-ft. rail, and that a better arrangement all around might be a spacing of 17, 19 and 20 for the three classes of track.

It seems to me we cannot, with any practicability, introduce any more elements into the problem, as we will find ourselves at sea when it comes to reconciling them as far as trying to establish a formula that will take all of these features into consideration, and that about all we can safely consider is rail strength and supporting strength of roadbed.

DISCUSSION.

The President:—In the absence of the chairman of the Committee, the vice-chairman, Mr. W. W. Curtis, will present the report.

Mr. W. W. Curtis (Consulting Engineer):—The report of the Committee presented at the last annual convention, not having been discussed, I will call attention to certain things. In that report the Committee recommended the adoption of certain definitions; that the specifications for ties, as amended, be adopted; that the rules for tie records be adopted; that the method of stamping, in addition to the use of the dating nail, be adopted; and also that ties treated with mineral salts be seasoned from four to six weeks prior to being laid in track. In the present report, besides embodying the points just mentioned that have not yet been acted upon, we have made a recommendation as to the standard size of ties; resubmitted the specifications for ties, with corrections and several additions; amended one or two definitions and resubmit those which have not been acted upon. We resubmit the rules for marking ties and the specifications for dating nails. We also submit for discussion, but not for adoption, specifications for various treatments of ties. The conclusions, found on page 8, on which the convention is asked to take action, are: (1) That the specifications for ties, as amended, be approved; (2) that the definitions submitted herewith be approved; (3) that the specifications for dating nail be approved; (4) that the rules for tie records be approved; (5) that the standard tie be 7 in. by 8 in. by 8 ft.; (6) that the specifications for tie treatment be discussed and referred back to the Committee for further consideration.

The President:—The chair desires to say that in the specifications for ties, under the heading "Woods to be used untreated," the Committee has added the words, "excepting the white cypress," after the word "cypress." After the word "Locust," the words "excepting the honey locust" have been added. At the end of the list of woods to be used untreated, "Black Cherry" has been added.

In the paragraph on "Dimensions," the words "or in half-round ties" have been added on the first line; on the second line, the words "width of" have been inserted.

Under "Allowable Variations," the words "sides and half-round ties, the width of" have been added in the first line, and in the last line of the same paragraph "width of" has been inserted.

In the table of dimensions, the heading of the second column has been changed to read, "Thickness by Width of Face." In the same table, classes F and G have been omitted.

In the paragraph headed "Piling of Ties," the words "and date when piled" have been added to the sentence reading "Each pile must be plainly marked with the owner's name." The following sentence has been added to the paragraph: "Sawed ties must be piled separately from hewed ties."

A new paragraph has been added, reading as follows: "Piling Treated Ties.—Ties treated with a water solution, like zinc-chloride, particularly red oak and beech ties, must be piled in close piles on well-drained ground, to prevent checking."

If there is no objection to the above amendments to the specifications for ties, they will be considered as having been approved.

Under the rules, discussion in regard to definitions will be omitted, but will be carried on by correspondence with the Committee. If there is no objection, conclusions 1 and 2 will be considered as adopted. The next is conclusion No. 3. The chairman of the Committee asks that the specification for dating nails be read.

The Secretary:—"SPECIFICATIONS FOR DATING NAIL.—Material.—The nail shall be ¼-in. in diameter, 2½ in. in length, with head ⅝-in. in diameter, having stamped therein two figures designating the year; the figures to be ⅜-in. in length and depressed into the head $\frac{1}{16}$-in., made of iron or steel, galvanized with a coating of zinc, evenly and uniformly applied, so that it will adhere firmly to the surface of the steel.

"Test.—Any specimen shall be capable of withstanding the following test: The sample shall be immersed in a standard solution of copper sulphate for one minute and then removed, immediately washed in water thoroughly, and wiped dry. This process shall be repeated. If after the fourth immersion there is a copper-colored deposit on the sample or the zinc has been removed, the lot from which the sample was taken shall be rejected.

"Chemicals.—The standard solution of copper sulphate shall consist of a solution of 34.5 parts of crystallized copper sulphate in 100 parts of water. This solution will have a specific gravity of 1.185 at 70 degrees Fahrenheit. While a sample is being tested, the temperature of the standard solution shall at no time be less than 60 degrees Fahrenheit nor more than 70 degrees Fahrenheit."

Mr. Edwin F. Wendt (Pittsburg & Lake Erie):—That is a very good specification. However, we have been using copper nails on our road for the last three or four years with somewhat the same result as is stated by the gentleman from the Pennsylvania Lines whose letter is printed on one of these pages. The reason for selecting the copper, after having used the galvanized steel nails, was this: In the industrial districts we found that the galvanized steel rail would not last. This was due to the fact that the figures were raised instead of being depressed. I think this specification covers that point, it requiring the figures to be depressed. I think that galvanized nails of this dimension are all right, when the figures are depressed, and when the coating will stand the test which this specification prescribes.

The President:—Unless there is objection, conclusion No. 3 will be considered as having been adopted.

The Secretary:—"RULES FOR TIE RECORDS.—Section foremen will be provided with daily record blanks having space for each day of the month to record the number of treated ties put into track that day and the number taken out the same day, the latter being according to the cause necessitating their removal, whether rotten, broken, burned or rail cut. They must also show the year in which these ties were treated as indicated by the stamp and by the dating nail. The section foremen must make these records each day, and at the end of each month the daily record must be forwarded to the proper superior officer. If no treated ties have been taken out or put into track during the month, section foremen must so note on report.

"Treated ties already in track, but taken up and relaid on another part of the same section, need not be inserted on this report as ties taken out or put in.

"Section foremen must see that a dating nail is driven in the upper side of every treated tie when it is first laid in the track, about ten inches inside of the rail, and on the line side of the track. The tie shall be laid with the end having the year stamp on it on the line side of the track. A supply of these nails must be carried on the hand-car whenever any ties are to be laid, and dating nail must be driven the same day the tie is put in.

"Foremen must be especially careful to see that neither they nor their men injure or destroy the marks or nails intended to identify the ties.

"At the end of each year all dating nails for that year remaining on hand and unused must be returned to the storekeeper, and requisition made for a new supply stamped with the following year.

"It is recommended that, in addition to the use of the dating nail, each tie be stamped at the treating plant, before treatment, with the year; and, preferably, be stamped on both ends.

"Conclusion. (4) That the rules for tie records be approved."

The President:—You have heard the reading of the conclusion and of the "Rules for Tie Records." Unless there is objection, they will be considered adopted and incorporated in the Manual of Recommended Practice.

Mr. John V. Hanna (St. Louis & San Francisco):—I would like to ask a question about the location of the dating nail. It is required to be placed on the inside. What led to that conclusion? It seems to me it would be better to place it on the outside.

Mr. Curtis:—That is a matter that has been discussed by the Committee. This is simply a statement of what we think is the most general practice and what we believe to be the better practice. If the nail is placed on the outside of the rail, it is where the tie is first injured and decays. The point is to place it where it will be accessible, where it will be seen, and where it will be the least likely to be injured and the most likely to remain. We selected for that purpose a point on the inside of the rail and far enough away where it is not apt to be injured by trackmen and still not likely to be covered with ballast. I think that the location recommended is the one most generally used to-day. If there is any good reason or a better reason for the other practice, that is a matter the convention, I think, would like to have light upon. The President also calls attention to the fact that it places it away from the salt water dripping from refrigerator cars.

The President:—There being no further discussion, the conclusion will stand approved.

The Secretary:—"Conclusion. (5) That the standard tie be 7 in. by 8 in. by 8 ft."

Mr. C. H. Ewing (Philadelphia & Reading):—I want to interpose an objection to the standard size of ties as proposed. I think I noted in one of the Bulletins published that on account of the scarcity of ties and the increase in price, the standard size recommended was 7 in. by 8 in. by 8 ft. I do not think that this reasoning should apply, in view of the traffic conditions to-day—the increase in weight of locomotives and equipment. I think it would be a mistake for the Association to recommend a tie as small as 7 in. by 8 in. by 8 ft.

Mr. A. K. Shurtleff (Chicago, Rock Island & Pacific):—I do not see why the Association should adopt a standard tie any more than a standard weight of rail.

The President:—This is an interesting and important subject, in view of the variation in the size of ties now in use. There are ties in use 6 by 8 and 7 by 8 and 7 by 10. We would like to hear from Mr. Rockwell of the Lake Shore upon this subject.

Mr. Samuel Rockwell (Lake Shore & Michigan Southern):—We do not think the standard ties—7 by 10 and 8½—are any too large.

The President:—That applies to cedar as well as to oak?

Mr. Rockwell:—No, sir; these are main line ties. We use cedar only for branch lines and for industrial tracks. We find we cannot use cedar even in our large yard tracks. We use, however, 6 by 8 hardwood ties on our branches and on our sidetracks, and, to some extent, on our third and fourth tracks, where the traffic is slow, but not on the main tracks where the traffic is fast. Therefore I think it would be a mistake to commit the Association to ties so small as are recommended.

Mr. Curtis:—I think a word ought to be said on behalf of the Committee. In its report presented two years ago, the Committee submitted a table of dimensions for ties. We were taken to task severely because we had not recommended a standard size of tie. The Committee thought it would be presumptive to make a recommendation of that kind, but some of the members present at that time did not look upon it in that light. This year we were directed specifically by the Board of Direction to take up this question of the recommendation of standard size and in a conference with the Track Committee the matter was very thoroughly discussed. It was then laid over until our second meeting, and at that time we decided to recommend this size. In reaching this conclusion we were guided by several things. It will be remembered that two years ago the Committee made an investigation as to the sizes of ties used by the various roads of the country; whether there was any reason other than sentiment upon which the size of ties was based; whether there was any reason for the belief that a 6 by 8 tie was too small. We also asked if there was any reason for the belief that a larger tie was undesirable. The result of that inquiry was a very large number of replies, representing a good many thousand miles of road. The replies were studied at the time they were received, and were again considered in formulating this recommendation, and we found this to be the condition: A majority of the roads reporting were using a 6 by 8 tie and reported them perfectly satisfactory. In those instances where the 6 by 8 tie was reported as being unsatisfactory, the objections were twofold—one that the tie was too thin for the length of the spike which is now being used, and that consequently after a few years' wear the spike would go entirely through the tie. For that reason we decided to adopt the 7-in. thickness. The other reason given was that the 6 by 8 tie was too light where the ballast was poor, or where there was no ballast. That is a condition that has to be met, but it is not a condition to determine the size of our tie. Nevertheless, we did increase the size of the tie to 7 by 8. The general consensus of opinion expressed in the reports was to the effect that where ballast was good, a 6 by 8 tie was ample for heavy traffic. There is a prevailing opinion that a 7 by 8 or a 7 by 9, or some other size tie, does not cost any more than a 6 by 8, but I think if you undertake to buy any great number on that basis, you will find it is a mistake; especially as we are coming to the condition of sawed ties instead of hewed ties. For these reasons, while we do not urge the adoption of any special size as a standard, and are not satisfied that it is desirable to adopt a standard, we believe the size recommended is the best that can be suggested for general adoption at present

Mr. Chas. S. Churchill (Norfolk & Western) :—The chairman of the Committee has reviewed the reasons as between the 6 by 8 and the 7 by 8 ties, but how about the length as between the 8 and the 8 ft. 6 in.?

Mr. Curtis :—There are two or three objections to the 8 ft. 6-in. tie In the first place, an 8-ft. tie is long enough for good ballast. Another difficulty, when you get into the sawed ties, if your tie is that long, it takes a 17-ft. log out of which to cut it, and they do not cut them that way. They may cut them that way if you tell them they have to, but unless there is good reason for a change, it seems to me it is not wise to adopt a size which will not work in with the present saw mill and lumber practice.

Mr. W. B. Poland (Alaska Central) :—I do not think it is wise to adopt a single standard for a tie. I think it would be as unwise as it would to adopt a single width of roadbed or a standard weight of rail. I think we should have at least two standards. I do not approve of the adoption of the recommendation for a single standard. I would suggest that the matter be referred back to the Committee, and that they recommend at least two standard sizes of ties.

Mr. G. H. Bremner (Chicago, Burlington & Quincy) :—There are three classes of roads we are providing specifications for, and it would seem that in drawing up these specifications for the size of ties, we should specify for each class of road, and should also specify differently for different kinds of wood. The size of tie for oak, for example, is not necessarily a good size for cedar, and in referring it back to the Committee—I second Mr. Poland's motion—I think that they should consider this.

Mr. Rockwell:—We use several different kinds of ties for the several different purposes—main line ties in fast traffic, main line ties in slow traffic, side line ties, yard ties, etc. Our experience is that we need different kinds of ties for almost every kind of use we put them to. While a 6 by 8 tie is all right enough for slow traffic, even where heavy engines are used, if they are of hardwood, they are not good enough on our lines where we have heavy traffic and high speeds, especially with the length of 8 ft. We think we need an 8-ft. 6-in. tie to give stability. But the greatest difficulty that we have in ties is to keep our rail from cutting through them. We find even that tie-plates do not help us very much on softwood ties. We have put in cedar ties in our tracks in large yards with heavy traffic, and they have given out entirely by the rails absolutely pushing the tie-plates right into and partially through the ties within six months, so that we had to take them out. We use a good many oak ties; in fact, we use almost every kind of tie, and we use them with and without tie-plates. Our experience is if you use enough ties you can keep the track up under ordinary slow traffic, but we have found that for stability, under fast traffic, you need 8-ft. 6-in. oak ties.

Mr. G. B. Woodworth (Chicago, Milwaukee & St. Paul) :—It is well-known that one of the greatest difficulties in the maintenance of a good surface in the track is the track getting what is called "center-bound," and that is caused by the bearing between the rails being in a greater proportion than that outside. As I understand, it has been demonstrated by experience that a tie 8 ft. 6 in. long equalizes the bearing, and the depression of the tie in the ballast will be uniform throughout for about that length, or perhaps in some ballast even more than 8 ft. So far as the width of the tie is concerned, it has been my experience, more especially with pole ties and not sawed ties, that an 8-in. face tie is the best tie for all purposes. While it does not give as much bearing surface as a 10-in. tie, it can be tamped better, and you can get the ballast in under it in a more solid condition. My experience has been entirely with 8-ft. ties, so that I do not know how an 8-ft. 6-in. tie compares with an 8-ft. tie; but as I understand from experiments which have been made, the 8-ft. 6-in. tie is the one which equalizes the bearing and should give the best service.

Mr. H. J. Slifer (Contracting Engineer) :—I understand and believe that the Association is on record in favor of three classes of track. Such being the case, I think Mr. Bremner's suggestion to refer this question back to the Committee and that we have three classes of ties, is the natural one to make. We should have a specification for each class of ties for the three separate classes of track which have been approved by this Association.

Mr. Shurtleff:—I do not object to having a specified tie, but I agree with Mr. Bremner and Mr. Slifer in their suggestions, covering the three classes of track; and I also believe that the Committee should state the number of ties per mile for each class of track, because that is equally as important as the size of the tie.

The President:—That would really be a matter for the Track Committee to decide—the number of ties per mile; but the question of the size of ties comes properly before the Committee on Ties. There is a motion that the conclusion in regard to the standard size of tie be referred back to the Committee with the request that they prepare a recommendation to be submitted at the next convention for three sizes of ties to correspond with the three divisions or classifications of track. Is there any further discussion upon this question?

Mr. Curtis:—I want to call attention to the fact that the Committee was struck by this same idea, and made an attempt to work along that line. One member of the Committee suggested that we should have three sizes, or at least that there were three classes of track that should have consideration, and he thought we should be able to formulate a recommendation and specification covering each class of track. We put the proposition up to the various members of the Committee, each one being requested by letter to submit suggestions along that line. There was only one member of the Committee who was industrious or enthusiastic enough to give anything more than a reply that it was impossible. One member did make an attempt to figure it out, with the result which you will find embodied in the report. I think the discussion here has shown pretty conclusively the difficulty the Committee would have in recommending a standard tie which would satisfy the convention. When you have first-class roads using 6 by 8 ties, others using 7 by 10 ties, and some using 8, 8½ and 9-ft. lengths, you are up against a serious problem to get anything like unanimity of opinion. The Committee will be glad to consider any request the convention may make.

The President:—We would like to hear from Mr. McGuigan on this subject.

Mr. F. H. McGuigan (Grand Trunk):—I have not heard all of the discussion in regard to tie specifications, but it has occurred to me that possibly the difficulty experienced by many roads in obtaining ties of any standard has not been mentioned. This seems to be so great a difficulty to-day, that most of us are glad to get ties of almost any dimensions. While I am sure that all agree with Mr. Rockwell that an 8-ft. 6-in. or even a 9-ft. tie would be better than an 8-ft. tie, we are not able to get them. While only a few roads have to provide for speed equal to the

Twentieth Century Limited, most of us have trains that run very fast and require a good, strong, safe track; therefore it would, in my opinion, be unwise, under existing conditions, for this Association to go on record as prescribing any specific size of tie as a standard. I have in mind now a railroad that receives a considerable number of ties so small that the face is only 4 in. wide, and I do not believe we would want to adopt any standard here that might result in sending the engineer in charge to jail for using such small ties, as they are bought at certain times when it seems especially necessary to buy ties in certain localities. The road I refer to is one of those government-owned roads we hear so much about. Having bought them, the engineer in charge of maintenance must certainly put them in the track. I think it would be wise to leave this question open.

Mr. Rockwell:—I want to say, in answer to Mr. McGuigan, that 7 by 10, 8-ft. 6-in. ties are standard sizes down around the Ohio River, and there is not much difficulty in securing them of that size. They are quite frequently made 7 by 9, to be sure, and we are pretty apt to get the same tie, whether they are called 7 by 9 or 7 by 10. That size tie is the standard down in that locality, and the Pennsylvania Railroad and the Lake Shore, I think, have done a great deal toward making it standard, and there is no difficulty as yet getting that size down in that section of the country. Perhaps there is some difficulty in obtaining that size of tie in some other parts of the country.

Mr. A. S. Baldwin (Illinois Central):—I suggest that the Committee might well recommend an ideal size of tie, leaving it to the railroad companies to approximate as closely as possible to that size. As a matter of fact, the size of the tie is governed by commercial conditions, and those conditions probably are not in line with what would be the most desirable size. To illustrate, on the Illinois Central we have the 6 by 8 tie on the Northern divisions; on one division we have 7 by 9, 8 ft. 6 in. in length. We use a smaller size on the Northern divisions, not because we would not prefer the larger tie, but because we cannot get them. In the far South, where the roadbed is softer, we use some ties which are 9 ft. in length. I understand that the Louisville & Nashville use ties as long as 10 ft. As the timber has become more difficult to get, it has been a matter of necessity to reduce the size of the ties, but the time is coming when we will have to begin to treat all ties used, and when that is being done, we will go to the sawed tie and return more nearly to what is the ideal condition as to the size of the tie. We will then certainly be in much better shape to do that. I believe if the Committee would suggest a size of tie that would be an ideal one, so far as giving a sufficient amount of bearing area and a proper length, that would give the railroads a standard to work to, and they could approximate this standard as closely as possible.

Mr. R. C. Barnard (Pennsylvania Lines):—If the convention thinks it should go on record as to size of tie, it might be well to adopt this fifth conclusion as a minimum size for main track use, and let a road use one as much larger as it wishes. Let the Committee state what they think is the smallest tie that should be used in main track.

The President:—The expression of the Association upon this subject may have far-reaching effects, and the chair would like full discussion and careful thought before the vote is taken. All in favor of referring the conclusion back to the Committee for further report, giving three standard sizes of ties corresponding with the three classifications of track, will place say aye; contrary, no.

(The motion was carried.)

The Secretary:—"Conclusion. (6) That the specifications for tie treatment be discussed and referred back to the Committee for further consideration."

O. Chanute (Consulting Engineer—by letter):—The writer believes that it is unwise for the Tie Committee to attempt to specify minutely just how ties shall be seasoned and be treated by the various processes. As pointed out by Mr. Kruttschnitt, no one method of treatment can be prescribed that will suit all kinds of timber, and it may be added that the same kind of wood requires modifications in the treatment in accordance with its condition of seasoning. As shown by Mr. Faulkner, the time required for drying depends upon local conditions. Foreign roads specify the dry weight per cubic foot as the pre-requisite for treatment.

It is suggested that it would be preferable for the Tie Committee to give to the tie users some more information as to the comparative economical value of the preserving methods under various conditions. Tie-preserving is yet in its infancy in this country. Many railroads are still hesitating whether to resort to it or not, and they probably want to know, among other things:

(1) *Which process it is best to begin with.* This is governed by the circumstances of the case; not only by the average life to be safely expected from any one process and by its cost, but also by the cost of the untreated tie, justifying more or less expenditure. Moreover, if the tie is to be finally destroyed by rail cutting, the better and more expensive process may not be the most economical.

(2) *What quantities of the antiseptic to inject.* This is governed by the climatic conditions and exposure. In regions of heavy and frequent rainfalls larger quantities are needed of the soluble salts. For instance it is understood that the Southern Pacific Company injects one-quarter pound of dry chloride of zinc per cubic foot. This is good practice for arid regions, such as Southern California and Western Texas, but it may be bad practice for Eastern Texas and for Oregon, because of the greater rainfall, each shower of which washes out some of the chloride.

As to creosote, foreign experience is the more reliable; yet, investigations on the line of the Houston & Texas Central Railroad and of the Central Railroad of New Jersey might possibly elicit some facts of value.

(3) *What doses of different antiseptics are equivalent to each other.* The principal antiseptics now used in this country are creosote and chloride of zinc. It is clear that a very small dose of the former, say half a pound to the cubic foot, will not give as good results as an equal dose of dry chloride. There is probably some point at which the dosings are equivalent, and this needs be known before determining the economy of those differing processes.

It is conceded that the inquiry suggested will be arduous. It will involve investigation into the average life and exposure, not only of the ties treated since 1885, but also of the quantities of antiseptics injected therein. It is a hard task. The Tie Committee will have the sympathy of the writer, and, if desired, his assistance, in case it undertakes it.

The President:—The Committee would like some discussion upon this subject and then have it referred back to them. Is there any discussion upon the subject of treatment of ties?

Mr. John V. Hanna (St. Louis & San Francisco):—The Rueping process is one of the creosoting processes.

The President:—This only refers to the general specifications for treatment; the different processes will come up later when the Committee report further. If there is no further discussion upon the conclusion, it will be referred back to the Committee for further consideration. The Committee desires that the report on methods of analysis of creosote oils be referred back to them. It had been the intention to refer this to a sectional meeting to-night for those interested in the subject—which is a purely technical or commercial question, you might say—but the Committee believes it would be better to have that particular subject referred back to it without any action at this time. The information, of course, is placed before the Association at length in the report of the Committee.

If there are any members of the United States Forest Service present, the Committee and the Association would appreciate very much any remarks they desire to make which will add to our knowledge upon this subject.

Mr. Carl G. Crawford (Chief of the Section of Wood Preservation, Forest Service, United States Department of Agriculture):—Mr. President and Gentlemen: I do not know that I have anything to add to the discussion this morning, but this subject, especially as it pertains to the utilization of our forests, is of very great interest to me personally, and to the Forest Service in general.

There are to-day but very few large companies or corporations which are not more or less interested in our timber supply. To some of these it is a matter of very great concern. The bountiful supply of the past is no longer at hand, that supply having consisted of the best species and the best grades which any country has ever known. A lack of plentifulness, especially of our best grades, has for some time been noticeable. It is this particular point which interests us the most and we are very anxious that we shall be able to do something to check this rapidly growing decrease.

The present condition has been brought about largely by the rapid depletion of our forests through the employment of wasteful methods in lumbering, wasteful methods in manufacturing the lumber into usable products, and especially by a lack of proper methods in making our lumber products serve their longest, and, therefore, greatest usefulness. This condition of affairs is causing many of our large companies and corporations to seek information as to the best method of saving that which we now have and putting each class of timber into its proper and most useful place.

This uneasiness, as might be expected, since they are among the largest users of wood in our country, is nowhere more noticeable than among railroad men. Purchasing agents are asking the question, "Where are we going to get our future supply of timber," and by this they mean the very near future, since those species which they have been using in the past are no longer at hand. It is well-known that our present supply will not last long unless something can be done to change the present conditions and not permit the timber to be used in the future as it has been used in the past.

The essentials for a good railroad tie are few as compared to the essentials in wood for other purposes. These essentials are mainly durability, resistance to the cutting action of the rail, and ability to hold the spike firmly. The last two can well be classified as one, requiring a timber with a long, tough fiber. The Forest Service has for some time been endeavoring to obtain information which will increase these characteristics and thus lengthen the period of service of the cross-tie, and to this extent stop the growing decrease of our present supply.

I am not prepared to say just what is the present average life of the cross-tie; perhaps somewhere between four and six years. Some things have been done to increase this length of service while many things have been done to decrease it. The crushed-stone roadbed, the use of the tie-plate, and even the small percentage of ties which have been treated have helped to increase this length of life. While on the other hand, the increase in the heavy traffic, the poorer condition of the ties —due to the small supply—which have been put into the track, and the increased scarcity of better grades and species, have tended toward decreasing this length of life. Something more must be done if this supply of timber is not to be greatly decreased.

So long as the timber supply of our country is held very largely by private owners and cannot be controlled except by supply and demand, and so long as our consumption is controlled by large corporations and companies, this change must be brought about through their desire to obtain the greatest possible usefulness from their material. This necessitates available information as to methods and processes whereby this length of service may be increased.

Of the essential characteristics of a cross-tie which must be improved in order to lengthen the period of service, durability perhaps is receiving the greatest attention. Comparatively little, however, is being done along this line. Of the one hundred to one hundred and twenty millions of ties which are used annually, less than 10 per cent. of this amount are treated. If all the treating plants in the country were to run at their full capacity and to treat nothing but ties alone they could not treat more than one-third of this amount.

With the conditions which I have just mentioned before us, it seemed evident that something must be done to encourage the treatment of a larger number of these ties and a larger amount of our lumber in general. That ties can be treated so as to greatly increase their service there is but little doubt. Among the many different processes and methods which are now before us there is great need of information which will help us to decide upon that treatment which will give us the best returns. To this end the Forest Service is working earnestly to furnish information which will not only produce the longest service in our timber, but will furnish the greatest financial benefits as well. We have been working for some time with the various treating plants throughout the United States in our experiments to obtain these results, but the ordinary commercial plant is not equipped with facilities for carrying on these investigations. The urgent need for this information has brought more clearly before us the necessity of making greater plans for the future.

Within the course of a year we hope to erect and equip a laboratory in Washington which will help us to solve some of these questions and afford facilities for carrying on a line of research work. In connection with this laboratory we hope to have sufficient equipment to test and to investigate the various methods now being used throughout the country; for it is pretty generally known that there is a very wide difference in the processes and methods now in use among the different treating plants throughout the United States. In fact, there seem to be about as many processes as there are plants. This question has brought to our minds the necessity of investigating the various methods and those minor questions such as steaming, temperature, vacuum, etc., together with those methods which will bring about a more economical form of injecting the preservative into the tie.

In connection with the question of investigating the preservative methods, we hope as well to have associated with this laboratory methods for testing the strengths of timbers before and after treatment, and also a section in which we can investigate the various preservatives themselves and their use and adaptability to different timbers as well as to draw relations between the various preservatives, the amount to be used, and their cost. In this way we hope to discover the best preservative, the best process, and to bring about a more uniform method of treatment throughout the United States.

We heartily invite the criticism, counsel, and co-operation of the various railroads and corporations throughout the country in our endeavors to solve some of these important problems. I have nothing further to state, more than to say that the Forest Service is at your command at any time in investigating any of these problems. We hope to make ourselves and our equipment sufficient in carrying on these investigations, that we may be of great service to you.

If I could ask the indulgence of the Association for a minute longer, Mr. Hall, of the Forest Service, is here and would like to say a few words.

Mr. Wm. L. Hall (in charge of the Office of Forest Products, Forest Service, United States Department of Agriculture) :—Mr. President and gentlemen, I simply want to say a few words to emphasize something which Mr. Crawford said.

A gentleman made the statement here a few moments ago that it would only be a little time before we must adopt preservative treatments for all ties. We of the Forest Service believe that to be perfectly correct, and so believing, I desire to say that we want to be as useful in bringing about that end as we possibly can. Up to a year ago, our Bureau was styled the Bureau of Forestry. That name was changed to the title Forest Service, because the word more truly indicates what we are desirous of doing. We want to be of service—that is our main object.

We think the problems of the treatment of woods may be divided into two groups. One group may be designated the local problems which one railroad or a group of railroads must work out for themselves with respect to the timbers which they use. In those problems the Forest Service, I believe, is in position to help materially, and we would be glad to have you call upon us at any time. The other group of problems concerns those fundamental questions which underlie preservative treatments such as those which you have thought best to refer back to your Committee this morning, because, as we all know perfectly well, we are not ready as yet to say what is the proper thing to be done in regard to such questions.

Now, in fundamental matters of that kind, concerning treatments, we believe that with a laboratory fitted out with the best appliances, such as Mr. Crawford has mentioned, where we can take hold of a problem and stick to until we get through with it, we can accomplish something that will be worth while to the railroads and also to all the other users of timber. It is in the getting of that laboratory that we want your co-operation especially. We know that your service can help us wonderfully, and that probably it will be only through the co-operation which we receive from you as representatives of railroads that we can secure this laboratory and do anything along this line. It is only to bring out these two points that I have asked for this privilege of addressing you, and I thank you for the time you have given me.

Mr. S. M. Rowe (Consulting Engineer) :—About twenty-one years ago it came into the line of my duties as Resident Engineer of the Atchison, Topeka & Santa Fe Railroad Company to erect the Las Vegas timber preserving plant and to operate and be responsible for its operation. Not being conversant with the operation of timber treating as then contemplated, it became necessary for me to go into it exhaustively.

With the assistance of the patentee of the Wellhouse process, which it was intended to use, and of Joseph P. Card and Octave Chanute, then associated with Mr. Wellhouse, from whom I obtained specific rules, I did so.

The work was taken up by the railroad company at that time to relieve the company from pressing necessity. In the West at that time no ties could be shipped from the East without great expense, and the mountain pine, being among the poorest class of timber we have anywhere, had to be relied upon.

The process used was new to me, but at that time well authenticated by specimens of softer timber that had been treated and in service some 17 or 18 years. Mr. A. A. Robinson, then General Manager of the company, was induced to authorize the expenditure of $30,000, or thereabouts, in the erection of the plant and I was obliged to take hold, and under the instructions of Mr. Wellhouse, Mr. Card and Mr. Chanute, who were the pioneers at that time, kept the works running and operated strictly under the rules given.

This necessitated not only my going into the details of the process to learn the principles upon which the work was done, but it necessitated an understanding of the different physical conditions obtaining. The work was carried on strictly according to the rules, as we had no one there who fully understood what the functions carried through meant exactly. The rules required that the timber should be steamed, ostensibly to season it; secondly a vacuum drawn to remove saps and all moisture possible, then subjected to the chloride solution and lastly to the solution of tannin, ostensibly to close the outer pores of the wood by combination of the tannin with the glue introduced in combination with the chloride of zinc into a leatheroid.

As there has lately been much criticism in regard to the steaming, I would wish to say that I have all along considered the steaming a seasoning process. I know that some sixty years ago a man engaged in the furniture business claimed that steaming expedited the seasoning of lumber very much. As to the necessity of steaming, the conditions are various with different timbers and in different localities and different ages drying and seasoning, that if any of the timber was not perfectly seasoned, that the steaming would correct the deficiency. A porterhouse steak may be very nice, but it is much nicer if broiled. On the same principle, steaming is considered proper even if the fiber be slightly weakened. My observation is that the timber is better prepared for absorption of the chemicals and is also toughened by steaming and its spike-holding power increased materially. Recently I have made some experiments with treated white pine where I was able to reduce the thickness of the board to one-third its original thickness without crushing the piece. I did observe early in the history of my experience on the Santa Fe that the spikes drove very nicely in the treated ties. In the case of some of these ties untreated, the end of the tie broke off at the spiking point when spikes were driven; they never broke with the treated ties.

The impregnation with the chloride of zinc and the application of the deterrent (combination of glue and tannin, the distinctive feature of the Wellhouse process) has called out a variety of opinions as to the value of the deterrent; but if you will go over the Santa Fe tracks to-day you will see ties treated by the Wellhouse process as intact on top as they were the day they were treated, and they have been in track twenty years. They are not checked into ribbons as untreated ties or as some subsequently treated ties do, but have retained their integrity and in my inspection of ties treated by the same process by Mr. Chanute I find the same conditions.

I want to call attention to criticism of results later obtained from the chloride of zinc treatment generally in the subsequent practice which are called failures. Whether these bad results are not rather due to lack of care in carrying out the process or possibly to the commercial instinct entering to do cheap work has not contributed much toward this, is a question worthy of consideration. Much of the failure complained of in results where the Wellhouse process is concerned may be due to lack of close attention of the management, to carelessness in selection of chemicals, to inferior ties or to rush work, for none of which the process should be held blamable.

I believe that it is better for each railroad company to have its own operator to do this work under their own direct supervision. I have no interest in any process, and never have had, but simply have tried to study each, and seek the best interests of the work.

I have made some computations of the Santa Fe ties recently, according to their own records, and have deduced a result which can be reasonably expressed. I find according to these tables up to 1904, that of ties treated and laid previous to 1900, equal to about 4,500,000, only about 30 per cent. have been removed up to 1904, a mean of nine and a half years, whereas the same class of ties not treated last not to exceed seven years with an average of about four years. In regard to the loblolly ties in Texas of which some were treated in 1897, and of which removals began in the sixth year, in 1873 I had about 3,000 of such ties cut and left in piles three years until 1876. At the end of three years not one of the three thousand were fit to put under the rail.

I found of the loblolly ties treated in 1897, about 2 per cent. coming out in the sixth year. Even at this date the failure seemed to be due to the corrugated seat of the tie-plate breaking through the glue tannin retardent, a spot under the plate being rotten, while the bulk of the tie remained measurably sound.

Mr. W. F. Tye (Canadian Pacific):—I would ask whether steaming is always necessary? There seems to be no question that steaming a tie reduces its strength, and it is important now that the strength should not be reduced, as from year to year we find it necessary to take a poorer class of timber. If the time of open-air seasoning was increased, would it still be necessary to steam? The Committee thinks a minimum of 90 days of open-air seasoning is necessary for the softwood. Suppose that period was extended to six or eight months—would it still be necessary to use steam before the injection of the preservative?

The President:—In this connection the chair desires to call attention to the exhibit made by the Forest Service in the anteroom, showing the effects of steaming on loblolly pine.

Mr. Tye:—That exhibit shows that the steaming certainly reduces the strength.

The President:—If there is no further discussion, the Committee will be relieved with the thanks of the Association.

W. K. Hatt (Civil Engineer, Forest Service—by letter):—It is admitted by all that wood may be seriously weakened by excessive steaming. Opinions differ as to the steam pressure and duration of pressure which will seriously weaken the wood. I desire to discuss this matter.

As I understand it, the object of steaming wood is to leach out the various resins, etc., that exist in the wood, and which clog the openings between the cells, and which, if not removed, would prevent subsequent penetration of the preserving fluid. Thus, in the case of red fir, it is said to be necessary to treat the wood in a green condition before the resins become solidified.

It is a common misconception that this steam bath evaporates the sap. As a matter of fact, ties steamed at ordinary pressures contain more water after steaming than before. The steam comes in contact with a large mass of cold wood, is condensed and fills the wood with water. The evaporation of this water would not take place under the pressure of the steam. If it did, the end in view would not be attained, for the solid substances would be left behind in the processes of evaporation. There is, no doubt, some evaporation in the vacuum following the steam bath, but this is probably confined mostly to the surface of the ties. Such records as I have seen indicate a greater weight of the tie after vacuum than before they were placed in the cylinder.

There is no doubt, however, of the leaching action. Some parts of the solid substances of the wood are extracted and blown off from the cylinder. The dry specific gravity of the wood after steaming is less than the dry specific gravity of the wood before steaming. This phrase, "dry specific gravity," refers to the specific gravity of the wood after the moisture has been driven off.

After the passageways through the wood are opened by steam, followed by the vacuum, and while the wood is still wet, the preserving fluid is forced into the volume of the tie.

The desire to open up the wood and secure penetration is evidently the explanation of the use of steam. There is no particular advantage in the removal of resins, starches, etc., except for this purpose. The supposed sterilization of the wood is of little importance, for decay-producing elements enter the wood after its exposure, and are not usually in the wood at the time of treatment.

It follows then that if penetration can be secured without steaming, the latter process should be omitted, since it is expensive, and liable in some cases to damage the wood seriously.

In what cases, then, will steaming damage the wood?

There is some, but an unimportant, loss of strength at the temperature of exhaust steam. As the temperature rises this loss increases. The moist heat seems to change the structure of the cell walls so that they will take up and hold more moisture, not only directly during the action of the steam, but permanently thereafter. Even if the wood is dried out subsequently to steaming, it will, upon resoaking, exhibit this increased capacity for the absorption of water; that is to say, its fiber saturation point is increased. In consequence of the increased moisture in the cell walls directly after steaming, the wood is pliable and weak like leather is when it is wet. Upon subsequent seasoning it largely regains its strength, provided the steam pressure has not been too high; that is to say, provided the temperature has not been so high that the process of disassociation of the cellulose has been too greatly developed. Just what this dangerous temperature is, is a matter of discussion.

It is evident that the temperature of the steam is not likely to work into the interior of a large stick of green wood under ordinary cylinder conditions. For instance, in the experimental plant of the Forest Service at St. Louis, a steam pressure of 20 pounds was applied for 4 hours (thermometer in cylinder reading 254 degrees F.) to green loblolly pine ties. Subsequently the ties were removed, a hole was immediately bored to the center of the tie and a thermometer inserted in the hole, surrounded at the top with cotton wool. The temperature observed inside the tie about midway between the surface and the center was from 200 to 210 degrees F. We should regard this operation, therefore, as a process by which the ties are stewed in their own juice, the temperature being below the boiling point.

The longer a given steam pressure is applied the more the temperature of the steam will work into the tie. The effect of a given steam pressure or the duration of pressure will depend upon the condition of the wood. Thus, green ties will bear (and, I understand, would require) a higher steam pressure, or a greater duration of pressure, than will seasoned ties before they are scorched or burnt. Thus, also, hard and heavy wood, or wood filled with resin, will bear, and will require, a higher steam pressure or duration of pressure than light, open growth. Thus, also, heart wood will bear a higher pressure or duration of pressure than will sapwood. In these cases it is simply a question of the rate of conduction of the temperature of the steam throughout the tie.

The actual results of some 6,000 tests relative to this matter are given in a circular published by the Forest Service, United States Department of Agriculture, now in press. The results bear out the remarks made in this discussion. Thus, in the case of green loblolly pine ties, an examination of the wood specimens showed that scorching began at 40 pounds steam pressure applied for 4 hours, and that at 5 hours' duration of 20 pounds pressure the scorching was evident. All the specimens were badly scorched at a pressure of 100 pounds applied for 4 hours, and at a pressure of 20 pounds applied for 20 hours. The evidence of scorching appears earlier in the case of seasoned loblolly pine.

In view of the fact that many plants do not steam seasoned loblolly pine, steam not being considered necessary in order to secure penetration, I do not see why the Committee specifies this steaming process for seasoned timber. Possibly it may be necessary at times to treat green ties upon a rush order, or there may be no assurance that all the ties are seasoned in ordinary cases, so that, as a matter of safety, an engineer may desire to specify this steaming process for both seasoned and green ties. Would not this point, however, be guarded by the penetration as shown by the tank readings? In other words, if the operator of the treating cylinder secures proper penetration of the required amount of creosote without using any process that is detrimental to the strength of the timber, why should the specifications limit the methods by which this may be accomplished?

Proceeding to the consideration of the further operation of injection of the preservative fluid, it appears that the presence of the creosote oil in the wood has no direct action on the fiber to weaken it or strengthen it. Creosote does not enter the cell walls, but apparently only fills the cell openings, or paints the surfaces of the walls. All the creosote can do, then, is to retard the seasoning of the wood. Thus, wood containing creosote will dry more slowly, which slow seasoning is not by any means a disadvantage.

The presence of zinc-chloride seems not to affect the strength of the wood, as evidenced under static loading, but the indications are that Burnettized wood is somewhat brittle, as shown by impact loading.

REPORT OF COMMITTEE NO. II.—ON BALLASTING.

To the Members of the American Railway Engineering and Maintenance of Way Association:

Your Committee on Ballasting begs to report as follows:

A meeting was held at the Association room in the Monadnock Block, Chicago, September 14th, Messrs. Hanna, Goodale, Ranno and Walker being present.

A joint meeting with the Track Committee was held at the same place October 31st, Messrs. Hanna and Milner, of the Ballasting Committee, and Messrs. Davis, Lee, Hickey and Stimson, of the Track Committee, being present.

A meeting was called for November 14th, but none of the members were present except the chairman.

A report was prepared for presentation to the 1905 convention, but owing to the time devoted to discussion of reports of other committees, it was given only a very brief consideration. This report contained definitions, conclusions relative to ballasting, specifications for stone ballast. principles of recommended practice for gravel, cinders and burnt clay, ballast cross-sections—both majority and minority reports—and some notes on use and characteristics of oyster shells and granulated slag. For details, reference is made to the report as published in Vol. 6 of the Proceedings, pp. 735-744, inclusive.

DEFINITIONS.

The definitions submitted had been approved by the 1904 convention and no changes were made. Written criticisms, in accordance with the President's circular, issued shortly after the 1905 convention, were submitted by four members. The Committee was unwilling to accept any of the changes suggested, but does wish to make one change on its own account; that is, to change the word "fuel" to "coal," in the definition for cinders (see Vol. 6, page 736), so that it will read as follows:

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

The reason for this change is that cinders for ballasting purposes result from the use of coal only, either hard or soft, and from no other fuel.

The Committee would also add one definition—Disintegrated Granite. This material is being used to a considerable extent in the West, and its importance, in the Committee's opinion, entitles it to a place among the definitions. The following is offered:

"DISINTEGRATED GRANITE.—A natural deposit of granitic formation, which, on removal from its bed by blasting or otherwise, breaks into particles of size suitable for ballast."

Mr. Hunter McDonald, Past-President, suggested that sand be defined by maximum and minimum sizes of particles as determined by sieves, sand to be any size which would pass a No. 4 and be caught on a No. 100 sieve. The Committee will be glad to hear from members generally on this point.

SPECIFICATIONS.

Specifications for crushed stone and principles of recommended practice for gravel, cinders and burnt clay, as presented to the 1905 convention, follow. Their status, as regards adoption, is indicated by footnotes.

*STONE BALLAST.

RECOMMENDED SPECIFICATIONS.

(1) *Quality.*—(a) Stone shall be durable enough to resist the disintegrating influences of the climate where it is used.

(b) It shall be hard enough to prevent pulverizing under the treatment to which it is subjected.

(c) It shall break in angular pieces when crushed.

(2) *Size.*—(a) The maximum size of ballast shall not exceed pieces which will pass through a screen having 2-in. holes.

(b) The minimum size shall not pass through a screen having ¾-in. holes.

† GRAVEL, CINDERS AND BURNT CLAY BALLAST.

RECOMMENDED PRINCIPLES OF PRACTICE.

‡GRAVEL.—Gravel should be screened or washed where prevention of dust is an object, but this need not be done where the character of traffic is such that dust is not particularly objectionable. It is recommended that gravel be screened or washed where the proportion of sand or clay exceeds fifty per cent. The minimum size should be such as is retained

* Adopted, Vol. 5, 1904, pp. 487, 495, 501-505; Vol. 6, 1905, pp. 737, 745.
† Adopted, Vol. 6, 1905, pp. 737, 738, 745, 746.
‡ Reported by Committee, but not formally approved by the Association.

on screens of 12 meshes per in. By this is meant the size pebble that would be retained in a thorough, careful test.

CINDERS.—The use of cinders as ballast is recommended for the following situations: On branch lines with a light traffic; on sidings and yard tracks near point of production; as sub-ballast in wet, spongy places; in cuts and on fills; as sub-ballast on new work where dumps 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.

BURNT CLAY.—The material should be black gumbo or other suitable clay free from sand or silt. The suitability of the material should be determined by thorough testing in small test kilns before establishing a ballast kiln.

The material should be burned hard and thoroughly.

The fuel used must be fresh and clean enough to burn with a clean fire. It is important that a sufficient supply be kept on hand to prevent interruption of the process of burning.

Burning should be done under the supervision of an experienced and competent burner.

Ballast should be allowed to cool before it is loaded out of the pit.

*Absorption of water should not exceed fifteen per cent.

DISINTEGRATED GRANITE.

As a matter of general interest the Committee submits the following notes on Disintegrated Granite, kindly prepared last spring by Mr. J. B. Berry, at that time Chief Engineer of the Union Pacific Railroad:

"In the Rocky Mountains disintegrated granite is usually in mass and very compact, with occasional dikes of hard granite sticking up through it to the surface.

"The bulk of it may be taken out by a very heavy steam shovel, but we have found it much cheaper to do some blasting. When blasted and picked up, it crumbles into small cubes about the size of peas. The dikes of granite are solid material and have to be blasted out and thrown to one side or used for riprap. We have been able to load with a steam shovel having a three-yard dipper about 2,000 cubic yards per day.

"It runs very easily out of the cars, is of a good size to ballast track, is easily handled under all conditions, becomes quite compact when in the track, little or no dust, will stand hard tamping with tamping bar, is one of the best ballasts to shed water I have ever seen, and we find it more economical, especially in renewals of ties, than any other kind of ballast we have used.

"We have used about a million yards of disintegrated granite for

*See amendment, page 89.

ballast within the last three years that we have definite figures about, and can report as follows:

	Average Cost Per Cubic Yard.	
Cost loaded on cars at pit..................	9.19	cents
Labor unloading from center dump cars and putting under track....................	13.37	"
Tools, engineering and miscellaneous expenses.	0.76	"
Total	23.32	"

Weight of ballast, 3,000 lbs. to cubic yard.

"This cost includes everything except haul, and each company must decide for itself what it costs to haul ballast per cubic yard. The items I have given included tools and repairs of same, powder and fuses, steam drills, wages of pit employés, labor putting ballast under track, repairs to cars, wages of locomotive engineer, fireman and trainmen who spot cars at the pit, roundhouse expenses, water supply, oil and waste for locomotives and steam shovel, fuel, rental of locomotive and steam shovel and rental of outfit cars. In other words, it includes every expense connected with the handling of this ballast except the haul.

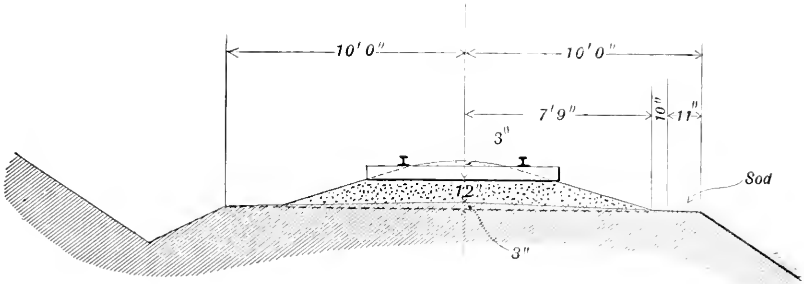
"While we did not meet with any granite boulders in our gravel pits, we found a good many seams or dikes of the solid granite throughout the pit and were obliged to shoot these. The loading of these after shooting was done by steam shovel and at times was a little slow, but still was the most economical method of handling them. The material that was too large for ballast was used for riprap. The expense of this shooting and loading was included in the figures given for cost of ballast, but the yardage is not included.

"It probably would be more expensive shooting boulders, as we are able to put holes down the depth of entire face of work. We find it economy to use powder in loosening the face of entire work for the shovel."

BALLAST CROSS-SECTIONS.

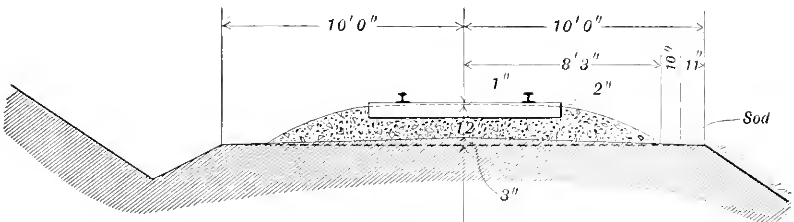
The Committee's last report showed two sets of ballast cross-sections, there being a majority and a minority report. These were referred back to the Committee with instructions to try to reconcile the differences. The members of the Ballasting Committee agreed among themselves upon a set of sections, which afterward, with slight modifications, were agreed on at a joint meeting with the Track Committee. The sections are given herewith.

As may be seen by referring to the section shown on pp. 739, 742, 743 and 744 of Vol. 6 of the Proceedings, these sections are in the nature

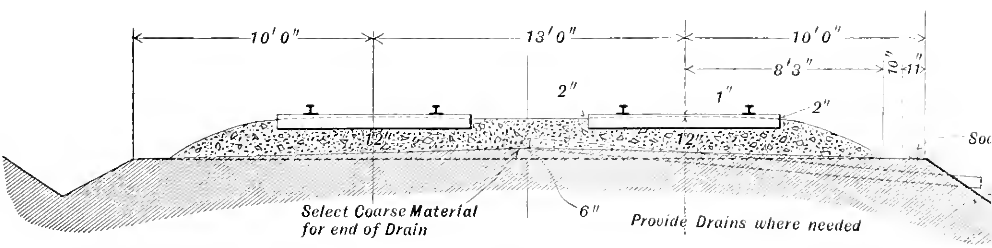


Single Track

Use above Section for Cementing Gravel and Chert.



Single Track



Double Track

Use above Sections for Crushed Rock, Slag, Gravel,

Burnt Clay, Chats, Cinders, Disintegrated Granite and Sand.

of a compromise between the different sets of sections proposed last year. It was the general opinion that some surface drainage was desirable, if not absolutely necessary, even with such material as crushed rock and slag. This requirement is met by the slight rounding of the surface between ties, the distance to top of ballast at end of tie being one inch lower than at center and space being left under the rail to allow passage of water. It was also the general opinion that a large body of ballast is necessary around the end of the tie to give support to that part of the material which is directly under the tie. Without this support, the ballast works out and allows the tie to drop. This requirement is met by allowing the ballast to come well up on the end of tie and providing a flat slope from there to the foot. It was thought that a steep slope, equal to the natural angle of repose of the material, had practically no resistance to a disturbing force and that the ballast should, therefore, be put at such an angle as would resist a disturbing force from the start.

Where the ballast contains clay, or material which makes it practically impervious to water, the latter must be carried away on the surface entirely. The importance of a steep slope, in this case, is greater than that of support at the ends of the ties, and a section is provided accordingly. This is shown for cementing gravel and chert. Ballast sections shown are for first-class track only. It was not thought proper for this Committee to attempt to provide for different classes of track until the Association had taken some action on classification.

A double track section for cementing gravel was not shown for the reason that it seemed probable that a double-tracked road would use a better ballast.

CONCLUSIONS.

(1) Your Committee recommends that the definitions for "Cinders" and "Disintegrated Granite," as given in this report, be approved.

(2) That the recommended principles of practice for Gravel Ballast be formally approved by the Association.

(3) That the Ballast Cross-sections submitted be approved as good practice.

Respectfully submitted,

John V. Hanna, Assistant Engineer Maintenance of Way, St. Louis & San Francisco Railway, St. Louis, Mo., *Chairman.*

C. A. Paquette, Superintendent, Cleveland, Cincinnati, Chicago & St. Louis Railway, Indianapolis, Ind., *Vice-Chairman.*

C. H. Byers, Assistant Engineer, Pacific Railway, Seattle, Wash.

A. Q. CAMPBELL, President Hogansville Quarry Company, Hogansville, Ga.

M. P. COTTON, Assistant Engineer, Canadian Pacific Railway, Winnipeg, Man.

L. F. GOODALE, Engineer Maintenance of Way, Chicago, Burlington & Quincy Railroad, St. Louis, Mo.

G. D. HICKS, Superintendent, Nashville, Chattanooga & St. Louis Railway, Tullahoma, Tenn.

B. C. MILNER, Superintendent, Southern Railway, Louisville, Ky.

J. O. OSGOOD, Chief Engineer, Central Railroad of New Jersey, Jersey City, N. J.

F. W. RANNO, Manchester, N. H.

SAMUEL ROCKWELL, Chief Engineer, Lake Shore & Michigan Southern Railway, Cleveland, O.

A. F. RUST, Resident Engineer, Kansas City Southern Railway, Kansas City, Mo.

G. M. WALKER, Jr., Assistant Engineer, Kansas City Belt Railway, Kansas City, Mo.

Committee.

AMENDMENT.

Change last paragraph under Burnt Clay Ballast to read: "Absorption of water should not exceed fifteen per cent. by weight."

DISCUSSION.

Mr. John V. Hanna (St. Louis & San Francisco) :—The principal thing the Committee has to offer at this time is the ballast cross-sections. We had some cross-sections prepared for last year's report, but on account of being one of the last committees to report, we scarcely got before the convention at all. We did have a few minutes, but so short a time that it was not practicable to get any discussion or consideration that was of real value. The members of the Committee disagreed among themselves at that time, and we were instructed to take up the sections again. We did, and this time we have compromised our differences and offer just a single set of sections. This is in the nature of a compromise. The members of the Committee, of course, held somewhat different views, but we believe that we have offered a good practicable section and one that can be adopted with good results. Discussion will of course be of a great deal of value. We are not beyond criticism, and with the benefit of discussion we can put the sections in good shape to be embodied in the Manual.

The President:—At the last convention the Association adopted the recommendations of the Committee for stone ballast specifications; also for cinder ballast. The specifications for gravel and burnt clay ballast have not yet been formally approved. Information has also been added of a new form of ballast—disintegrated granite—which is used by one of our Western roads.

Mr. Hanna:—The last-mentioned are recommended principles of practice rather than specifications. The Committee concluded that it was not worth while to attempt to draw a specification for gravel, as we were really held down to what we could get.

The President:—The Secretary will read the paragraph in regard to gravel ballast.

The Secretary:—"Gravel.—Gravel should be screened or washed where prevention of dust is an object, but this need not be done where the character of traffic is such that dust is not particularly objectionable. It is recommended that gravel be screened or washed where the proportion of sand or clay exceeds fifty per cent. The minimum size should be such as is retained on screens of 12 meshes per in. By this is meant the size pebble that would be retained in a thorough careful test."

Mr. E. E. R. Tratman (Engineering News) :—Would it not be well to make some mention of the minimum size of pebble that shall be allowed in gravel ballast? Some "gravel" ballast has numerous pebbles as large as a man's two fists. These should be crushed, but very few roads crush gravel ballast.

The President:—That point is open for discussion.

Mr. Hanna:—The Committee, in arriving at this recommendation, had obtained information on the practice in handling gravel from quite a number of roads. All of that is really old; that is, the information we obtained in regard to gravel was contained in letters that were before the Committee for two or three years, and I do not recall much of the detail. I do not think, however, that it was brought out in any of the communications that there was any necessity or desirability of taking care of the larger stones that occur in gravel. I can understand, of course, that it might be desirable in some cases, but apparently, with the information before us, that did not occur often enough to make it advisable to cover with a general recommendation on the practice. The important point that was dwelt on most was how small a stone should be taken out? The principal idea is to get rid of the dust, and aside from the dust-producing feature of gravel, it would really be advisable to leave the sand in. That seemed to be the consensus of opinion of the roads that had experience in that line.

The President:—If there is no further discussion, the paragraph will stand approved as read. There seems to be some doubt as to whether the requirements for burnt clay ballast were formally adopted last year, and I would ask the Secretary to read the items pertaining to burnt clay ballast, and if there is no objection, it will be considered adopted.

The Secretary:—"Burnt Clay.—The material should be black gumbo or other suitable clay free from sand or silt. The suitability of the material should be determined by thorough testing in small test kilns before establishing a ballast kiln. The material should be burned hard and thoroughly. The fuel used must be fresh and clean enough to burn with a clean fire. It is important that a sufficient supply be kept on hand to prevent interruption of the process of burning. Burning should be done under the supervision of an experienced and competent burner. Ballast should be allowed to cool before it is loaded out of the pit. Absorption of water should not exceed fifteen per cent."

Mr. F. S. Stevens (Philadelphia & Reading):—I would like to ask if the absorption of water is by weight or by volume.

Mr. Hanna:—I am obliged to say that I will have to consult our records about that. This is one of the things that is about two years old. It has not come up in our Committee meetings since then.

Mr. A. W. Johnston (New York, Chicago & St. Louis):—Is it really of great importance to include the third paragraph from the last—"Burning should be done under the supervision of an experienced and competent burner?" It is presumed in the railroad service that we get the best talent that we can.

The President:—Your idea would be to omit the paragraph?

Mr. Hanna:—I would like to hear discussion on that.

Mr. Johnston:—My only reason for asking that is because we generally get the best talent we can for any particular work; we generally get the best talent obtainable for specific purposes.

The President:—Do you make that in the form of a motion, Mr. Johnston?

Mr. Johnston:—I make that in the form of a motion.

The President:—A motion has been made and seconded that the paragraph requiring that the burning be done under the supervision of an experienced burner be omitted.

(The motion was lost.)

The President:—Mr. Stevens, do you desire to make a motion relative to the percentage, whether it be by volume or weight, in order to bring it before the convention?

Mr. Stevens:—I think it should be by weight, and I will make a motion that it be by weight.

The President:—It has been moved and seconded that the last line in this article be made to read, "Absorption of water should not exceed fifteen per cent. by weight," that the words "by weight" be added.

(The motion was carried.)

Mr. Hanna:—The first cross-section shown is for cementing gravel and chert. I might say that that was intended also to apply to any ballast where the necessity for carrying the water off from the surface rather than allowing it to pass through was the principal consideration, and in order to attain that end it is necessary to give a good sharp slope to the surface of the ballast. The only way to accomplish that seems to be by giving it a pretty good height in the center and sloping down to the end of the tie. From the end of the tie to the top of the roadbed, the slope, as you will notice, is rather flat. My recollection is that in figuring the distance out we thought that should be about three to one, that such a slope is stable and will stay where it is put. At the foot of the ballast slope you will notice a space is provided of ten inches. The idea of that is that the foot of the ballast should be lined up; as the stones composing the ballast are displaced they will roll down and the flat space, without sod, will facilitate the work of picking this up with a shovel and dressing up the ballast again. Following that is a space for sod between this shovel width and the shoulder of the bank, and as shown it is simply with the idea that a sodded bank will be more permanent than one without this protection, and that the sod should come as close up to the foot of the ballast as is practicable, and allow the ballast to be worked with ease. There was some question in the Committee as to the width of that small space—ten inches is about the width of the shovel. I do not think that it is a very vital matter, but the width should be such as to make it easy for the trackmen to work and handle their shovels. It is plain that shoveling in the grass is a very difficult thing. The width of roadbed shown, as will be noticed, is twenty feet and has a triangular ditch. In that case we were following the recommendations of the Roadway Committee. We did not prepare any sections for the different classes of track. While I think it probably would be entirely proper, now that the track is to be classified, to follow that up and apply it to ballast cross-sections as well, in advance of a definite report by the Committee on Classification of Track and action of the convention on their recommendations, we concluded to adhere to first-class track only and that modifications could be made afterwards. There have been some suggestions made with regard to the shape of the ballast section from the end of the tie to the point where it meets the roadbed. It will be noticed that we have shown that as a straight line, the idea being that such a slope would stand well of itself, and that a sharp slope of that kind would shed the water faster. It has been suggested that instead of making this a straight line, the slope should be flatter, immediately out from the end of the tie, and then rounded off with a sharper slope just before leaving the roadbed.

Mr. R. C. Barnard (Pennsylvania Lines):—I believe that this Association has adopted a roadbed without a crown. If such is the case—and I think I am right about it—I do not think the Ballasting Committee should publish sections not in accord with those already adopted.

Mr. Hanna:—My understanding is that the roadbeds adopted were adapted for new work, and we did not consider that we were limited in preparing the ballast cross-sections or prevented by that from showing a little crown. It is hardly practicable in a new roadbed—I believe that was the sense of the convention—to finish with a crown. It is practicable, at least in some cases, to make a crown of that sort in preparing your track for ballast. I think there are some cases where that would not apply. That point came up in the Committee, and the members held different views about it, but the final conclusion was that it was practicable under certain circumstances to prepare the roadbed with a crown, and that it was a desirable thing, when it could be done, and that we would show it on that account.

Mr. Robert Trimble (Pennsylvania Lines):—I think the crowning of the roadbed is an unnecessary refinement. I saw a report not long ago in which the construction department was somewhat criticized for not crowning the roadbed, and as my line of work is more in the line of construction than maintenance, I was interested in the criticism. For a number of years I believed in crowning the roadbed, but as a result of my observation I concluded that you may make very nicely crowned roadbed construction, but if you make an examination a year or so after the road is in operation, you will not find any well-defined crown there, and you will find the ballast hammered down into the roadbed. About a month ago, in order to get some information in regard to this question, we went to a place where we had abandoned the track on an old roadbed and made an examination of a trench right across from the roadbed with a view to securing a profile of the bottom line of the ballast, and found it to be very irregular, varying six or eight inches from the level line at which it was originally put in. There is another point that occurs to me in regard to the proposed cross-section. I doubt very much the advisability of having a uniform cross-section for gravel ballast and stone ballast. Stone ballast is much more expensive in our country than gravel ballast, and it will stand at the end of the ties at a somewhat steeper slope than gravel, and it does not seem to me desirable or necessary to use as flat a slope for stone ballast as we do for gravel ballast. You must have a flat slope for gravel ballast in order to have easy maintenance, but it is not necessary with stone, and I think that it is rather a wasteful use of stone on the lines recommended by the Committee.

Mr. Hanna:—In that connection, I think the opinion of all the members of the Committee and of the Track Committee, which conferred with us, was that it was desirable to flatten the slope, even with stone ballast as it is ordinarily used. There was, of course, some difference of opinion among the members on the slope desirable for different classes of material. I will say in that line that personally the chairman was in favor of showing the sections with different slopes for rock and gravel. Personally I believe that to be the thing, and if I were doing the ballasting, I should certainly arrange for different slopes for rock and gravel, but following what appeared to be the desire of the convention last year—that we try to harmonize our differences—we put the section in here according to a majority vote, and the chairman on that point was out-voted by the rest of the Committee.

Mr. C. H. Ewing (Philadelphia & Reading):—I note on the cross-section for stone and other kinds of ballast, the top of the ballast is at a point one inch below the top of the tie, and the minimum depth of ballast under the tie is six inches. On the other cross-sections the depth under the tie is twelve inches. It seems to me that six inches under the tie for a standard cross-section is not sufficient. I would like to see that increased.

Mr. Hanna:—That was an error in making the drawing. It was intended to be twelve inches.

The President:—It is hoped that there will be a free discussion of this cross-section. The Committee have presented an expression of opinion, for which we have been waiting a long time. If the cross-sections are adopted as presented, they will represent the unanimous opinion of this Association. There are many important features in them, and I am sure that the Association at large and the Committee want the matter fully discussed.

Mr. F. S. Stevens (Philadelphia & Reading):—I would be glad to hear from the chairman of the Committee as to the advantages that they have discovered by banking in the ends of the ties in any class of ballast. The principal use of ballast, I think we will all agree, is to afford drainage. If water accumulates under the ties, the only way it can escape is out at the ends. We must also have a free circulation of air under the ties, otherwise, during moderately wet weather, we will have water. If we do not get air freely circulating, each tie becomes a pump and it will draw water there, which is a very bad condition. My opinion is that the ballast cross-section shown at the top, as a general proposition, is better for all classes of ballast than the section recommended for stone, gravel, etc. There is nothing to be made by banking the ends of the ties with any class of ballast, for the reason that a track that is in surface will remain in line and no amount of banking in with ashes, gravel or crushed stone will hold it in line, if it is not in surface; therefore, the matter of surface is the whole thing, and there is nothing gained by banking in the end of the ties at all. If the end of the tie is banked in and it makes a pit for the accumulation of water, it is impossible to retain the surface. The work required to keep the track in condition is multiplied many times, and nothing is gained.

Mr. Hanna:—The Committee can hardly agree with Mr. Stevens on that proposition. We believe there is something definite to be gained by banking in the ends of the ties with a gravel which allows the water to pass through it freely. The intention was that that section would be applied with such ballast. We will say that it is true that if the track is maintained in surface, once being in line, it will stay in line with such work, but we believe that the additional material around the ends of the ties or between the ties near the end would tend to maintain the track in surface; that having that additional body of material, there would be more resistance to displacement in any direction. The ballast, say, that is under the tie, once it is compact, can get away only by moving either laterally or longitudinally as regards the tie, and there will certainly be a resistance to any such motion of the ballast immediately under the tie if there is, so to speak, a weight on the ballast that surrounds it; and I believe there is quite a decided advantage in having that material there. The slope for drainage in ballast of that kind is not necessary. What the water actually does when it falls on ballast of that kind is to go through to the roadbed under it, and then it gets away either by soaking into the roadbed or finding its way out to the side. We know that we do not always have perfect track, and there is some advantage of having material that does tend in itself to prevent a lateral displacement—that is, lateral with respect to the track or longitudinal with respect to the tie. The tie must be held in place by the friction between it and the ballast that is under and along the sides, and you will certainly increase the surface which creates that friction when you extend the ballast out to the end of the tie. The ballast that is immediately against the end of the tie possibly does not serve any very marked purpose, but you cannot carry the ballast out to the end of the tie, between the ties, without having it around the end also. It must have some slight effect, anyway, in preventing displacement.

Mr. Barnard:—I would like to ask, whether, in the first diagram, the

Committee intends to leave any space between the inside of the base of the rail and the gravel?

Mr. Hanna:—Yes; at least an inch.

Mr. Barnard:—I think it should be shown here in figures.

Mr. Hanna:—It was the intention to have at least one inch of space between the base of the rail and the gravel.

The President:—We would like to hear from Mr. Hickey, of the Michigan Central.

Mr. T. H. Hickey (Michigan Central):—It is my experience that in trimming track in gravel ballast, it is best to carry it within three inches of the top end of the ties, and have an opening of about one inch under the rail to the height of the top of the tie in the center, and the slope to be carried out in that way to about five feet outside of the rail. I trim broken stone in the same way, but I would not carry that ballast out quite so far. Instead of five feet I would make it four, keeping it down the same distance from the top of the tie at the end and under the rail, and I believe that ballast between the ties of that height would require the ends to keep the ties in place, as well as keeping the tie in good surface and line. I believe the track will stand up and remain in surface better where the tie is the same—I am speaking of gravel and stone—three inches above the bottom of the tie at the ends, as, if the ballast is taken down to the bottom of the tie at that point, it will work away lower, and consequently the track cannot be maintained as in good surface or line as if supported by the ballast three inches above the bottom of the tie at the ends.

The President:—We would like to hear from Past-President McDonald upon this subject.

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis):—I had not expected to say anything on this subject. I am in such a state of mind regarding ballast cross-sections that I hardly know exactly what to think. Taking these sections up in the order that they come, I should certainly not approve of any gravel ballast being raised up above the top of the tie; I should not approve of any attempt to show a crown in the roadbed. My experience is that if put there it will not remain twelve months under traffic. If the earth is thoroughly tamped and a hammered paving placed on it to receive the ballast, it might hold the crown for some years. I think there is little cause for difference in cross-section between cementing gravel and chert, and any other kind of gravel, as far as shedding water is concerned. While these gravels are apparently cementing and there is a certain amount of clay in the chert which might act temporarily to shed the water, it soon disappears and the difference in the end is apparent only. My reason for stating that I did not know exactly where I stood on the ballast cross-sections is that while the rock ballast is fresh, and is of course porous, the water passes off freely, but it is only a matter of two or three years until the ballast becomes foul either by pushing the mud up from below, or from dust and cinders from above. When that condition is brought about, the shoulder at the end of the tie is very destructive to the condition of the track. I have found that under those conditions it was much better not to have a shoulder on account of the churning of the tie. I think the common practice under those conditions is to continue to raise the track and put new ballast under it at the rate of about two inches every two years. The final result is that all structures affected must be raised. I should say, therefore, that under these conditions the cross-section of the ballast which shows no shoulder above the bottom of the tie is the best. I would like to know the prevailing practice in treating ballast that is foul. I have sought information upon this point for a long time. I have been told by a Roadmaster of the Pennsylvania road that they were in the habit of taking it out and forking it; but when I asked him how he conducted his traffic while that was being done, the answer was not satisfactory. In riding over the various lines of this country I have seen no forking going on except of the ballast in the shoulders and between the ties. The ballast under the ties, I think, is never forked.

Prof. C. Frank Allen (Massachusetts Institute of Technology):—It has been suggested to my mind, especially from what the last speaker said with relation to the fouling of the ballast, that perhaps another precaution might be taken that would prevent, to a considerable extent, this fouling, and that is by putting some fine gravel or sand or cinders between the broken stone ballast and the original surface of the roadbed, when this is clayey material or any material that will readily soften with water. That is a practice that prevails, the acknowledged, accepted practice with the best highway engineers for the construction of macadam roads, and the same practice has been followed by railroad engineers in many cases to great advantage. If it should be recommended here not only to provide drains where needed, but also to provide sand or gravel or cinders where needed, I believe very much better results might be reached than are obtained when the water has a chance to get into the soft material directly underneath, and so work itself up and out as a lubricant, and to a considerable extent disturb the stone and prevent its performing its proper functions. I am not sure but that a practice of that sort, if consistently followed, would in many cases allow a slight slope in the roadbed to be used, and even maintained—I am not sure but that the slope might persist if it had a chance.

Mr. G. B. Woodworth (Chicago, Milwaukee & St. Paul):—I believe there is no uniform shape of cross-section, but that we have all kinds of gravel as well as stone. If the gravel is free, it would be necessary to have a poor roadbed, and on one of our lines it is the practice to put the gravel further out in order to keep the track in proper surface under the jar and high speed of trains. If the gravel is of a free sandy nature, the chairman states the water runs through and it is not necessary to make any slope. If the gravel is of a cementing nature, it is necessary to slope even down to the ends of the ties; but there is another matter that comes up, and that is, it is always necessary to have a little surplus gravel on the line. If the track is put down in what might be called an ideal shape, the attempt to raise the track or work it into better shape without making the crown bed would destroy this cross-section, and I think that the cross-sections would then be a good deal different from what might be termed an ideal shape. So far as the crowning of the roadbed is concerned, while this is not common practice and is not necessarily done in new construction, it is always the practice in my experience to do so in regraveling the road. The old material is taken out at the slope at the crown before putting the new ballast on.

Mr. A. K. Shurtleff (Chicago, Rock Island & Pacific):—Regarding the crowning of the section, I can hardly see how they can place a crown in the center where a track is already laid. In digging out the track I do not see how they can place that crowning in the center. I think that any foreman who would attempt it would lose his position.

Mr. Hanna:—The way to accomplish the crowning is this—you have probably been running your tracks on dirt before beginning to ballast, and in cutting that dirt out from between the ties, if you will cut it down so that the dirt at the center of the track is even with the bottom of the tie, and, as you go down toward the end, get a little deeper, you will have a slope about such as is shown here, and by cutting that deeper than the bottom of the tie, when you get to the end, so that you are a couple of inches below the bottom of the tie, and you then have a kind of trough between the ties that gives an opportunity for the water to get away from under the tie, and the tendency of it is to carry it out to the edge of the roadbed. I know that that can be done, because I have taken hold of the shovel and done it myself.

Mr. Stevens:—The great point in this question was touched upon by Mr. McDonald when he referred to the temporary character of the ballast. Sparks from the locomotive and a few ashes from the ashpan soon destroy the form of all kinds of ballast. It will soon draw more or less dirt and mud from the bottom, no matter how far it may be down. This bed becomes impervious to water, and unless there is an opening at the end the water simply lies there and causes more trouble. The only way is to drain the tie at the end, even though the end of the tie is banked three inches, as suggested, to leave the ditch open leading to the end of the tie, at the bottom, even though it may be only two or three inches wide, so that the tie may be drained at the end. That is the main point.

Mr. Hanna:—There is one point in connection with the advantage of having the ballast up to the end of the tie, as the President suggested, which I think is a very good one, and that is it very greatly increases the resistance to motion of the tie as a whole in the direction of the length of the rail. For instance, wherever there is a tendency to creeping, you want to take some means to stop the rail from creeping, and you want to put on an anti-creeper. You must prevent the tie from moving in order to get any effect from it. The additional ballast will certainly have a very beneficial effect in that case. It is a condition which frequently arises, particularly on double track, where the traffic is all in one direction.

Mr. Stevens:—It may be a little foreign to the subject, but I would like to speak a word in relation to a statement made by the chairman of the Committee as to the assistance gained in retarding the longitudinal movement of the rail by this small amount of ballast placed outside of the rail, which, I suppose, on a double track railroad it would be necessary to place only in one direction. I have had a good deal of trouble of that kind, but I find that the only thing that is necessary to prevent the creeping of the rail is to keep the joints tight; keep the ties tamped; keep a good surface and prevent the undulating movement of the rail. If that is done, the addition of the ballast here or there would cut no figure. That is the whole thing. We have a piece of track to a grade of 175 feet to the mile, maintained in excellent surface, traffic in one direction down that grade carried year in and year out—a very large volume—without any great creeping of rails—very little, indeed. Surface is all that is necessary to prevent that.

Mr. Edwin F. Wendt (Pittsburg & Lake Erie):—Theoretically, crowning the roadbed is all right, but practically I think that it is useless. Experience goes to show that in building railroads, a single track is originally constructed; then, after a lapse of years, a second track is constructed; subsequently, a third track, and, finally, a fourth track; so that practically the subgrade in cross-sections is local. I therefore favor the modification of this section accordingly, because that is the way railroads are practically built. The section submitted is all right in many of its features. In my judgment it should show first six inches of ballast under the ties; secondly, a cross-section which is level, that is, the subgrade being level transversely. The height of the ballast, it seems to me, is all right as shown in the double track section. I do not think, however, that four feet of ballast is necessary outside of the ties. In this case, our limit to the ballast is eight feet three inches from the center line. If the tie is eight feet six inches long, there will be four feet of ballast outside of the end of the tie. With stone ballast this amount is not necessary. Furthermore, in my experience, it has not been possible to buy stone ballast at times as rapidly as it would be needed. When new track was being constructed, and when a third track is being built on embankment through a valley, along a river, it is good practice and common practice to make the subgrade thirty inches below the top of rail, to lay the track and ballast it with ashes, using six inches of material. Then the traffic—slow traffic, such as freight—may be turned over this track, and as the ballast is received the track is brought up to final grade, thus getting the six inches of stone under the ties. In this way I think the point with respect to drainage is solved. I mention that merely to show that that is the way the track is actually built, and when it can be done that way there is excellent drainage. Experience of this character shows that the subgrade is always in track level transversely.

Mr. Ewing:—I am not inclined to favor very much the idea of dispensing with the crown. It is undoubtedly true that roadbeds heretofore have been made with a level surface. That, however, is because the rule covered that method. The height of an embankment is greatest in the center of the roadbed and will, of course, settle more at that point than it will on the outside edge, so that the center of the roadbed will naturally be lower than the outside slope. I think, therefore, that we should provide for the crowning of the roadbed in the original construction, just as the plan shows.

Mr. Barnard:—I do not think that this discussion on the crowning of the roadbed is in order. It seems to me that, having adopted a section of roadbed without the crown, the Ballasting Committee should make their sections to conform therewith. I therefore move that these diagrams be revised to show no crown in the roadbed.

(The motion was carried.)

Mr. C. H. Fake (Mississippi River & Bonne Terre):—I notice, at the end of the tie, the shoulder is in the shape of an arc or a circle. It seems to me that circle is going to be difficult to maintain.

Mr. Hanna:—I think not. You will observe that curved surface in a good many roads. I do not believe there will be any difficulty about it.

The President:—Conclusions 1 and 2 have been adopted by the Association. Conclusion 3 has been referred back to the Committee under the motion of Mr. Barnard.

Mr. Hanna:—If there are any other changes to be made besides the crowning of the roadbed, it seems to me they ought to be indicated now by the convention. The other features—the slope and the width out to the foot of the ballast—are essential, and if any changes are to be made we should have the views of the convention in regard to them.

Mr. Chas. S. Churchill (Norfolk & Western):—I would suggest that the Committee be asked to make a cross-section applicable to either stone ballast or slag ballast, in addition to these cross-sections, which I think are applicable to gravel ballast.

(The motion was carried.)

Mr. McDonald:—I move that the Committee be instructed to leave off the projection of the ballast three inches above the ties, and that the top of the ballast—gravel section—should conform to the top of the tie at the center.

The President:—That is in the first cross-section?

Mr. McDonald:—The only one in which it appears.

(The motion was carried.)

Mr. Hanna:—I understand that the sections where we show three inches above the top of the tie, that that is to come flush with the top of the tie and the lower sections, where we show one inch, it raises it?

The President:—No; it only applies to filling in between the rails flush with the top of the tie. The chairman of the Committee calls attention to the fact that the drawings show the ballast in the other two cross-sections to come one inch below the top of the tie in the center and not flush with the top of the tie, and he desires an expression of opinion upon that subject, whether the ballast is to come up flush with the top of the tie in the center, or is to be below the top of the tie, as shown in the two cross-sections, the second and third from the top of the page. As it stands now, unless there is objection, the action of the convention would be to approve the cross-sections showing the ballast below the top of the tie in the center.

Mr. Hanna:—On that point, in the discussion in the Committee meetings, I was personally in favor of bringing rock ballast and the other ballast for the lower cross-sections flush with the top of the tie, and I understood Mr. McDonald's motion to make that applicable to all sections of ballast. Personally, I am in favor of that.

The President:—The chair did not understand Mr. McDonald's motion in that way. Did you intend that, Mr. McDonald?

Mr. McDonald:—No, sir; I have not observed that feature of other sections. My motion simply covered the fact that no ballast was to be above the top of the tie.

The President:—That is the way the chair understood it.

Mr. McDonald:—Personally, I think the ballast should be shown level with the top of the tie. I do not think it would stay that way more than a month or two.

Mr. Wendt:—I would call attention to the fact that, where electric track circuits are installed, you must be careful to work the ballast below the rails, and the Committee has shown the ballast below the rails.

Mr. Hanna:—We thought that essential, and it was intended to provide that clearance under the rails.

Mr. Stevens:—It would add very much to the appearance of the track to have the ballast an inch below the top of the tie. Nothing is more untidy than to see ballast strewn over the top of the ties. The ballast will get high enough; the trouble is to keep it low enough. I am therefore in favor of keeping the top line of the ballast where it is.

The President:—Any further discussion upon this feature?

Mr. Hanna:—There is another point. We were instructed, by a motion a while ago to prepare sections for crushed rock and slag. I would like to have some expression on the proper slope or the proper width from the center to the foot of that ballast compared with what we now have.

Mr. McDonald:—Mr. Churchill is the man who has taken exception to this cross-section. I think he should be called upon to explain his objection.

Mr. Churchill:—I beg to say that I was not the one who attacked the cross-section. I followed some suggestions to the effect that too much money is spent in having a large quantity of stone ballast at the ends of the ties when it is not necessary. I think experience has shown that stone ballast will stand on a two to one slope, and that will decrease the total width of stone ballast section somewhat. I simply offered that as a suggestion in connection with the criticisms made early in the discussion that it was not necessary to have so much stone ballast beyond the ends of the ties.

Mr. Hanna:—That means that the suggestion of the two-to-one slope is all right. The members of the Committeee generally agreed with Mr. Churchill's views. The only reason we used something else was that there was a majority in favor of one type of the cross-section, and we thought it best to make that stable for gravel, and consequently we gave a slope that would be suitable for gravel.

Mr. Wendt:—My experience agrees with that of Mr. Churchill. We have a four-track road ballasted with rock, and after some experimenting we arrived at the conclusion that the rock ballast on the slope of two to one was about right, and that will certainly lessen the amount of ballast outside of the tie as compared with this section.

The President:—If there is no further discussion, the report of the Committee will be accepted and the Committee relieved with the thanks of the convention.

Mr. W. C. Cushing (Chief Engineer of Maintenance of Way, Pennsylvania Lines West of Pittsburg, S. W. System—by letter):—At the last annual convention several members made remarks during the discussion concerning the proper slope of ballast from the ends of the ties, and, quite rightly, in the writer's opinion, the Committee was instructed to make different ballast cross-sections for stone and gravel, respectively.

About two and one-half (2½) years ago, when the operating officers of our lines were discussing this question during an inspection trip, at which time the roadbed and ballast had been put in good condition and were properly dressed up, a careful watch was kept to determine which section of ballast appeared to be the most suitable and most easily kept in place. The sections which were marked for measurement are shown on the accompanying Plate "A," and they may be of some use to the Committee as a guide in working up their reports for the next convention.

Some time ago Mr. Thos. H. Johnson, Consulting Engineer of our lines, called the attention of the writer to an article in a German magazine, *Glaser's Annalen für Gewerbe und Bauwesen,* by Railroad Director Schubert, which describes in a clear manner, with the aid of drawings and photographs, the condition of roadbed and ballast, with which we are more or less familiar, but which the writer has never seen treated elsewhere with the same degree of carefulness and interest. Mr. Johnson had this article translated into English, and it is presented herewith, as a part of this discussion. This article contains much food for thought, and is especially valuable at this time, while the Association is considering the subject of proper formation of roadbed and depth of ballast under the ties.

The writer has experienced just such trouble with clay cuts as Director Schubert illustrates, and no doubt a great deal of the trouble is due to insufficient depth of ballast and lack of proper protection of the surface of the roadbed underneath, so as to prevent the clay from

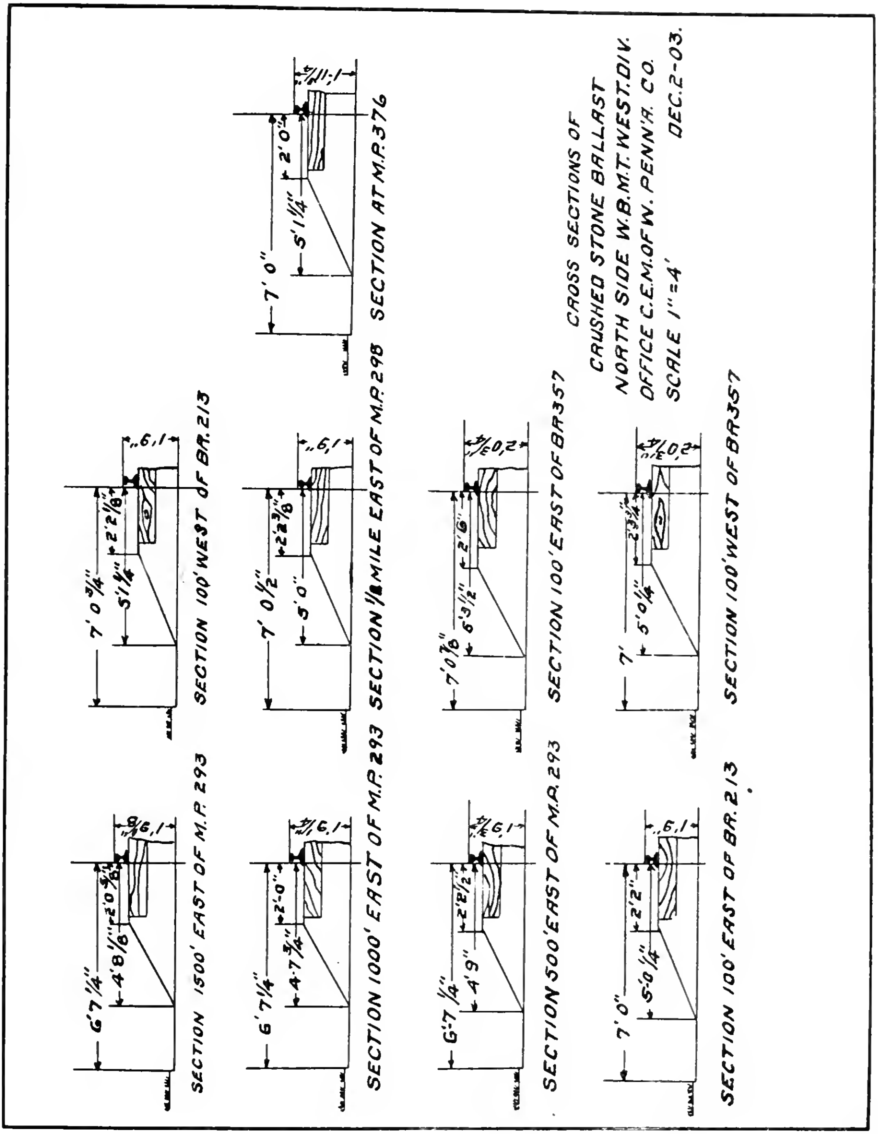

CROSS SECTIONS OF
CRUSHED STONE BALLAST
NORTH SIDE W.B.M.T. WEST. DIV.
OFFICE C.E.M. OF W. PENN'A. CO.
SCALE 1" = 4'
DEC. 2-03.
SECTION AT M.P. 376
SECTION 100' WEST OF BR. 213
SECTION 1/8 MILE EAST OF M.P. 298
SECTION 100' EAST OF BR 357
SECTION 100' WEST OF BR 357
SECTION 1500' EAST OF M.P. 293
SECTION 1000' EAST OF M.P. 293
SECTION 500' EAST OF M.P. 293
SECTION 100' EAST OF BR. 213

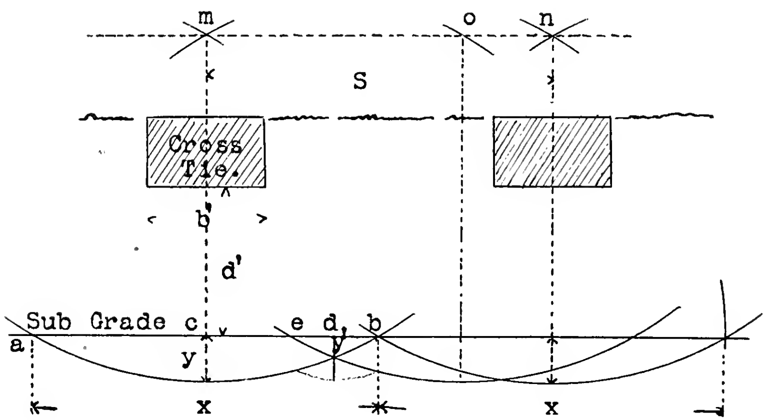
PLATE A.

oozing up. These adverse conditions are much more frequent and much more emphasized when the single-track railroad grows to four (4) tracks or more. They are also more emphasized in this country by the enormously heavy axle loads of our rolling stock, and it is time for the Maintenance of Way Engineer to endeavor to keep pace with the requirements of economical transportation, which has called into existence the heavy axle loads.

Mr. Johnson made a study from this report with a view to deriving a formula which would show the thickness of ballast necessary to produce an equal distribution of the axle loads on the surface of the roadbed underneath the ballast, and this study is also submitted herewith, as Plate "B."

DISTRIBUTION OF PRESSURES AT BOTTOM OF BALLAST.

For gravel $ab = x = b' + \frac{1}{2} d'$.
For stone $ab = x = b' + d'$.



The relatively small arcs will approximate to parabolas, and may be considered as such.

The intensity of pressures is proportional to the ordinates of the curve.

Areas of parabolic segment $= 2/3\ xy$; hence, mean ordinate $= 2/3\ y$, or mean pressure $= 2/3$ maximum pressure, or maximum pressure to $3/2$ mean pressure.

Pressure at $b = o$. Hence, to obtain an approximately uniform distribution over the surface of roadbed, the tie spacing S must be such that the curves overlap and have a common ordinate $y' = \frac{1}{2}\ y$. This will occur when $db = \frac{1}{4}\ cb$; or $eb = \frac{1}{4}\ ab$; or $mo = 3/4\ mn$.

Hence, tie spacing $S = 3/4\ x$.
For gravel $S = 3/4\ (b' + 1/2\ d')$,
or $S = 3/4\ b' + 3/8\ d'$.
$3/8\ d' = S - 3/4\ b$
and $d' = 8/3\ (S - 3/4\ b') = 8/3\ (23'' - 3/4\ (8'')) = 45'$.
For stone $S = 3/4\ (b' + d')$,
or $S = 3/4\ b' + 3/4\ d'$
and $d' = 4/3\ (S - 3/4\ b') = 4/3\ (23'' - 3/4\ (8'')) = 22\tfrac{2}{3}''$.

LECTURE DELIVERED BY RAILROAD DIRECTOR SCHUBERT BEFORE THE "VEREIN FUR EISENBAHNKUNDE," AT BERLIN, AT THEIR MEETING OF MARCH 14, 1899, ON THE ACTION UNDER THE TIE OF A RAILROAD TRACK.

From Glaser's Annalen für Gewerbe und Bauwesen, May, 1899.

From experiments made during the years 1887 to 1890, the results of which were published in the *Zeitschrift für Bauwesen,* Vols. 1889 and 1891, under the caption of "The Transformation of the *Planum* (i. e., Roadbed)," it was determined that in a railroad track whose roadbed consists of clay, a swelling of the same between the ties will not occur, even under the most favorable conditions, when the height of the bed "B" is increased 0.20 m. (8 in.) over the clear distance between the ties, whence $b = a + 0.20$ m. (8 in.). See Fig. 1.

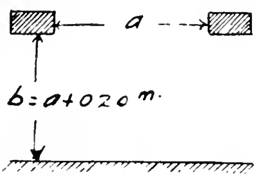


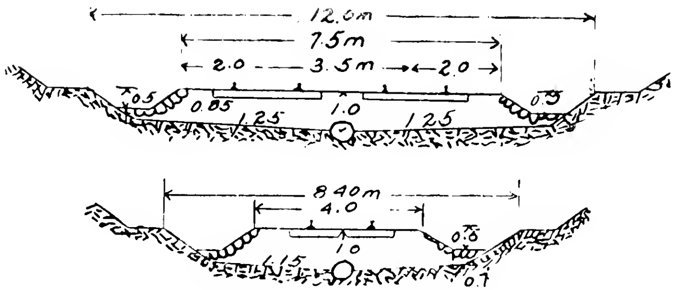
FIG. 1.

The entire results of the experiments made at that time lead me to suggest in place of the usual section for clay cuts and embankments, a cross-section, the base of which at the middle of a double track roadbed shall be 1 m. (3.3 ft.) below the base of rail; the cross-tie being 2.7 m. (8 ft. 6 in.) long. (See Figs. 2 and 3.) At the base in the middle of the section a tile or cement pipe of 0.3 (12 in.) to 0.4 m. (16 in.) perforated on top, should be laid, in order to secure complete drainage and freedom from the effect of frost. These pipes can be laid with a corresponding grade to the railroad through the cuts, and thence to the ditch along the road.

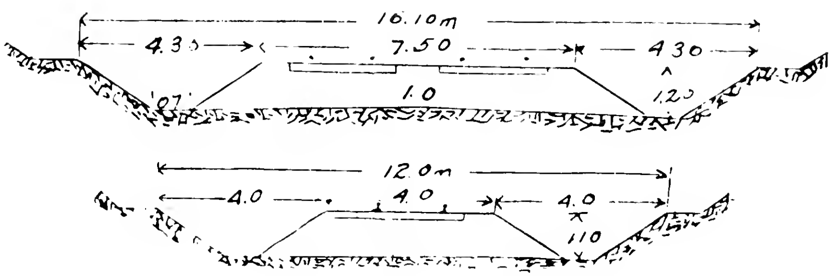
If we intend to maintain the old section of the roadbed, then it will be necessary to make the ditches 1.20 m. (4 ft.) deep in order to drain the bed, which is 1 m. (3.3 ft.) deep. The width of the cut is then of course about 4 m. (13.2 ft.) greater, and consequently more roadbed material is required.

It has been frequently asserted that this depth of ballast is too great, and it has also been said that my experiments did not demonstrate the actual conditions, inasmuch as they were only made on a scale of 1 to 10.

I admit the first assertion, as far as embankments of clay mixed with stone are concerned; that, in the use of plastic clay, however, such as is found in Lausitz, the results obtained from my experiments correspond



Figs. 2, 3—Cross-Section for Clay Cut.

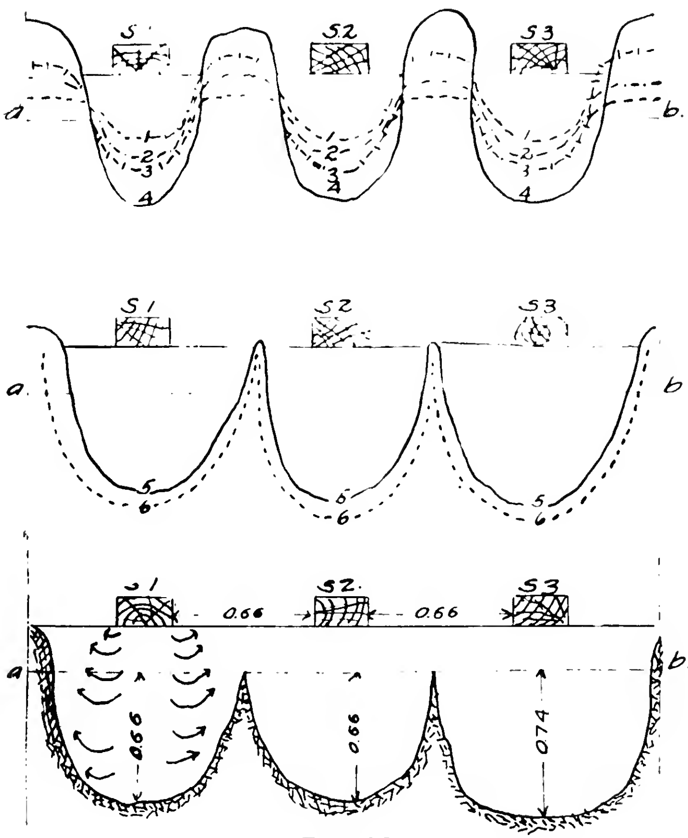


Figs. 4, 5—Cross-Section for Clay Cut.

with the actual conditions, I am prepared, this day, to furnish you the necessary proof.

In Figs. 6 to 11 you will find successively the various sections determined by the previous experiments with cross-ties. Figs. 6 to 8 represent the results of roadbed of rough gravel and Figs. 9 to 11 show the experiments from sand roadbed.

I would ask you to compare with the first mentioned illustrations the photographs in Figs. 12 to 14, which were taken from the existing roadbed of the branch railroad from Sorau to Benau, which was opened on September 1, 1896. In order to quickly and economically construct this road the ties were laid directly without the use of ballast upon clay. This practice, which unfortunately has become very common in recent years, has the disadvantage that very seldom the *minimum* height of ballast = 0.20 m. (8 in.), is provided afterwards, and the result is that in yielding ground, sinking under the ties will very soon occur, and the clay between the ties and also at the ends of the same will rise and



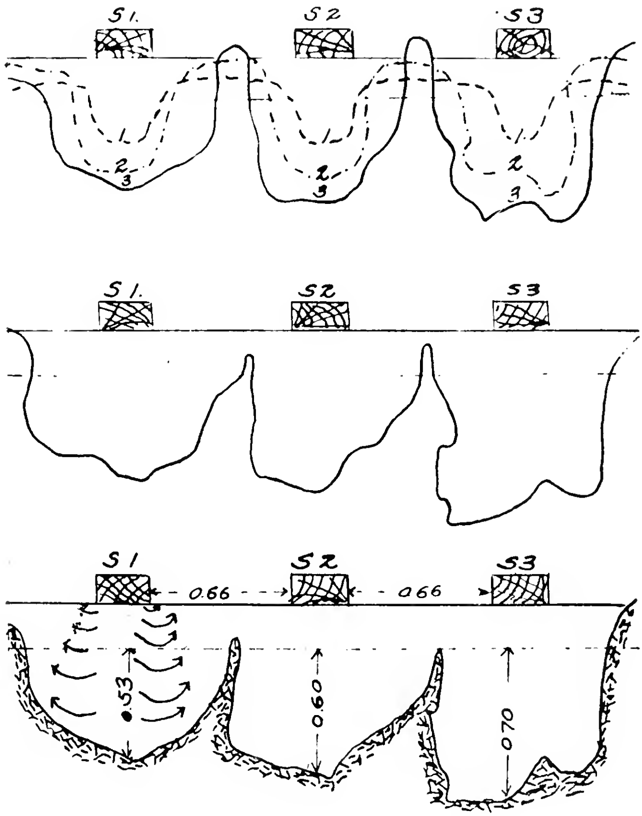
Figs. 6-8.

thus form a sort of trough under the tie, which is increased in size very rapidly in wet weather.

Fig. 12 shows a profile of a roadbed with a layer of about 0.6 m. (2 ft. 0 in.) of blue clay, which was taken on February 22, 1898, or about 1½ years after the opening of the railroad. The depressions under the ties are from 10 cm. (4 in.) to 15 cm. (6 in.) deep. On June 4th of the same year a second view was taken (shown in Fig. 13) which very clearly shows the progress of the same.

Still plainer is this progress shown in the view taken at the same place on March 10, 1899 (see Fig. 14), where the trough had reached a depth of 0.35 m. (14 in.).

I am indebted to Mr. Schweitzer, director of the Lausitz Railroad, for



FIGS. 9-11.

the illustrations of two longitudinal sections of the branch railroad from Teuplitz to Sommerfeld, which are both taken from clay cuts (km. 41.35 and 41.65), and are very interesting, for the reason that during the construction on account of the existing clay bed, a depth of 0.50 m. (20 in.) to 0.60 m. (24 in.) was given to the ballast, or about 0.3 m. (12 in.), or 0.4 m. (16 in.) more than the normal requirements.

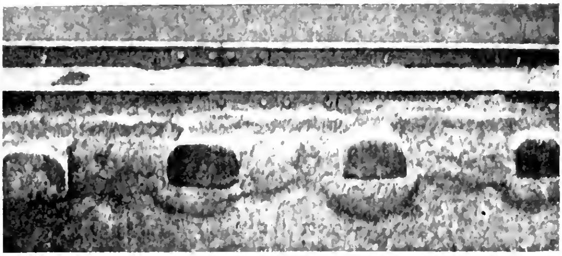


FIG. 12.

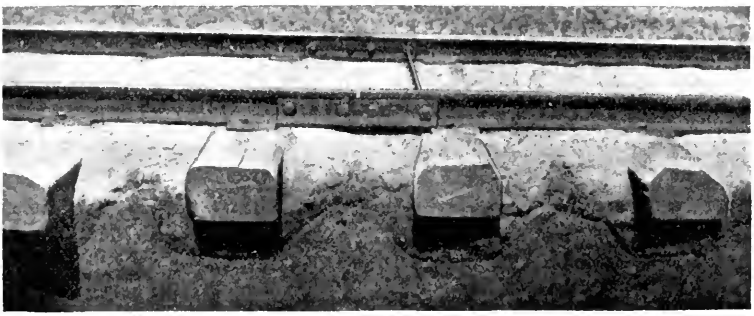


FIG. 13.

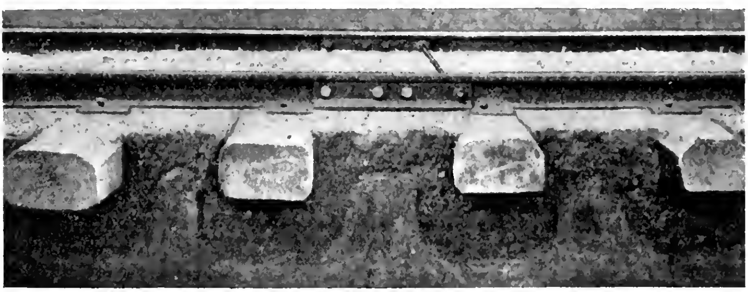


FIG. 14.

As you will see from Figs. 15 and 16, ribs of clay have formed in the ballast between the ties, which are about 0.8 m. (32 in.) apart. These ribs appear to be more or less regular.

The similarity between these views and the results obtained by me from experiments in 1887 and 1889 are quite noticeable. The views 12 to 14 correspond with the lines 2 and 4 of Fig. 6, where in both cases

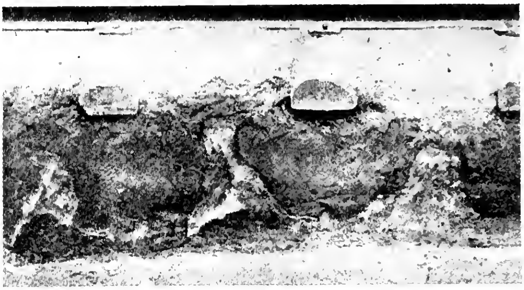


FIG. 15.

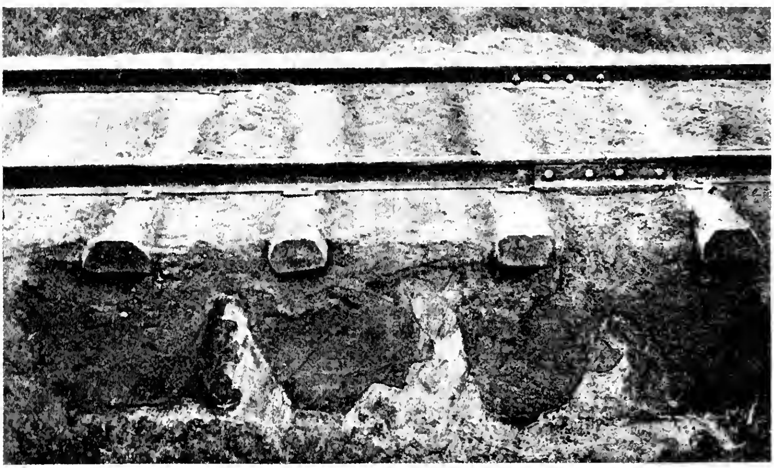


FIG. 16.

gravel ballast was used; and the views 15 and 16 correspond with line 3 in the Fig. 9, and that of Fig. 10, where the ballast consists of gravel.

Our standards prescribe a minimum depth of ballast of 0.20 m. (8 in.) and that the same shall be thoroughly drained. This depth appears to have been considered a maximum by most of the construction officials and without taking into account the character of subsoil.

Inasmuch as it has ceased to be the practice to put in ballast to the bottom of the ties before laying the track, the trough formation under the ties is practically introduced at the very start. From this it is very readily explained how the transformation should be noticeable in such comparatively short time of operation, as the photographic view shows us.

That the cost of maintenance of such places could be 5 to 10 times greater than the original cost of excavating the clay and the construction of a roadbed of 0.8 (32 in.) to 1.0 m. (39 in.) in depth hardly needs any proof. And especially when we consider that in order to secure the necessary foundation for the track a subsequent excavation of the clay will have to take place at any rate.

More extensive and of greater import become these transformations when the longitudinal stringer construction is used on a clay roadbed. It would therefore recommend itself that the requirements of the standards (4, Sec. 2) should be supplemented to the effect that in clay or quicksand embankments and cuts the depth of ballast should be at least 0.20 m. (8 in.) greater than the maximum distance between ties, and that the ballast can be of sand or other porous material up to a height of 0.15 m. (6 in.) below the bottom.

Three years afterward a greater number of experiments with the various kinds of ties and ballast upon clay and other sub-grade materials were made, the results of which were also published partly in the *Zeitschrift für Bauwesen,* and partly in the *Organ für den Fortschritt im Eisenbahnwesen.*

For the solution of the question, "Which ballast material affords the best distribution of force upon the subgrade (or roadbed)," the experimental box, which was 0.95 m. (37 in.) long, 0.50 m. (20 in.) high and 0.15 m. (6 in.) wide, was fitted with a layer of clay 0.20 m. (8 in.) high at the bottom, on top of which was placed a layer of sand 0.15 m. (6 in.) high, and then a layer of gravel 0.15 m. (6 in.) high, upon which a tie of T shape was laid. This tie was tamped with the ordinary tamping pick and then subjected to a load of 4 kg. sq. cm. (57 lbs. per sq. in.), or 8,200 lbs. per sq. ft., by which the rail level was depressed. By the use of an eccentric the loading was alternately lifted from the tie and again returned, thus imitating the process of passing a loaded wheel over the track. As soon as the tie had settled 30 mm. (1.2 in.), which was registered upon an attached sliding plate, the tie was again raised and tamped. From time to time photographic views and observations as to the stage or condition of the experiment were taken by removing the front wall of the experimental box. After the eleventh tamping the experiment was considered as complete, and the section shown in Fig. 17 was taken. From this view we can easily see how a short depression, measuring about 32 cm. (12 in.) to 36 cm. (14 in.) wide has been formed in the clay with an upward swelling on each side. The pressure transmitted from the tie has accordingly distributed itself over this small width when the depth below the bottom of the tie was 0.30 m. (12 in.).

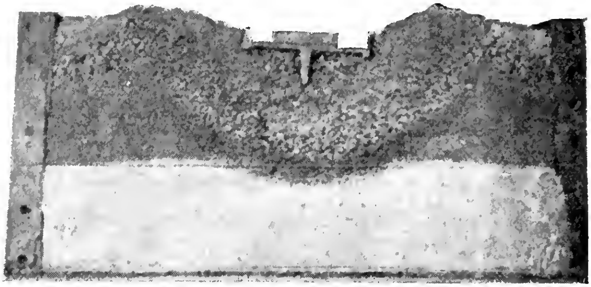


FIG. 17.

It is also interesting to note how a peculiar coffer formation had developed between the sand and gravel, whose circumference has a radius of 0.37 m. (14½ in.).

In a subsequent experiment broken stone was used in place of gravel, otherwise the procedure was the same. From a photograph of the section after the fifth tamping (see Fig. 18) a depression in the clay

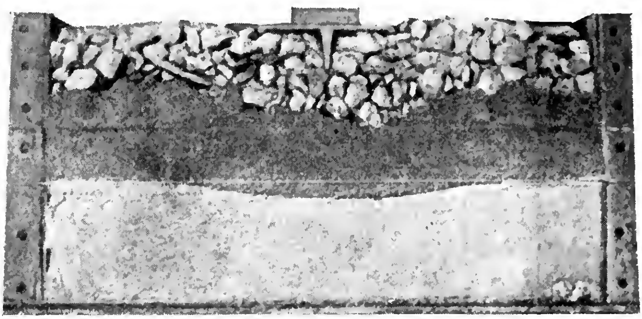


FIG. 18.

extending nearly over the entire width of the experimental box (0.70 m.—27½ in.—to 0.75 m.—29½ in.—wide) is noticeable. The distribution of the force is consequently double that of the previous experiment.

Still more favorable appears this distribution when the height of the stone ballast is increased; in doing this it is judicious to retain a thin layer of sand so as to prevent the larger pieces of broken stone from entering into the clay. As will appear from the section shown in Fig. 19, a depression in the clay has not taken place, and only a few of the broken stones have gone through the sand to the clay. In emptying the experimental box, only a very unimportant depression was noticeable.

Finally the behavior of a foundation layer was investigated, and

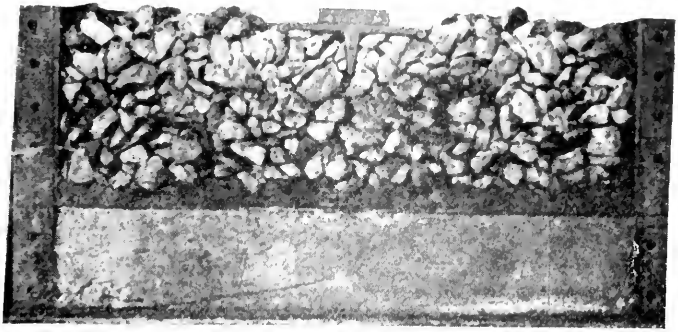


FIG. 19.

after the fourth tamping the section shown in Fig. 20 was taken. The stones of the foundation layer have penetrated the clay rather deep, and not only those in the center, but also the stones on the sides, from which we can conclude that the force transmitted through the tie has distributed itself nearly over the entire width of the box.

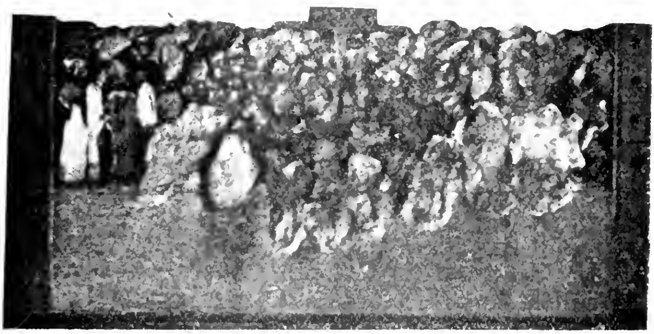


FIG. 20.

Hence the most favorable distribution of forces is accomplished by the use of ballast of broken stone, with or without a foundation layer. The latter is, however, not suitable in a yielding sub-grade, inasmuch as the stones penetrate into the same, and the yielding soil will swell into the spaces, thus making the drainage ineffective.

Another group of experiments covers the quality of the ballast material and its endurance under the pounding of the loads.

Trials were made with gravel from 6 cm. (2½ in.) to 12 cm. (5 in.) in size, and various kinds of broken stone from 3 cm. (1¼ in.) to 7 cm. (2¾ in.) in size.

At the end of each test after the sixth to seventh tamping, the stones were thoroughly dried and screened from 6 mm. (¼-in.) in size to dust. The resulting quantities of the reduced and pulverized ballast material, taking into consideration the number of blows employed in tamping, gave the measure of quality of the material.

At 1,000 tamping blows the following amounts of the various materials tested were transformed into dust:

	Litres.	Quarts.
Porphyry from the quarries at Neurode	1.25	1.13
Basalt from Sproitz	1.50	1.36
Basalt from Laubau	1.55	1.41
Graywacke from Wildeman	1.62	1.47
Carboniferous sandstone from Piesburg	1.76	1.62
Quartzite from Neisky	2.33	2.21
Granite from Moltke-felsen	2.64	2.39
Diorite from Saarbrücken	2.87	2.60
Slag from Julien Furnace	2.89	2.62
Slag from Menenkirchen	3.45	3.13
Granite from best layers at Striegan	4.02	3.65
Screened gravel from Sagan	4.54	4.12
Ordinary furnace slag	4.80	4.35

According to this, the harder stone is possessed of a resistance three times greater than that of gravel. And as the difference in lines of depression as found between stone and gravel led to a further investigation, it was found that the use of broken hard stone as ballast requires only about one-sixth to one-seventh of the material and only one-third the cost of labor for track maintenance compared with the use of gravel. From this, however, we should not reach the conclusion that it is advantageous to use hard stone ballast in all cases, for not only must we consider the cost of the same, but also the amount and character of the traffic.

In assuming the following prices:

	Cu. Meter.		Cu. Yard.
Stone ballast made of best hardstone	5 M.	=	$1.12
Stone ballast of medium quality	4 M.	=	0.74
Gravel ballast (screened)	2 M.	=	0.37

We find from a rough calculation that for a traffic of 2,000 axles per day the use of stone ballast made from the best stone is advantageous; where traffic ranges from 1,000 to 2,000 axles per day the use of stone ballast of medium quality is desirable, and with less traffic screened gravel or even ordinary gravel ought to be used. Should the broken stone be cheaper, naturally it would be better to use it where the traffic is less than stated above, and the same holds with the gravel where its price is low.

The quality of the gravel, i. e., the hardness of the same, must also be taken into consideration, for it makes a great difference whether the gravel comes from sandstone mountains or is taken from an ordinary gravel deposit, derived chiefly from primitive rock formations.

In the use of broken stone, besides the quality of the stone, the sizes of the individual stones is of importance to secure a solid foundation for the tie. If the broken stone ballast consists of stones from 3 cm. (1¼ in.) to 7 cm. (2¾ in.) in size, as it is mostly delivered, then with the use of an iron tie (see Fig. 51), it requires five or six tampings before it acquires a permanent position, i. e., enough of the stones under the ties must be reduced so as to fill up the vacant spaces. It is, therefore, advisable to retain in the broken stone pieces so small as 8 mm. (⅓-in.) in size, and even 6 mm. (¼-in.).

Such ballast (broken stone with small fragments) is generally about 0.5 M. (12¼ cents), or 9.3 cents per cu. yd. cheaper than the former, and besides has the advantage of securing a solid bed after the second or third tamping.

During my visit to Sproitz this year, where a great basalt quarry is in operation, I found a dump of material which the operators call "gries basalt kies" (small basalt screenings), and explained to me that it was the screening from broken stone. It varied from 6 mm. (¼-in.) to 30 mm. (1¼ in.) in size, and is not now used for railroad purposes. In examining the dump I found small broken material free from dust, which, in my opinion, is splendidly fitted for tamping. After an experiment on a small scale I obtained more of this material and met with very good results, particularly with the longitudinal superstructure.

The owners, the Sproitzer Quarry Company, have about 80,000 cbm. (155,000 cu. yds.) on hand, and are willing to dispose of the same at 2.50 M. per cbm. (46½ cents per cu. yd.). This offer seems very reasonable, and I can certainly recommend the material.

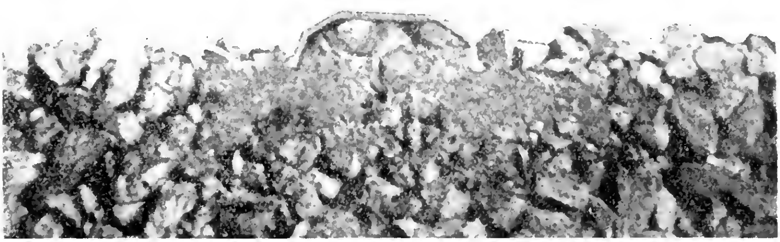


FIG. 21.

How the ballast under the tie in course of time becomes pulverized and thereby crusts the upper layer of the ballast, thus causing obstruction to the drainage, is shown in another test made with slag from Neuenkirchen.

The section shown in Fig. 21 was taken after the tie has been tamped six times with the originally even and pure broken slag, and was each time brought down 20 mm. (0.8 in.) by loading it. Only a small condensation is noticeable under the edge of the tie. In the section shown in Fig. 22, taken after the tenth tamping, the pulverization has assumed a greater proportion; it has even advanced into the coffer of the tie.

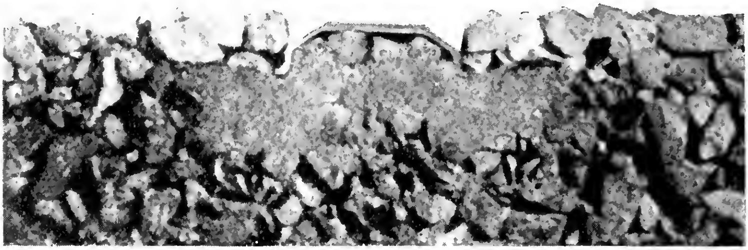


FIG. 22.

The third section (see Fig. 23), taken after the fourteenth tamping, and more so the section in Fig. 24, which was taken after the seventeenth tamping, illustrate very clearly the further progress in the destruction of the ballast. The pulverization has extended under the entire coffer of the tile and has penetrated the ballast 0.15 m. (6 in.) below the tamping

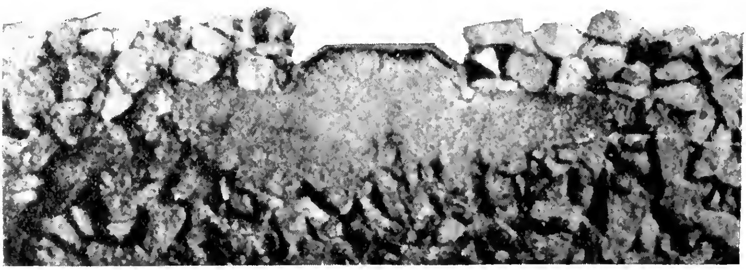


FIG. 23.

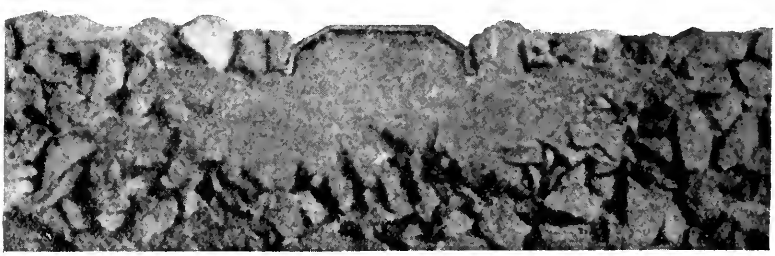


FIG. 24.

edge of the tie, extending on both sides from 20 (8 in.) to 24 cm. (10 in.). This body became so tight as to prevent water from going through, while the lower part of the ballast, even filled up with smaller parts, was still capable of discharging all surface water.

This general destruction of the ballast, called "mud pumping," and particularly so with the use of worn ties, is very noticeable in all tracks where the renewal of the ballast is not taken up in time. I might call this the weakest point in the entire maintenance of track, because wherever it occurs it is impossible to have a good track. The entire rail assumes a waving motion each time a load is applied, the ties become centerbound and the fastenings wear off and become loose, so as to require renewal in a very short time if the ballast is not renewed.

To a considerable extent the opinion still prevails that this mud formation is caused less through the destroying effect of tamping than through the swelling arising from the clay sub-soil. This impression, however, is erroneous, as we can readily see by excavating the ballast from under a muddy tie. We will always find with iron as well as wooden ties that the mud comes directly out from under the tie, and below it for about 10 cm. (4 in.) to 12 cm. (5 in.) we will find a crusty, dark-colored body, preventing any discharge, while at a greater depth, whether ballast is of sand, gravel or broken stone, it is found to be clean and with drainage properties.

In order to make this clear the following experiment was made: In the bottom of the experiment box a layer of clay was put: on it a thin layer of sand, and then broken stone of the best Striedauer granite, upon which the tie (pat. 51 of the Prussian State Railways) was laid, tamped in the ordinary manner, and the loads applied. After the first

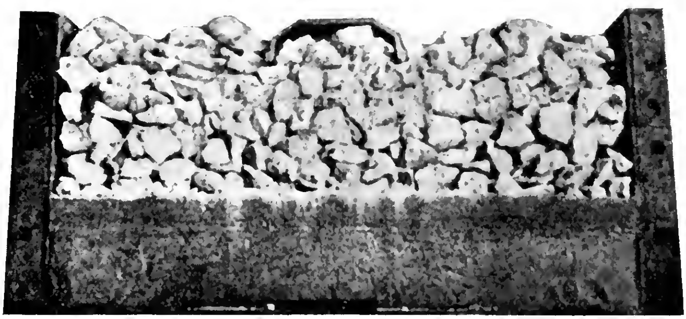


Fig. 26.

tamping the section shown in Fig. 26 was taken, from which no change is apparent.

A little more can be noticed after the fourth tamping, shown in Fig. 27, but a considerable progress in the destruction is noticeable after

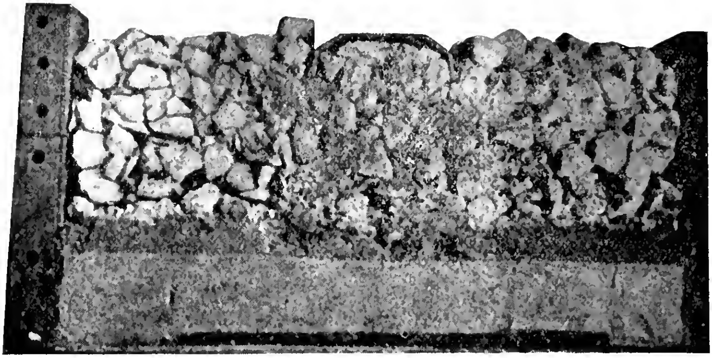


FIG. 27.

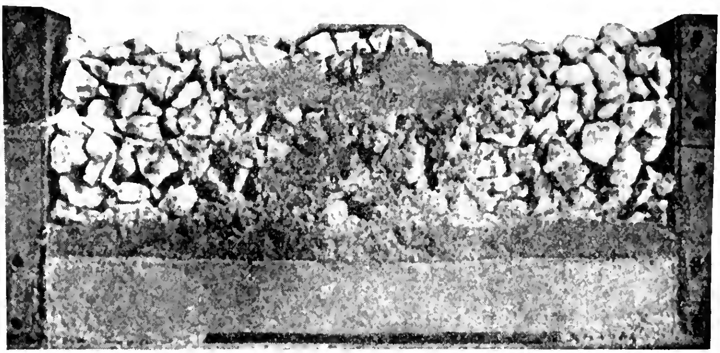


FIG. 28.

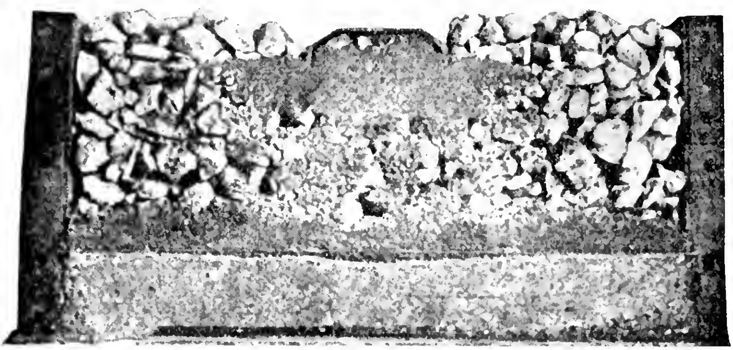


FIG. 29.

the eighth tamping, shown in Fig. 28, where we will notice the formation of a peculiar coffer under the tie, and also a slight depression in the clay. A swelling of the clay towards the tie has, however, not as yet occurred.

Fig. 29 shows a section taken after the twelfth tamping, that part of the ballast under the tie is thoroughly pulverized, and prevents drainage, while the lower part of the ballast will still let water go through. A swelling of the clay up to this pulverized formation is not as yet noticeable, but a depression in the clay extending over the entire width of the box, similar to that shown in Fig. 18. This again is an illustration of the favorable distribution of the loading, which can be obtained with broken stone.

The removal of the mud formation in gravel as well as broken stone ballast is best accomplished by a complete renewal of the ballast down to where drainage still exists, which generally takes only about 0.5 cbm. (0.65 cu. yd.) per linear m. of track, inasmuch as at least 0.2 cbm. (0.26 cu. yd.) of the old material can be used again after it has been dried and screened.

If the ballast is not renewed, as is the case generally where wooden ties are in use, a ditch should be made between the ties, reaching to the top of the still draining ballast (see Fig. 30), so that the water and

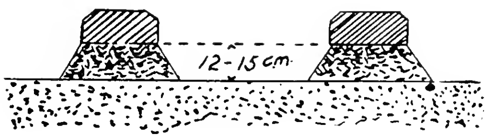
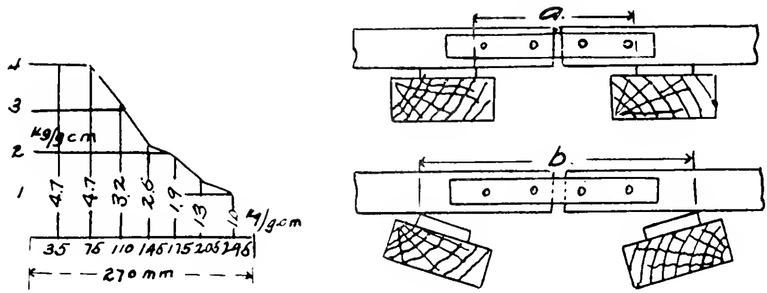


FIG. 30.

mud can discharge into the same; new ballast material should be used in filling up the ditch, which can eventually be used for tamping, etc. For this method about 0.25 cbm. (0.32 cu. yd.) per lin. m. of track is required.

Recently in an effort to strengthen the joint, the ties at that point were laid so close together (on the St. Gotthard Railroad, 0.15 m.—6 in.—between the ties) that it became impossible to properly tamp the ties from the side next to the joint. Partly the tamping of the ties from the sides of the joints has been purposely omitted, under the assumption that it is sufficient to tamp the ties from one side. This, however, is a mistake, and in order to prove this by figures a sufficiently loaded timber tie was placed upon selected fine sand, and after several ordinary tampings was raised about 3 cm. (1.2 in.) and then tamped from one side only. Afterward the tie was very carefully removed from its bed, and the firmness of the same was tested in the simple manner of loading a rammer (stamp) of 3 cm. square (1.2 sq. in.), and Fig. 31 shows the average loading line which was formed from several readings.

At about 70 mm. (2.8 in.) from the corner of the tie the resistance amounted to 4.0 kg. per sq. cm. (56.88 lbs. sq. in., 8,208 per sq. ft.), decreasing, however, very rapidly and becoming only 2.5 kg. sq. cm. (35.55 per sq. in., or 5,119 per sq. ft.) at a distance of 145 mm. (5.7 in.). From the last point the line of loading ran somewhat flat and showed at a distance of 245 mm. (9.6 in.) only 1 kg. sq. cm. (14.22 per sq. in.). The resistance of the untamped part of the tie is consequently only one-quarter as great as that of the tamped part.



FIGS. 31, 32, 33.

The tie must, therefore, on the application of a load, tilt toward the inner side, so that instead of the distance between supports ("a" in Fig. 32) a greater length occurs ("b" in Fig. 33).

In order to determine how far a one-sided tamping can extend, an experiment was made with a 40 cm. (15¾ in.) wide plank, thoroughly tamped on one side, and readings were taken which showed a resistance of 5 kg. sq. cm. (71.10 per sq. in.) at a point 9 cm. (3½ in.) from edge

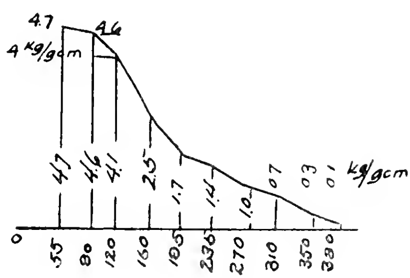


FIG. 34.

of the plank, decreasing, however, very rapidly to 1.7 kg. sq. cm. (24.17 per sq. in.) at a distance of 195 mm. (7.7 in.), and reducing to the hardly perceptible amount of 0.1 kg. sq. cm. (0.142 per sq. in.) at a distance of 38 cm. (15 in.). (See Fig. 34.)

The form of the tamping pick has also some influence on effective tamping. The form generally used is curved to a radius of 1.0 m. (3.3 ft.) (see Fig. 35), with which an ordinary-sized man can perform right good work, with ties having at least 0.31 m. (12.2 in.) (for wooden ties) of clear space between them. In shorter spacing a pick with a shorter radius must be used, and some are made with a radius of 0.6 m. (2 ft.). For wooden ties 0.26 in. (10.2 in.) wide and 0.16 m. (6.6 in.) deep, a minimum distance of 0.50 m. (19.7 in.) from center to center of tie is the limit for the use of curved tamping pick, when good tamping is expected. Iron cross-ties of the pat. 51 of the Prussian State Rail-

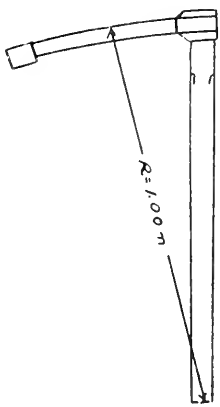


FIG. 35.

ways can be tamped at 0.20 m. (8 in.) and ties of T form even at 0.10 m. (4 in.).

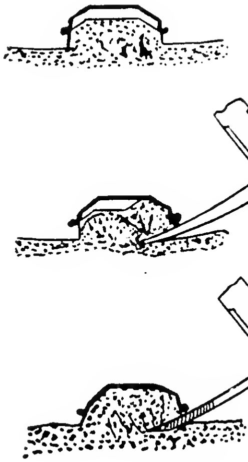
As a result of a debate which took place here about five years ago, at which Messrs. Heindl and Hohenegger were present, I have made a number of experiments as to the influence of the form of this tie, and I wish to inform you of the principal object I had in view. When an iron tie of hollow form is to be tamped it becomes necessary to loosen the ballast, and only after the rail has been lifted (see Figs. 36 and 37) can the ballast be forced into the hollow space of the tie (see Fig. 38). The extra work of loosening the ballast and forcing the same upward is peculiar to all ties of the hollow shape.

With wooden ties whose under surface is even the filling of the space caused by lifting the tie occurs at the time of lifting. It is the same with iron ties with a middle rib.

A result of these various effects is the fact, which is known to nearly all who are entrusted with the maintenance of the roadbed, that a *box-shaped tie* in gravel ballast will settle about 15 (0.6 in.) to 20 mm.

(0.8 in.) after tamping before the tie secures a solid bed, while a wooden tie will settle not quite half so much.

From a number of investigations made with various tie spacings it was further demonstrated that in both kinds of ties a reduction in the spacing is beneficial and that the cost of track maintenance for the various spacing of 95 cm. (36 in.); 75 cm. (27 in.); 55 cm. (18 in.), are in the ratio of 6 : 5 : 4, which agrees quite well with the results obtained in practice.



FIGS. 36, 37, 38.

Another result of the experiments showed that the cost of track maintenance for ∩ shaped ties compared with T shaped ties is in the ratio of 2 : 1 for gravel ballast. This, however, has not been verified from practice. It is, however, generally known that with the ∩ shaped tie, broken stone is used in tracks where, with the use of wooden ties, gravel would answer. The loosening of the ballast necessary at each tamping of the ∩ tie is no doubt extra work, compared with the wooden tie and ties of T pattern.

The sections which were taken from these experiments were at that time published in the *Zeitschrift für Bauwesen*, 1896 and 1897, and also in the *Organ für den Fortschritt im Eisenbahnwesen*, 1897, and I desire to call your attention to the fact that the form of ballast coffer found by these experiments was alike in both types of ties.

On the process which the ballast undergoes as to transformation and movement, Dr. Zimmer in his work, "The Calculation of Railroad Track," page 112, gives some theoretical calculations and discussions from which he found that the ballast tends to form logarithmical spiral lines leading from the top part of the tie. That such was also the case in my experiments can be seen in Fig. 39.

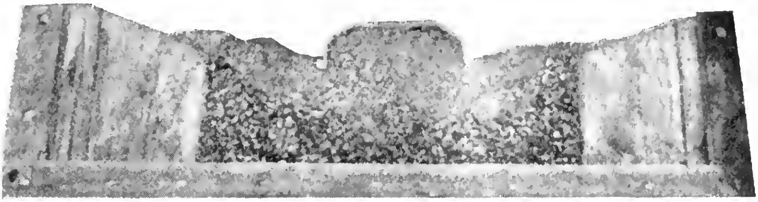


FIG. 39.

These movements are more prominent in moist ballast and less when in a dry condition; for that reason more trouble is experienced with the track in wet weather.

The same appearance occurs both with wooden ties and with the T tie. In the latter these movements follow very closely the shape of the tie, and this tie will perform its function best when the ballast is most compressed at the edges of the ties.

These advantages of the T tie lead me to recommend for use as cross-ties the shape of the longitudinal tie used as early as 1860 by MacDonnel on the Great Western Railroad. In doing so I have endeavored to devise a mode of fastening which requires neither clamp plates nor bolts, nor punching of the top part of the tie. The form of this tie was made /+\ The fastening is made of two parts, i. e., one clamp level and one wedge. Fig. 40 represents the first execution of this type.

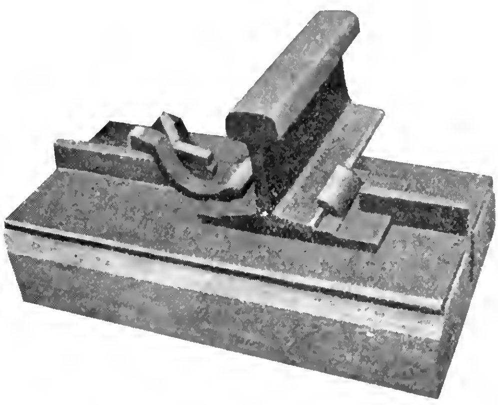


FIG. 40.

The rib in the top of the tie is cut out for the rail seat and the tie-plate which is fitted with lugs. The clamp lever is slotted, catching under the rib on top of the tie and resting with its short end on the foot of the rail, and the other end is fastened by means of a wedge riding upon the rib of the tie. Originally this wedge was smooth, but later was made toothed. The sample shown in Fig. 41 also shows the

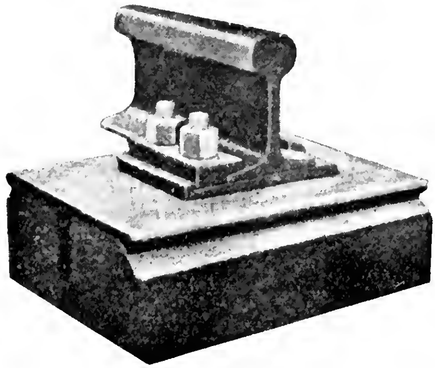


FIG. 41.

spacing of the ties at the joint, which by the use of these ties can be brought down to 10 cm. (4 in.) between the ties, without tamping being made difficult. The angle bars extend on both sides and also between the ties, thus transferring directly to the ties the thrust due to creeping.

The State Railway managements at Breslau and Kattowitz were each authorized by the Minister of Public Works to build an experimental line of 1,000 m. (3,280 ft.) in length. One of these lines, between Leignitz and Breslau, was laid in October and November, 1897, and the smooth wedge (Fig. 40), with a bent strip of tin, was used. Other kinds of fastenings were also tried, such as wooden wedges, clamp screws and lateral wedges, none of which, however, gave satisfaction. Then the arrangement shown in Fig. 41, with the long clamp lever and tooth wedge, was applied and has given perfect satisfaction.

The other experimental stretch is between Staventizitz and Kandrzim, where the traffic is from 60 to 70 trains per day, and with a grade of 1 : 100 (Kandrzim to Gleiwitz). It was built as shown in Fig. 41, except that teeth in the wedges were made slightly higher.

While it is out of the question to pass final judgment upon this type of construction, still we have been able to learn after three-fourths and 1½ years that these ties do not sink any more than the wooden ties and those of pattern No. 51, with which the line chosen for the experiment was laid. The joints are remarkable for their especially solid support.

It has also been proven that these ties are more easily tamped than any other form. For ordinary tamping no lever (or track jack) is needed.

In the district of Essen, on the State Railroads, a small experiment with this tie was also made, but no confidence was placed in the use of the wedge, and a bolt fastening was used instead.

Should the clamp lever fastening really prove a failure, or should the fear be realized that the slotting of the upper rib is a disadvantage, then of course it would be better to abandon the upper rib and adopt a construction of the type shown in Fig. 42. This the experiments will

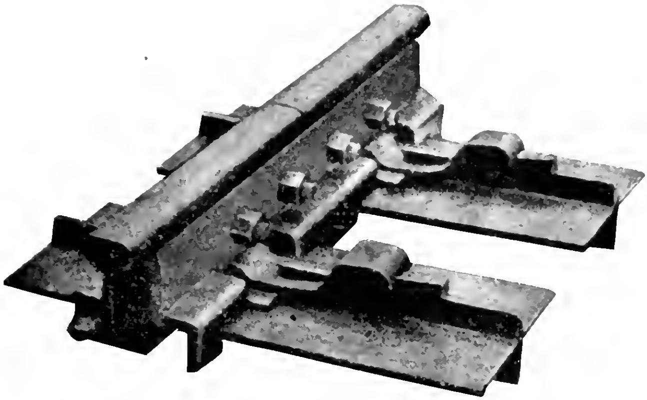


FIG. 42.

soon prove. But, in conclusion, I would recommend you use in place of a completely hollow tie of the usual shape, one with a middle rib, whether it be of the form described or not.

DISCUSSION.

Privy Counsellor of Construction, Mr. Blum:—I desire first to make a few remarks on the "packing layer." Mr. Schubert has stated that the packing layer works itself into the clay. It is necessary that the packing layer be technically constructed so that it will not be like an arch. Further, the sharp ends of the stone should be upward, then the evil complained of will not occur. What we see from the photograph is not a packing layer but mere stone put in rather regardless of any plan. It is quite natural that in a *bad* packing layer the stones should bury themselves in the clay, and therefore it is necessary to put in a thin layer of sand over the clay and then the broken stone; the packing layer, however, is considerably cheaper than broken stone, as no doubt is generally known.

I would ask if experiments with "basalt lava" have been made? This is the best stone ballast, for the reason that it retains its edges.

Regarding the tamping of the ties from one side, I wish to say that

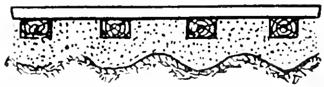


Fig. A—Longitudinal Section Showing Distortion of a Clay Roadbed.

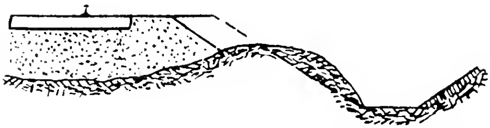


Fig. B—Cross-Section Showing Distortion of a Clay Roadbed.

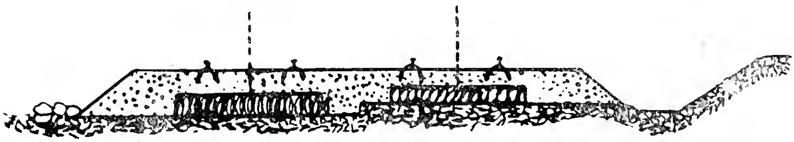


Fig. C—Section of a Roadbed with Packing Layer Constructed Through a Clay Cut in 1879.

Fig. D—Section of Roadbed Shown in Fig. C as Found in 1888.

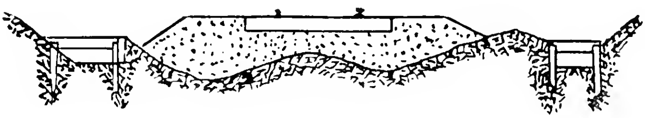


Fig. E—Section of a Single-Track Roadbed Built in 1873, Showing Vertical and Lateral Distortion of Subsoil.

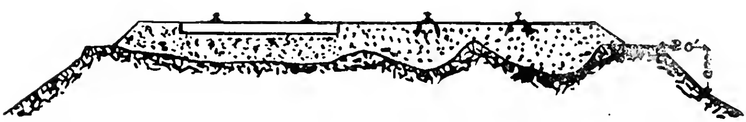


Fig. F—Section of Double-Track Roadbed on Clay Embankment Built in 1873, Showing Distortion Both Under Cross-Ties and Longitudinal Sleepers.

Mr. Wassutizky made observations on the Warsaw-Vienna line, from which it was found that the support of the ties is still open to question, even though the ties are put close together; therefore if the ties were laid so close as to touch each other and tamped from the outside, we would meet with better results.

As far as the tie with a middle rib is concerned, it beds itself very well; while with a hollow shaped tie the support is always uncertain. In the tie described by Mr. Schubert, I find, however, the weakness in cutting out the rib where it is most needed; therefore the greater resistance which is thought to be accomplished through the middle rib is again removed.

Mr. Schubert:—Experiments with basalt lava have not been made.

The speaker referred to an ideal packing layer, which could only be constructed with considerable difficulty and surely cannot be made in practice. I would rather recommend that the stone be laid flat, tightly against each other; for it is all important to prevent the clay from coming through the stone. The packing layer shown in Fig. 20 was originally placed tightly together upon the horizontal surface of the clay; the stones under the tie were accidentally placed with their broad sides vertically to the view, the other stones stand differently, however, and these, even though they are more distant from the center, have penetrated the clay.

Privy Counsellor of Construction, Mr. Wolff:—I can only confirm Mr. Schubert's statement that ideal packing layer cannot be had in practice and that it is better to use sand. I have noticed the upswelling of clay in broken stone ballast 70 cm. (27.5 in.) deep.

REPORT OF COMMITTEE NO. XIV.—ON YARDS AND TERMINALS.

To the Members of the American Railway Engineering and Maintenance of Way Association:

Your Committee on Yards and Terminals submits herewith its seventh annual report. This report is principally the result of conference by correspondence.

The work of the year has been devoted mainly to the subject of hump yards, especially in regard to the profile of the hump and the results of operations of yards of this class. In addition to this, there has been some revision of the definitions and conclusions submitted in former reports.

A.—YARD AND TERMINAL IMPROVEMENTS.

One of the notable feature of the extensive railway improvement works that have been carried out during the past few years (and are still in progress and projected) is the number of cases of reconstruction or improvement of yards and terminals. This is, however, but a beginning in view of the rapid growth of traffic and the consequent necessity of proper facilities for handling it promptly, efficiently and economically. In fact, it is hardly too much to say that yard improvement and terminal facilities deserve as much attention as the revision of grades and curves. This applies not only to large city terminals, but also to division yards in which the traffic must be handled on its way to destination. In this connection your Committee thinks it of sufficient interest to quote the following extracts from an article in the *Iron Age* of September 7, 1905:

"The transportation facilities of the country broke down under the weight of prosperity in 1902 and 1903, not so much because the supply of locomotives and cars was insufficient, though that was a factor, as from the utter inadequacy of terminal facilities. It will be recalled how the president and other leading officers of the Pennsylvania Railroad spent days at Pittsburg when the freight blockade of early 1903 was at its worst, concentrating the managerial talent of the entire system upon a problem that for weeks had been drifting into a hopeless state.

In every important railroad city in the country the question of terminals has been a threatening one for years. Naturally it is one of infinite difficulty, the acquisition of needed property being often a matter of years. Moreover, expenditures for terminals have so much of the element of providing for the distant future that directorates find it expedient to postpone them and put money into equipment that can begin paying its way the day it is delivered from the maker. Frequently the heavy outlay involved in terminal improvements and the obstacles to financing them in times of slack business have put them off indefinitely. Yet it has been demonstrated time and again that the returns terminal expenditures would have yielded in the next burst of prosperity following their completion would have paid interest on the money for years.

"What is spoken of as the 'usual car shortage' of crop-moving time is already having attention in trade forecasts. If it becomes accentuated in the next few months, it can be set down as due not so much to the lack of engines and cars as to the continued failure to adopt and carry out through thick and thin a policy of providing adequate tracks and yards at the centers in which freight congestion has been most aggravated."

B.—BIBLIOGRAPHY.

A bibliography of literature on the subject of yards and terminals generally was given as an appendix to the Committee's report last year, and this will be brought up to date by a list of some of the most important papers on the subject in technical literature published during the year 1905, and printed in a later Bulletin.

C.—HUMP YARDS (DESCRIPTION).

The main functions of a railway yard are to receive trains passing over the road, to separate and classify the cars for their proper destinations, and to put the cars together into trains for forwarding. An important consideration is that this should be done in the most economical way, both as to time and cost, and the evidence at hand seems to show very conclusively that these results can best be attained in the "hump" type of yard. In the replies received by the Committee, the opinions expressed were almost universally in favor of the hump yard as compared with other types, and the advantages were summarized by one writer as follows:

"Hump yards, in my opinion, are very much more rapid in their work and in the handling of cars than any other types of yards in general use. If thoroughly equipped with engines of sufficient tractive power, humps of proper grades, enough riders to handle each cut of cars without delay, and a proper system of marking cuts and indicating to the switchmen where they go, the yard will not only work faster than any other type, but will do it at less cost, and with much less damage to the cars and to the merchandise handled in them."

On the other hand, it must be remembered that the hump yard is still in its infancy as to design and in a minority as to actual numbers. Consequently, an absolute unanimity of opinion cannot be looked for, and this type must be expected to have some opponents. One objection that has been made is that cars are more liable to be damaged when handled in this way by gravity, but this is quite at variance with the experience of most of those who have had such yards under their charge. It is, of course, possible that in a yard improperly handled considerable damage might be done, but this is no argument against the type of yard.

A hump yard is one in which the movement of cars is produced by pushing them over a summit, beyond which they run by gravity. A train of cars to be separated or classified is slowly pushed over the summit, each car or cut of cars being uncoupled and acquiring an impetus on the steep down grade which enables it to run onto the proper classification track by gravity without other assistance. A car rider or brakeman boards each car or cut of cars as it starts down the grade and controls it so as to stop it at the desired point on its track and to prevent damage due to cars being run together at too high a speed. The movement from the base of the summit may be facilitated by an assisting grade. Connecting or run-around tracks provide for the movement of cars which do not require to pass over the hump.

To provide for the proper performance of its work the yard should comprise receiving tracks, classification tracks, and departure tracks. The receiving tracks should be of sufficient length to hold a maximum train and sufficient in number to receive in quick succession a number of trains which may have been detained out on the line by a wreck or other cause. This number of tracks will, of course, depend upon the amount of traffic on the road. The grade of the receiving tracks should be such that one engine can push the entire train over the hump.

The receiving tracks are connected with the classification tracks over the hump by switches in such a way that cars on any receiving track can be pushed over the hump into any classification track. The tracks approaching the summit should be on a slight up grade to ensure that the cars are closed up so that they can be readily uncoupled at the hump without causing delay.

Hump yards cannot be properly operated without riders on the cars, and in considering the accelerating grades for the hump this fact must be borne in mind. The descending or accelerating grades of the hump should be such that the cars will run by gravity from the summit to their proper destinations on the classification tracks. The exact grades must be determined by experience with the class of business handled and the local conditions. The amount of elevation and rates of grade required will vary with different kinds of cars and traffic handled, and also with the varying climatic conditions: that is to say, loaded cars will run more easily than empty cars, and the cars will run more easily in summer than in winter. The details, therefore, vary in practice in different yards. Some examples are given in this report. (See also Appendix No. 2.)

The tracks in the classification yard need not, as a rule, be of sufficient length to hold full or maximum trains. Their length will depend upon local conditions and the number of classifications needed. A length sufficient for half a train is usually enough, provided a sufficient number of tracks can be put in to allow of the number of classifications wanted for the different destinations and for bad-order and hold-over cars. It is desirable to keep the distance from the hump to the end of the switches as short as possible, and for this purpose the "double-V" shaped layout for switches is usually the best. (See Appendix No. 1; Enola Yard; Fairview, Pa.; Pennsylvania Railroad.)

Beyond the classification tracks are located the departure tracks. These should be of full length to take a maximum train, and of sufficient number so that trains can be pushed from the classification tracks as soon as they are made up. These tracks should be provided with a compressed air plant for testing the train brakes and hose so that there will be no loss of time by requiring the road engine to do this service. In some cases the cars are made up into trains on the classification tracks which thus serve the double duty of classification tracks and departure tracks. The tracks of a classification yard so used should be of full train length.

The cars on any one track in the classification yard are, as a general thing, not arranged in proper order for handling in trains. A considerable amount of shifting has therefore to be done in order to put the cars in proper train order, and it has been suggested that this part of the work might be greatly facilitated by passing the cars over a second hump into the departure yard. Inquiry was made by the Committee to see if this plan would be considered advisable, but the replies received were almost unanimously opposed to the use of a second hump for this purpose.

D.—HUMP YARDS (OPERATION).

The Committee has made a special endeavor to obtain information as to the operating results of hump yards, and is able to put on record some valuable information in this direction. The comments and statement made in regard to each case are made by the persons furnishing the information.

In regard to the engines employed for pushing the trains over the hump, attention may be called to the immense locomotives of the decapod (0-10-0) type, specially built for this purpose in the gravity yards of the Lake Shore & Michigan Southern Railway. These have a tractive power of 57,000 lbs., as compared with 28,200 to 38,220 lbs., for other engines noted in the records given below. The dimensions of the engines for the Lake Shore & Michigan Southern Railway are as follows:

Cylinders	24x28 in.
Driving wheels	4 ft. 4 in.
Wheelbase, engine	19 ft. 0 in.
Wheelbase, engine and tender	45 ft. 5½ in.
Boiler, diameter	6 ft. 8 in.
Boiler pressure	210 lbs.
Firebox	9 ft. x 6 ft. 1½ in.
Weight, engine	135 tons.
Weight, engine and tender	210 tons.
Tractive power	57,000 lbs.

HASELTON YARD (PITTSBURG & LAKE ERIE RAILWAY).—The following statement concerning the handling of cars in this yard was the result of observation of the work done in the yard by a man placed there for that purpose on November 16, 17 and 18, 1905. The time selected had no relation to any particular movement being made through the yard, and as the observations were made without the knowledge of the operating officials, they represent a fair daily average of the work done:

Number of trains observed	35
Total number of cars observed	1,242
Total number of cuts	494
Average number of cars per train	35.5
Average number of cuts per train	14.1
Average number of cars in cut	2.51

Total time consumed from time draft starts for hump until cars are disposed of and engine returns and clears hump track.	525	minutes.
Average per train	15	"
Average per car	0.42	"
Total delays at hump awaiting rider	115	"
Actual time required to handle said cars over hump (525 less 115)	410	"
Average per train	11.71	"
Average per car	0.33	"

During the time of observation one train of 44 cars with 5 cuts was handled over the hump in 8 minutes.

Average time per car.....................0.18 minutes.

Total number cars handled over this hump:

September, 1905—day	15,919
September, 1905—night	13,163
October, 1905—day	17,260
October, 1905—night	13,853
Average in 24 hours	987

Full crew at Haselton hump is as follows:

1 Engineman.
1 Fireman.
1 Conductor.
1 Brakeman (with the engine).
1 Brakeman (to cut the cars).
8 Riders.
2 Switchmen.

The trains are handled as follows: Upon the arrival of a train in the receiving yard it is inspected and the yard clerk takes a list of the cars in the train in their order and brings it to the yardmaster's office, where the conductor makes out a list of the cuts in the train in their order, designating the destination of each cut. This list is furnished to each switchman and the train is classified in conformity with it. It takes about 25 minutes to make the average train ready for classification. (A profile of the hump in the Haselton yard is given in Fig. 12.)

Elkhart and Collinwood Yards (Lake Shore & Michigan Southern Railway).—These are among the most recent of large hump yards, and are notable for the enormous engines used (as noted above). Each of these yards has two humps, and a partial plan of the Elkhart yard is shown in Fig. 1. The grades for each hump are as follows:

Committee on Yards and Terminals.

ELKHART YARD, L. S. & M. S. Ry.

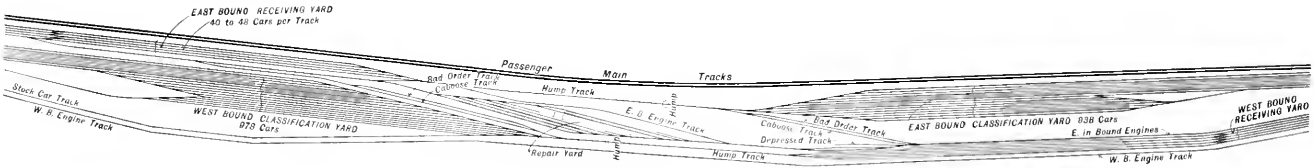


Fig. 1—Elkhart Yard, Lake Shore & Michigan Southern Railway

Eastbound, 0.83 per cent. for approach, 0.85 per cent. to summit, 4 per cent. accelerating grade, and 1 per cent. on the leads to the classification tracks. Westbound, 0.63 per cent. for the approach, 2 per cent. to the summit, 4 per cent. accelerating grade, and 2 per cent. and 1 per cent. for the two leads on opposite sides of the classification yard. One engine (0-10-0 type) of 135 tons is used for each hump, having a tractive power of 57,600 lbs. As an average there are nine riders to each hump (nine by day and eleven at night at Collinwood). The switches are operated by hand, with three switchmen to each hump. At the Collinwood yard four switchmen are employed by day and by night, but as the humps are opposite each other, it is possible to double up the switchmen so as to work two crews day and night with twelve men. The westbound classification yard has 18 tracks: 7 for 90 cars, 1 for 130 cars (stock-car cleaning track), and 10 for 45 to 55 cars each. The eastbound classification yard has 14 tracks: 7 for 90 cars and 7 for 45 to 55 cars each. The cuts are designated by means of a switch list, copies being furnished to the switchmen and to the conductors who attend to the cutting of the cars. The list shows the number of cars in each cut and the track upon which they are to go.

As many as 130 cars have been handled in one train over the hump at the Collinwood yard, but the average is from 70 to 80 cars at both Collinwood and Elkhart. The number of cars in each cut varies very much, but averages six cars westbound and three cars eastbound, the westbound trains being more solid on account of having already passed through the Collinwood yard. At Collinwood they average 60 cuts per train westbound and 40 cuts per train eastbound. The average time required for classifying the maximum train varies according to the number of riders employed. The trains are handled rapidly, and at Elkhart nine cuts will go over the hump in less than ten minutes; if there are more than nine cuts in a train there is a delay, of course, while waiting for the riders to return. At Collinwood a maximum train can be properly classified in about 25 minutes with ten riders, but when able to double up with men from the other humps this can be reduced to 10 minutes. The number of cars put through the Elkhart yard in 24 hours is about 2,000, or from 1,600 to 2,900. At Collinwood the average over each hump is about 900 cars, the maximum capacity of the hump being considered as 100 cars per hour; the movement through the entire yard is about 5,500 cars; but of course a large number of cars are not handled over the hump.

The hump yard is considered far superior to other methods both as to speed and economy, the economy implying not only less damage to cars but also greater service from the terminal plant. As to the economic handling of cars, it is estimated by the officials furnishing the information as to this road that as a general proposition a business of 1,500 cars and upward per day that require grouping, would justify the adoption of a hump yard. The advantages of such a yard are felt to a much greater extent at the next division terminal than at the yard itself.

As to the advisability or practicability of passing cars over a second hump beyond the classification yard in order to put them in order for trains in the departure yard, this depends upon the volume of business and whether or not the conditions justify the holding of cars of some particular class to make full trains. As a rule, two or three groups are run in each train, and with a sufficient number of classification tracks a second hump would be not only unnecessary but inadvisable. It is also considered that for grouping cars on the departure tracks, switching on the flat is cheaper and more satisfactory, because the cuts would be larger and consequently require a greater number of riders on each cut to control it. In addition, the length of yard would be increased too much. A departure yard should lie at the extreme end of the classification yard, and so connected that the groups could be pushed readily into the departure yard and run therefrom without again handling them, this yard being practically a storage yard for completed trains. It is further stated that a departure yard for a large business is quite desirable as a relief yard in cases of shortage of power or delays from other causes, but as a daily proposition it simply me..s one more yard movement an1 considerable cost and delay.

West Albany Yard (New York Central & Hudson River Railroad).—The grades and arrangement of summit are shown on the accompanying profile (Fig. 2). Two engines, day and night, are used in classifying cars over the summit. These engines are the heaviest switching power; their rating is 34.3 per cent.

The number of car riders varies. In October, 1905, there were twelve, but during the heavy rush of eastbound freight there are sometimes as many as twenty car riders in that part of the yard during certain periods of the day. When the business is light this number is often reduced to eight. The switches are operated by hand. Five switchmen are employed, each man having charge of five switches.

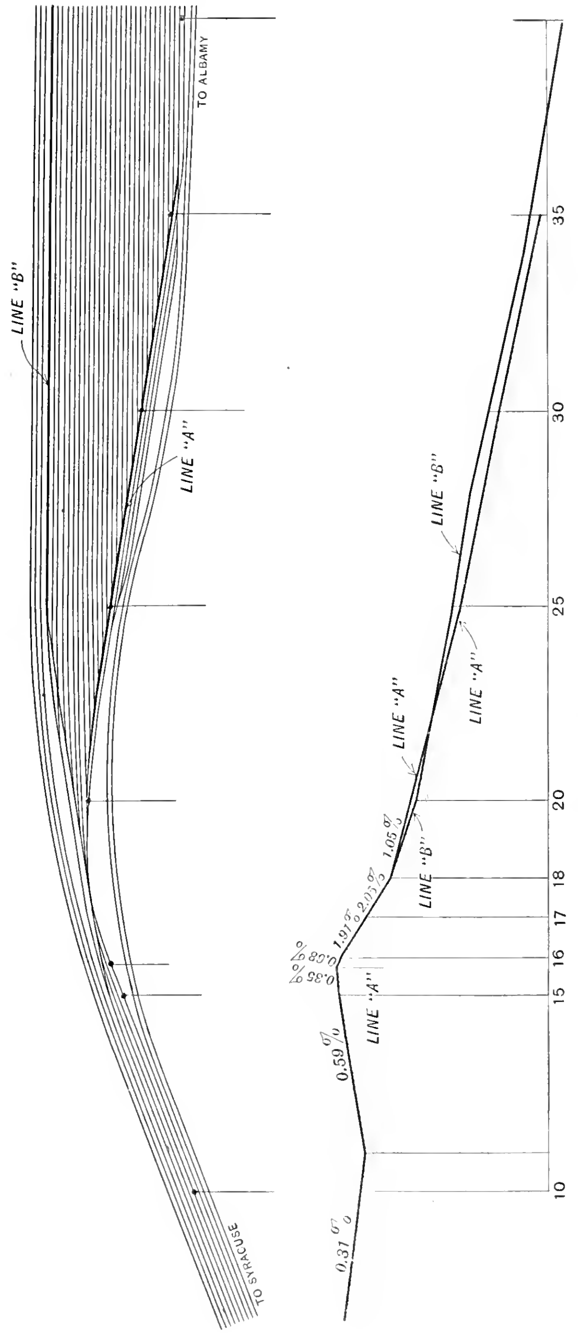


FIG. 2—PROFILE OF HUMP AT WEST ALBANY, N. Y. C. & H. R. R. R.

There are twenty-five tracks in the classification yard, and the length of these tracks is 2,450 ft.

For designating the number of cars of each cut, the cars are switched from chalk marks placed on them by the car marker, the necessary information being obtained from the running slips. The chalk mark shows the destination, grouping and tonnage.

The number of cars handled in one train over the summit varies according to the number of cars arriving in trains from the west. Ordinarily the 85-car trains are cut in two parts, as this facilitates the handling, but in some cases full trains of 80 cars have been handled. The average number of cars per cut over the summit is 1¾. From 70 to 75 cars per hour are handled over the summit, and an average of 1,200 eastbound cars are handled over the summit each 24 hours.

The opinion as to the value of summit or hump yards is that the "hump" switching greatly facilitates the work of handling cars in the yard and is much more economical than the old method of tail switching, as there is a large decrease in the number of cars damaged by switching in this part of the yard. Under the present conditions and arrangements for handling the eastbound business at West Albany it is not believed that a second "hump" in the classification yard would be of any material assistance, as there is not a sufficient number of cars of any one group to make a full train, it being necessary to double up several groups in order to get a sufficient number of cars for a train. An advance or departure yard should be so arranged that the work of starting trains with road engines and crews will be entirely uninterrupted by the handling of trains from the classification yard. In order to do this there should be sufficient space between them to enable the engines to continue their work without interruption.

Hawthorne Yard (Chicago, Burlington & Quincy Railway; Lines East of the Missouri River).—This yard is between Hawthorne and Clyde, Ill. The profile is shown in Fig. 3. The grade of the hump at the steepest part is 3.2 per cent., and length of hump proper is about 250 ft. The ladder has a grade of about 0.5 per cent. and is about 500 ft. long. The plan and profile show the layout of track and grade in detail. Two engines are used in classifying cars over the hump, working from 9 a. m. to 9 p. m. A scale is located on the hump and cars are weighed when switched. The tractive power of the engines is 28,200 lbs. each. Eight men are employed as riders. The switches are operated by hand; three switchmen are employed with the engine—two to throw switches and one to uncouple cars on the hump. There are twenty tracks in the

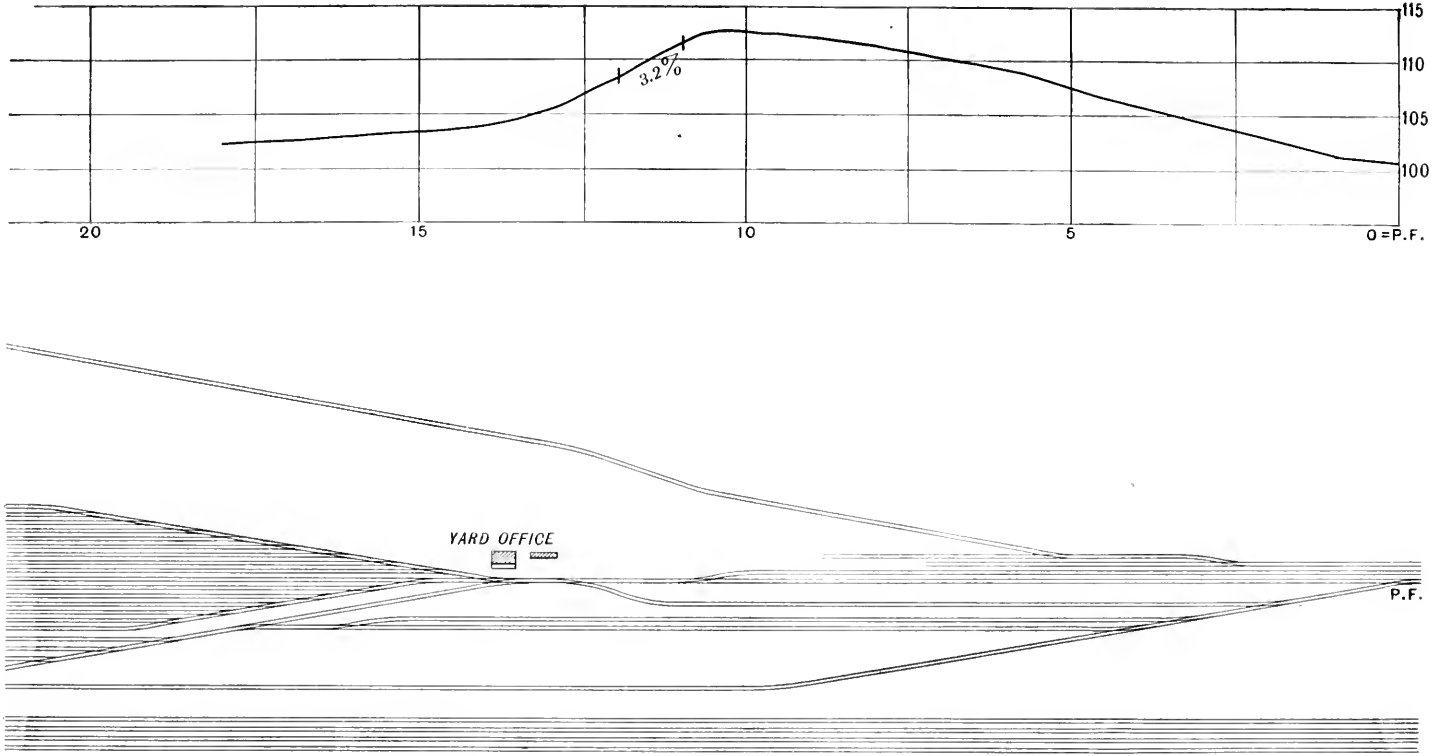


FIG. 3—PROFILE OF HUMP AT HAWTHORNE, ILL., C., B. & Q. RY.

classification yard. The length of classification tracks varies from 20 to 35 cars each. The method of designating proper cuts of cars is to mark on the leading end of the car in chalk the number of the track on which it is to go, indicating to the men throwing switches the track they are to line up. Whenever it is wet or dark a list is made simply showing the cuts of cars without numbers and the tracks on which they are to go.

The maximum number of cars handled in one train over the hump is thirty. The average number of cuts per maximum train is approximately twenty. The average time for classifying trains when all conditions are favorable is approximately fifteen minutes. The average number of cars passing through the yard in 24 hours is approximately 600, of which 400 pass over the hump.

The value of a summit or hump yard in comparison with other yards depends upon the amount of switching done. If a train has to be cut in small parts the hump is valuable even when a comparatively small number of cars are switched. If, however, a train only requires one or two cuts, the hump is somewhat of a detriment and there would have to be a very large traffic before it would be economical.

The same remarks are true of a second hump. A very large amount of switching and the necessity of having cars in train in station order might make it economical to have this second hump, but it would only be in exceptional circumstances that a second hump would be advisable.

If such a departure yard were necessary it should be so arranged that the second hump would be just beyond the first classification yard where cars are received from the first hump. The second classification yard would be beyond the second hump, and the departure yard beyond that. However, all yard arrangements depend to a very great extent on the locality to be served.

East St. Louis Yard (Terminal Railway Association of St. Louis).—The hump yard is located at East St. Louis, parallel with and next to the receiving yard. The grades, etc., are shown on the accompanying profile, Fig. 4. One engine is used in classifying cars on the hump. The tractive power of the engines is 34,000 lbs. Fourteen car riders are employed when business is heavy, and from eleven to twelve when business is light. The switches are operated by hand. Three switch tenders are employed to throw the switches. There are sixteen tracks in the classification yard. The length of these tracks is about 1,500 ft.

For designating the number of cars to each cut, cards are attached to the cars by yard clerks, showing the destination or connec-

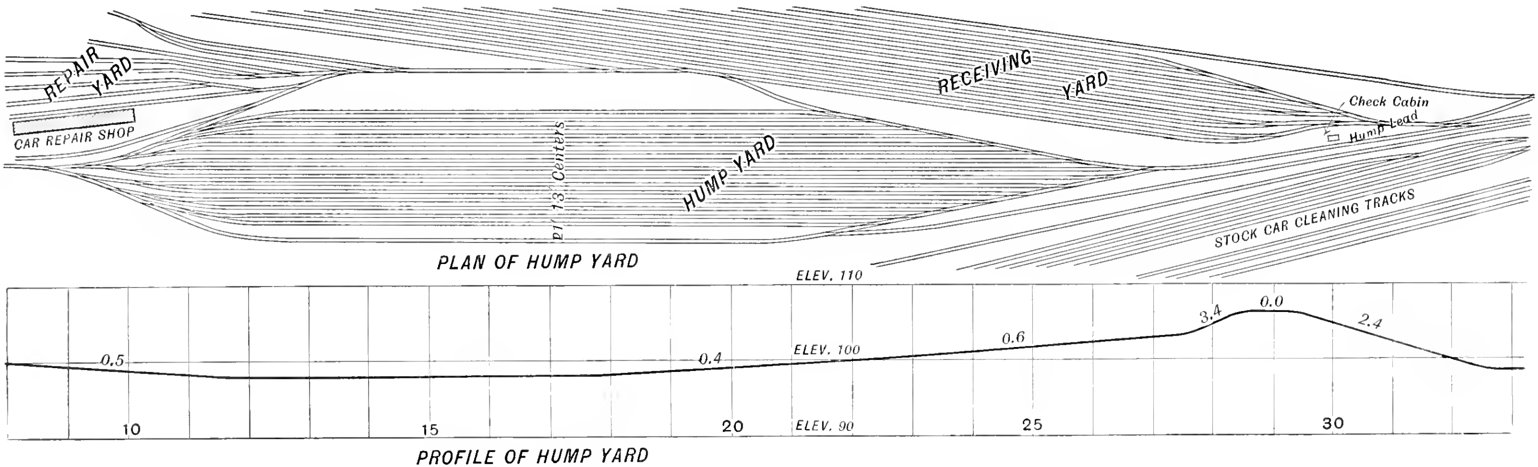


Fig. 4—Plan and Profile of East St. Louis Hump Yard, T. R. R. Assn. of St. Louis.

tions to which they are consigned. The maximum number of cars handled in one cut is twenty-five. The average is eleven cuts per train. The average time for classifying a maximum train is five minutes. Between 1,300 and 1,400 cars are put through the yard in 24 hours. There is very much in favor of hump or gravity yards, for the reason that while there is no decrease in the number of yard men employed there is a great saving in time, and a saving in the number of switches. The reason is that when a train is started over the hump it is seldom, if ever, necessary to stop it and back up, as is the case in an ordinary yard, which results in a very large decrease in the number of couplers pulled out and other damage to equipment and contents of cars.

This yard is so arranged that when cars pass over the hump they are classified into trains. The engines are coupled onto the cars from the opposite end and haul them to their destinations. This makes the passing of the cars over a second hump or any further switching with them unnecessary.

This hump yard is very well adapted for use as a departure yard, as well as a classification yard, except that if it had been possible to make the tracks in the yard longer than they are it would have been more advantageous, as the present yard can be filled entirely in three or four hours. If there had been room, also, the entire lead would have been elevated to the same level as the hump, so that it would require very little tractive power to push the train over the hump. This would have enabled very much longer trains to be handled when necessary.

Clearing Yard (Chicago Union Transfer Railroad).—This company's yard is located at Clearing, Ill., fifteen miles from the center of Chicago. The accompanying drawings, Figs. 5 and 6, show a profile of the hump and a plan of the general layout of the yard; the latter has been foreshortened and is meant only to give information as to the different tracks.

The hump grade is 4 per cent. for 125 ft., then 1½ per cent. for 160 ft. The assisting grade on the ladders is 0.9 per cent. for 1,740 ft. Two engines are used for classifying cars for each hump, one engine bringing up a section of the train at a time. The tractive power of the engines is 38,220 lbs. The number of men used as riders in the tests noted below was fifteen. The switches are operated from a central tower by a pneumatic-electric system. There are 42 tracks in the classification yard, each of these being 2,400 ft. long.

A printed card is used for designating the number of cars to each

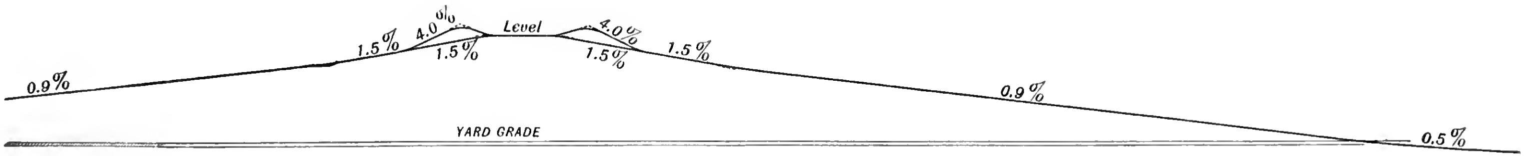


FIG. 5—PROFILE, CHICAGO UNION TRANSFER RAILWAY.

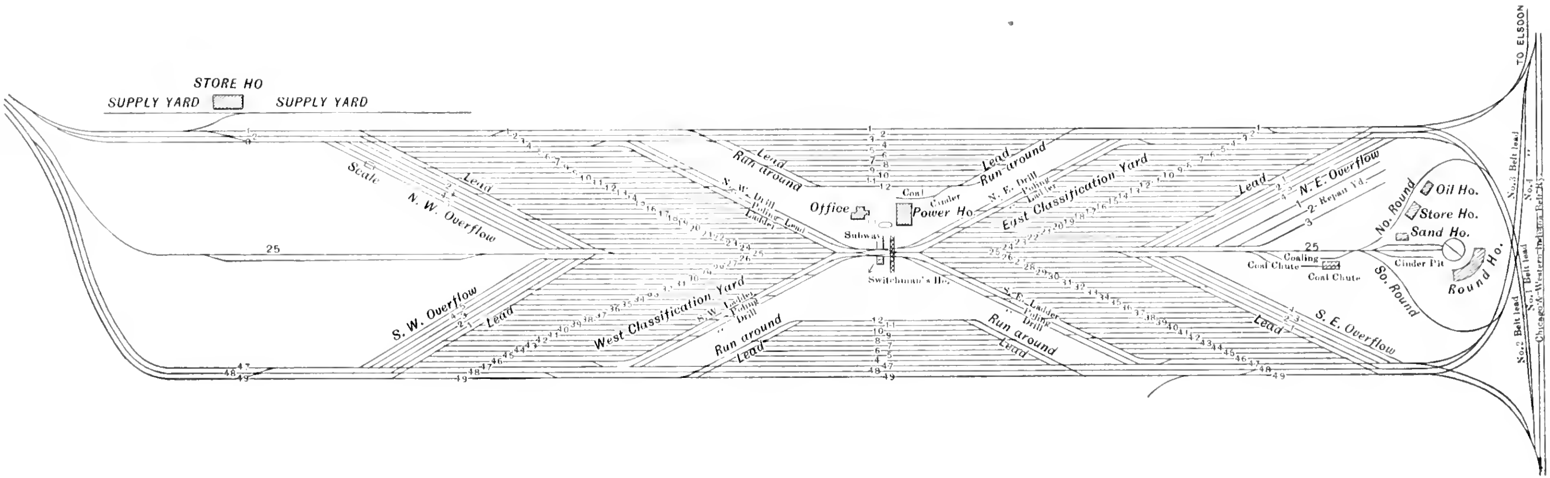


FIG. 6—CHICAGO CLEARING YARDS.

cut and the track on which it is to be classified. These cards are made out in duplicate, one being given to the operator in the tower and the other to the hump foreman, who cuts all the cars. A copy of these cards (size 4¼x9¼ in.) is given herewith, Fig. 7. The maximum train that has been handled over the hump was 1,700 tons, and this was in August under very favorable conditions.

CHICAGO UNION TRANSFER RAILWAY.

SWITCHING REPORT FOR TRAIN OF.......................... R. R. Eng........................

Marked..................................M. Switched................................M.

....190 190

No. of Cuts	No. of Track.	Cars in Cut	No. of Cuts	No. of Track	Cars in Cut
1			31		
2			32		
3			33		
4			34		
5			35		
6			36		
7			37		
8			38		
9			39		
10			40		
11			41		
12			42		
13			43		
14			44		
15			45		
16			46		
17			47		
18			48		
19			49		
20			50		
21			51		
22			52		
23			53		
24			54		
25			55		
26			56		
27			57		
28			58		
29			59		
30			60		

....
MARKER.

....
FOREMAN OF HUMP.

FIG. 7.

Upon the completion of the yard it was determined to make a test of the physical conditions, and through the courtesy of a connecting road a number of its trains were classified through this yard for a period of four weeks. The test was made during November and December and the yard force had had no experience with gravity switching. The trains were received very irregularly and it was therefore impossible to operate continuously throughout the 24 hours. Nevertheless, the results obtained were considered very satisfactory.

A record of every train was kept and the actual time of passing each train over the hump was noted. Two engines served the hump, and the trains (which averaged 40 to 60 cars) were cut in two; each section was drilled or handled by a single engine. This arrangement was found to be very efficient, for while one engine was classifying the other was bringing up a section, and in this way the throat of the yard was kept served continuously and with the least possible delay. Owing to the irregularity with which trains were received and the consequent delays in marking, carding, etc., each section was considered as an individual train, and in the following record the interval of time between the last car of one section or train and the first car of the following section is omitted. These intervals can be reduced to a minimum in the general course of operation. The following table shows the results of each day's work for a majority of the days that the test was in progress. It is the result of work over one hump:

Number of Trains.	Number of Cars.	Number of Cuts.	Number of Minutes Switching Trains.	Number of Cars Per Cut.	Average Cars Per Train.	Average Minutes Switching Per Train.	Average Cars Per Hour.
10	271	124	146	2.2	27.1	14.6	111.2
10	210	101	115	2.1	21.0	11.5	109.0
12	290	157	137	1.8	24.2	11.4	127.0
23	571	293	293	1.9	24.8	12.7	116.9
18	465	234	189	2.0	25.3	10.5	147.6
27	530	222	189	2.4	29.4	9.0	168.2
15	348	196	151	1.8	23.2	10.6	138.2
18	431	214	177	2.0	24.0	9.8	146.1
18	361	172	151	2.1	20.0	8.4	143.0
25	543	268	297	2.0	21.7	12.0	109.0
16	404	209	203	1.9	25.2	12.4	118.9
18	433	215	190	2.0	24.0	10.5	136.0
15	341	143	103	2.3	22.7	6.8	198.0
14	371	200	151	1.8	26.5	10.7	147.0
17	437	236	252	1.8	25.7	14.8	104.0
16	379	167	168	2.2	23.7	10.5	135.0
26	630	349	509	1.8	24.2	19.5	74.0
23	464	230	186	2.0	20.1	8.1	149.0
21	460	226	262	2.0	21.9	12.4	105.0

During the entire test there were 11,244 cars handled, the cars being brought up in 488 trains of 23 cars each. The average number of cars per cut was 1.9. The average time of passing a train over the hump was 12.1 minutes, and the average number of cars classified per hour was 113.3.

It was found that on very dark nights the operation of the yard was very slow on account of the insufficient light given by the ordinary arc lamps. Owing to this, the riders were inclined to brake their cars immediately on reaching the ladder tracks, and thus caused frequent blockades. Since the time of the test experiments have been made with a parabolic reflector for each arc lamp, throwing the rays of light in the direction of the descending grade, and thus lighting up all tracks on the ladder and for a distance of some 600 ft. down the yard. This permits the riders to see at all times what is in front of them, and it is believed that this improvement will greatly facilitate and increase the speed of classifying trains at night.

Nonconnah Yard, Memphis, Tenn. (Illinois Central Railroad).—The accelerating grades of the hump and ladder are as follows: 275 ft. of 2 per cent., 100 ft. of 1 per cent., 500 ft. of 0.2 per cent.

One 96-ton engine is used in pushing trains over the hump. Five men are employed as riders and two as switchmen, the switches being operated by hand. There are seven tracks in the classification yard. At the hump the man cutting off the cars calls out the number cut off, and the switchman passes it to the riders.

The maximum number of cars in a cut is twelve, and all cuts of seven cars and over are controlled by two riders. The average number of cuts per train is twelve. The average time required for classifying a maximum train is twenty minutes. The number of cars put through the yard in 24 hours is about 700.

The hump yard is a great improvement over other types of yards for the speedy handling of cars. As to the advisability or practicability of passing cars over a second hump into the departure yard as a substitute for the present shifting, it is thought there is no necessity for a second hump if the necessary number of classification tracks are provided in connection with the first hump. At Nonconnah there is a northbound and southbound yard, and with the required number of classification tracks there would be no necessity for the second hump.

Dewitt Yard (New York Central & Hudson River Railroad).—The grades of the two humps in this yard are different for eastbound and westbound traffic. For the westbound traffic, which includes many empty cars and is handled against the prevailing winds, there is a grade of 4 per cent. for 150 ft. from the summit, then 1 per cent. for 1,200 ft. through the ladder tracks, while the remainder of the classification tracks are on a grade of about 0.25 per cent. For the eastbound traffic, which consists mainly of loaded cars, there is a grade of 2.5 per cent. for 150 ft. from the summit, followed by 1 per cent. for 1,200 ft., beyond which the classification tracks are practically level. The yard is designed for a capacity of 50 trains (or about 3,500 cars) in each direction in 24 hours. A profile of the hump is shown in Fig. 12.

Alexandria Yard (Washington Southern Railway and Richmond, Fredericksburg & Potomac Railway).—This yard was built in 1905 for interchange service, and was described in the *Engineering News* of Nov. 30, 1905, in an article by Mr. W. A. MacCart, Assistant to the Principal Assistant Engineer of the Pennsylvania Railroad. The following is an extract from that paper, and the profile of the hump is shown in Fig. 8:

"The movement of perishable or fast freight is largely northbound, and therefore a separate receiving and classifying yard has been provided for this business, but at the same time so arranged that when necessary the receiving tracks can be used for ordinary freight passing over the hump. The receiving tracks northbound for fast freight were made for a 50-car train; for ordinary freight a 45-car train. The northbound advance tracks were made for a 50-car train. Southbound the receiving tracks will hold a 60-car train and the advance tracks a 50-car train. The classification tracks were made so that a portion of the number would hold a full train length."

"The grades adopted for the hump are fixed from experience gained elsewhere, allowance being made for the kind of traffic and different climatic conditions. The rate of grades approaching the humps, especially southbound, does not look well and may provoke criticism. In explanation it may be said that the location for the yard was fixed, and is between two summits of the main track grades and topography in such a position that the humps are in the sag of the grade. The southbound cars have to leave the yard on an ascending grade, and to reduce this by raising the hump would but have increased the grade into the southbound receiving tracks."

"In order to save room in the length of the yard No. 7 ladders were used with No. 8 frogs, which is the ruling frog used, although there are a few specials needed for speed at the main connections or for other reasons."

Connellsville Yard (Baltimore & Ohio Railroad).—The plan and profile of this yard are shown in Fig. 9. One engine is used in classifying cars over the hump in this yard; its tractive power is 38,145 lbs. Twelve men are employed day and night as riders. The switches are operated by hand, one man being employed by day and two at night. There are 11 tracks in the classification yard.

For the purpose of designating the number of cars to each cut, a yard clerk gets a list of the train as it stands. The yard conductor then makes a list for his men according to the destinations of the cars. The

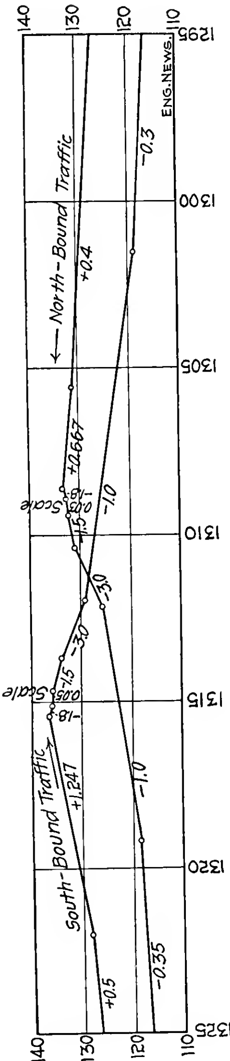


FIG. 8—ALEXANDRIA YARD, SOUTHERN RAILWAY, FREDERICKSBURG & POTOMAC RAILROAD.

Committee on Yards and Terminals.

TYPES OF HUMP YARDS.

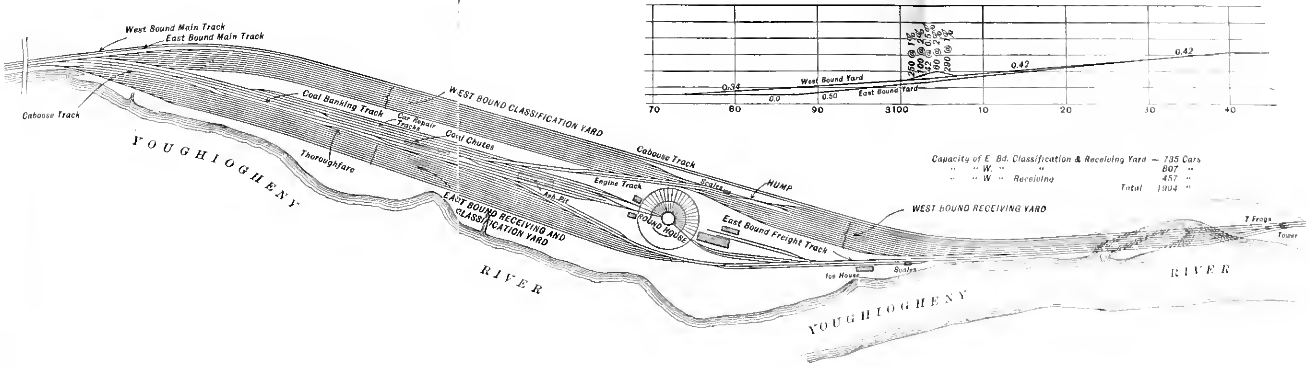


Fig. 9—Connellsville Yard, Baltimore & Ohio Railroad.

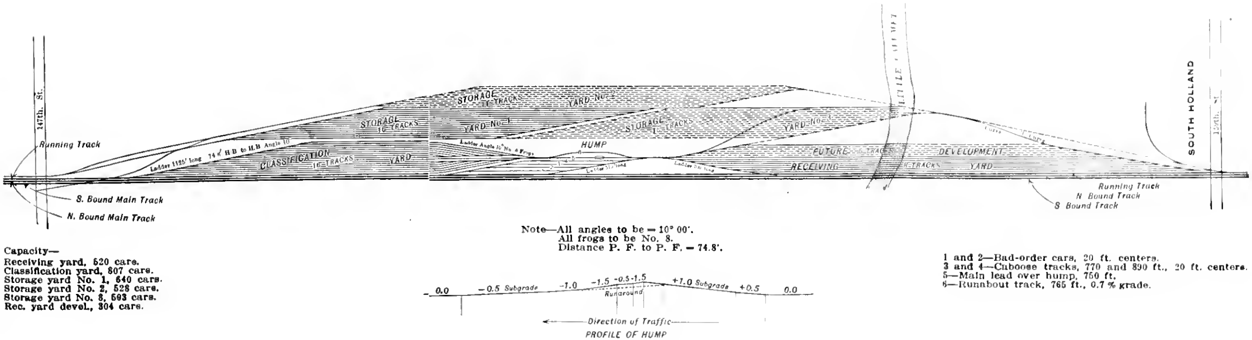


Fig. 11—Dolton Yard, Chicago & Eastern Illinois Railroad

maximum number of cars handled in one train over the hump is 60. Most of the cars handled through this yard are loaded with coke, and each car has to be weighed. The average time for weighing and classifying a train of 50 cars of coke is about 40 minutes. A minimum of 900 and a maximum of 1,100 cars are put through this yard daily. With reference to the value of hump yards as compared with other yards, the Baltimore & Ohio officials have the following to say: "It is the opinion that a hump is the only way to classify cars as far as speed and economy is concerned. Of course there are some accidents and damages to cars in handling them in this way, but it is believed that all concede that the time saved more than repays all costs of damage."

In reference to the advisability of passing cars over a second hump into the departure yard, the Baltimore & Ohio officials state as follows:

"With the present conditions an engine has to be used at the west end of the yard to classify cars after they are put over the hump; that is, we do not have tracks enough to separate the air and non-air cars, and this engine has to be used to switch sufficient air cars into the trains. The time will no doubt come, and that soon, when all cars will be equipped with air, and this feature will therefore be eliminated. We do not see that any benefit would be derived from the second hump. The conditions would be just the same on the second hump as they are on the first unless there were sufficient tracks to classify all cars. What would seem more desirable would be a storage yard where trains could be taken after they are made up and stored until power was available to move them. With the present arrangement, when the classification yard gets full the weighing and running of cars over the hump has to stop."

The plan and profile are given in Fig. 9 and the profiles of humps in other yards of the Baltimore & Ohio Railroad are given in Fig. 10.

Dolton Yard (Chicago & Eastern Illinois Railroad).—A plan and profile of this new hump yard are given in Fig. 11.

Pennslyvania Yards.—The following extracts from a paper in the *Railroad Gazette* of March 12, 1905, by Mr. W. C. Cushing, Chief Engineer of Maintenance of Way of the Southwest System, Pennsylvania Lines, give some operating results for other hump yards. Appendix No. 2 also gives a table of grades of hump yards which is taken from Mr. Cushing's paper, and the profiles of several humps in yards on the Pennsylvania Railroad as shown in Figs. 12 and 14.

"At Sheridan, Pa., a train of 35 cars can be put over the hump and separated into 30 cuts in 25 minutes. In another yard where the method of switching is "push and pull" the time required to break up

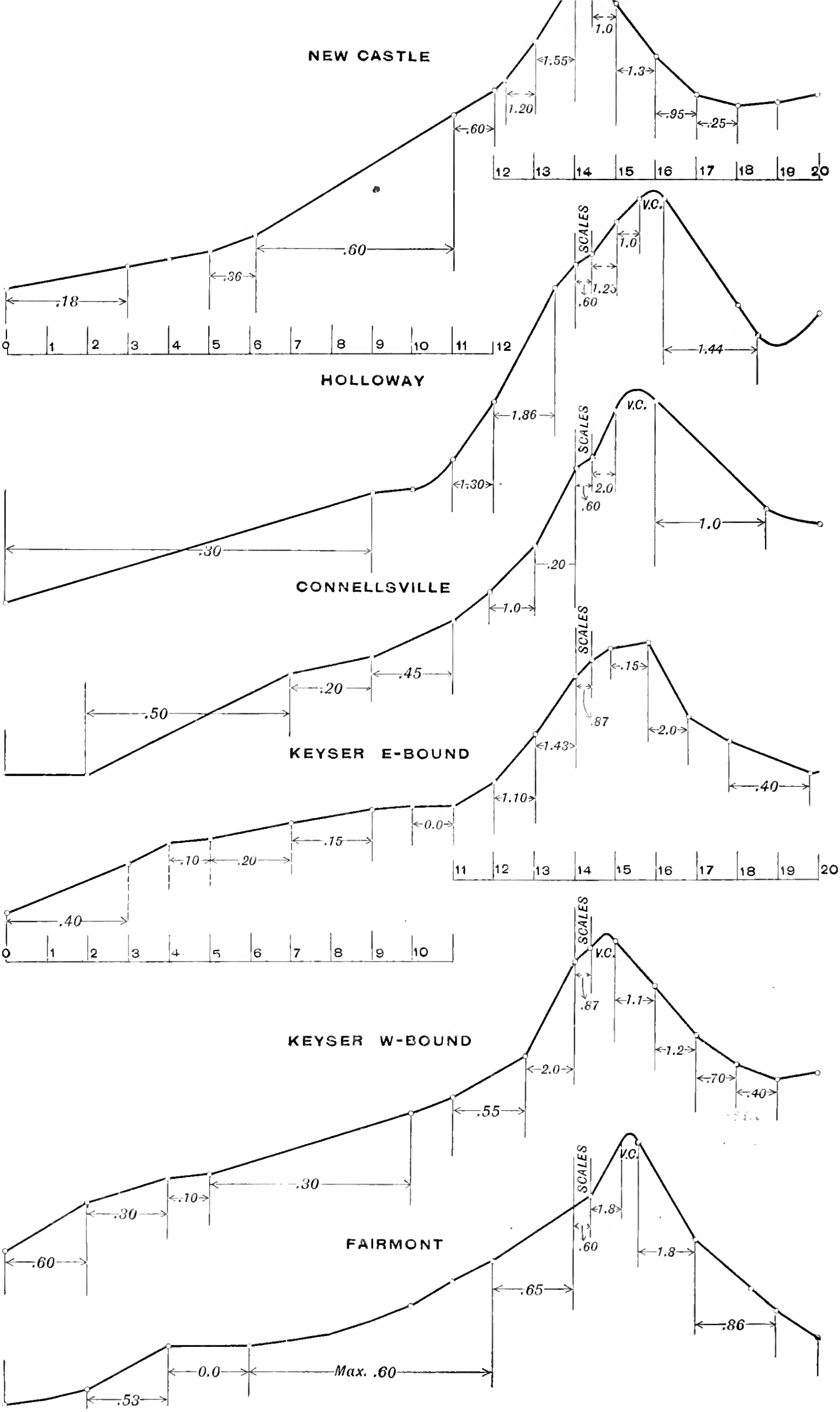


FIG. 10—PROFILES OF HUMPS OF VARIOUS YARDS, BALTIMORE & OHIO RAILROAD.

a 35-car train into 15 cuts is one hour and 15 minutes. The weight of engine used at Sheridan is 169,800 lbs.

"At Harrisburg, Pa., the Pennsylvania Railroad has a series of yards which were operated until recently by poling. No. 1 of this series of yards, the largest eastward unit, is a poling yard where two engines are used. No. 5, the eastward yard, is now a hump yard. In these yards the average time for breaking up, by poling, an eastward train of 80 cars is 50 minutes, while a westward train of 100 cars can be broken up into 50 cuts over the hump in 35 minutes. A train can be pushed over the hump in nine minutes, or at the rate of six cuts of two cars each every minute.

"A consolidation engine weighing 193,000 lbs. can push 130 cars over the hump as long as the temperature does not drop below 25 degrees above zero, but below that point it requires two engines coupled."

At the Conway yard (Pennsylvania Company) under good working conditions an 80-car train can be broken up over the hump into 60 cuts in about one hour, while by the old method of drilling three hours were required. It must be borne in mind, too, that the cars are weighed just as they come in the train, while formerly the way cars were cut out and weighed separately. Every conceivable kind of freight, iron ore, merchandise, stone, sand, sewer pipe, grain and a large number of empty coal and coke cars eastwardly and coal, coke, merchandise and minerals westwardly are handled in the yards. The humps work well, except in the case of empty cars, due to the poor arrangement of the old ladders, and the consequent long distance the cars have to run, the result of gradual growth for many years. The experience emphasizes the desirability of well-designed ladders. With long ladders, high humps and heavy grades are necessary. Two consolidation engines, each weighing 174,300 lbs., are required to push trains over the humps.

"At Logansport, Ind. (Pennsylvania Company), the standing capacity of the yard is 2,124 cars. The average business handled is 2,000 cars a day, and the maximum is 2,821 cars. In ordinary weather it required from 20 to 25 minutes to break up a train of 85 cars over the hump, and in zero weather about 50 minutes An engine weighing 174,200 lbs. is used for the west hump (built in 1900), and one weighing 193,500 lbs. for the east one (built in 1902).

"At Crestline, O. (Pennsylvania Company) there is a standing capacity of 1,784 cars in both yards, and the daily business is about 1,100 cars, the maximum being 1,330. Under good working conditions it takes a consolidation engine weighing 124,800 lbs. about 10 or 12 minutes to dispose of a train of 35 cars into 18 cuts over the hump. These switches are handled by mechanical levers in a tower nearby."

E.—HUMP YARDS (CONCLUSIONS).

*(a) A hump yard is the best form of yard for receiving, classifying and making up trains, because cars can be handled through it faster, with less damage and at less cost than through any other form of yard.

*(b) Hump yards should consist of receiving, classification and departure tracks, in consecutive order as enumerated.

*(c) Receiving tracks should be of sufficient length to hold a maximum train.

(d) Receiving tracks should be sufficient in number to hold a number of trains arriving in quick succession. The number will depend on the amount and character of traffic handled, and upon the relative location of the yard with respect to other yards and connections.

(e) If it is possible, the grades of the receiving tracks should be such that one engine could push the maximum train over the hump.

(f) No definite recommendation can be made for the length and number of classification tracks, except to say that they need not be full train length, except when used as departure tracks. Local conditions will govern.

(g) Departure tracks must be full train length and of sufficient number to provide ample standing room for trains while being tested for air and while waiting for engines.

(h) The departure yard should be provided with an air hose and air brake testing plant.

(j) Grades after leaving the summit should be such as to carry the cars to their proper destination in the yard.

(k) Where the cars to be classified are largely empty or light cars, the following grades are recommended for average conditions: 75 ft. of 1.5 per cent. up grade, approaching summit; 300 ft. of 2.5 per cent. grade from the summit down; thence down through the several switches in the yard, 1.0 per cent.; thence down through the remainder of the yard, 0.5 per cent.

(l) Where the cars to be classified are largely loaded or heavy cars, the following grades are recommended for average conditions: 75 ft. of 1.5 per cent. up grade, approaching the summit; 300 ft. of 2 per cent. grade from the summit down; thence down through the several switches in the yard, 0.7 per cent.; thence down through the remainder of the yard, 0.3 per cent.

(m) Where the traffic and climatic conditions require it, the grades should be made steeper in winter and restored again in the spring.

*See amendments, page 156.

(n) When required, scales should be located at such a distance from the summit (75 ft. is recommended) that when the car to be weighed reaches the scales it will be properly spaced from the following cars and running slowly enough to render correct weighing easy.

(o) For average conditions it is recommended that a No. 9 frog be the sharpest used for classification yards, making the angle of the body track with the ladder that of a No. 7 frog.

F.—REVISION OF DEFINITIONS AND CONCLUSIONS PREVIOUSLY SUBMITTED.

In compliance with instructions from the Board of Direction we submit for final action the definitions adopted temporarily by the convention of 1905 as follows:

TERMINALS:

TERMINAL.—The facilities provided by a railway at a terminus for the purpose of handling its business.

*FREIGHT TERMINAL.—The arrangement of terminal facilities for the handling of freight business.

*PASSENGER TERMINAL.—The arrangement of terminal facilities for the handling of passenger business.

RAIL AND WATER TERMINAL.—A terminal where freight is interchanged between railway cars and vessels.

SWITCHING DISTRICT.—That portion of a railway at a large terminal into which cars are moved and from which they are distributed to the various sidetracks and spurs to freight houses and manufacturing establishments served from this district by yard or switching engines.

YARDS:

YARD.—A system of tracks arranged in series, within defined limits, for separating and making up trains, storing cars, and other purposes.

RECEIVING YARD.—A yard for receiving incoming trains.

SEPARATING YARD.—A yard adjoining a receiving yard, in which cars are separated according to district, commodity or other required order.

CLASSIFICATION YARD.—A yard adjoining a separating yard, in which cars are classified or grouped in accordance with requirements, preliminary to forwarding in trains.

Departure or Forwarding Yard.—A yard in which cars are assembled in trains for forwarding.

*Storage Yard.—A yard in which cars are held awaiting disposition.

Cluster or General Yard.—An arrangement of yards in series for the separation, classification, assembling and storage of cars.

Gravity Yard.—A yard in which the separation or classification of cars is aided by gravity.

*Poling Yard.—A yard in which the movement of cars is produced by the use of a pole or stake operated by an engine on an adjoining parallel track. The movement may be facilitated by an assisting grade.

*Summit or Hump Yard.—A yard in which the movement of cars is produced by pushing them over a summit, beyond which they are run by gravity. The movement from the base of the summit may be facilitated by an assisting grade.

Assisting Grade.—The inclination given to tracks of a yard to facilitate the movement of cars.

TRACKS:

*Body Track.—Each of the parallel tracks of a yard or group of tracks upon which cars are switched or stored.

*Ladder Track.—A track connecting in series the body tracks of a yard.

*Lead Track.—An extended track connecting either end of a yard with the main line.

*Drill Track.—A track connecting with the ladder track and used for movements in yard switching.

Open Track.—A body track reserved for movements through a yard.

*Running Track.—A track reserved for movements through a cluster or general yard.

*Crossover Track.—A track connecting two adjacent tracks.

*Special Tracks.—In a typical yard there will be several tracks devoted to special purposes, varying with the local conditions. These will include caboose tracks, bad-order tracks, scale tracks, coaling tracks, ash-pit tracks, repair tracks, icing tracks, feed tracks, stock tracks, transfer tracks, sand tracks, depressed tracks, etc.

Y-Track.—A triangular arrangement of tracks used in place of a turn-table for turning engines or cars.

Transfer Slip.—A protected landing place for car floats, with adjustable apron for connecting the tracks of the pier and car float.

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* Adopted by the Association in 1905.

SIDING OR SIDE TRACK.—A long track away from a yard connected with the main or running track at one or both ends and used for storage or irregular movements of cars or trains.

PASSING SIDING.—A special siding, usually connected with the main track at both ends, and used to enable trains to pass each other.

RELIEF TRACK.—An extended passing siding, long enough to allow an inferior train to continue running.

STUB TRACK.—A short track connected with another at one end only.

SPUR TRACK.—A stub track, usually leading to and serving an industry, or warehouse, freight house, etc.

HOUSE TRACK.—A track alongside of or entering a freight house and used for cars receiving or delivering freight.

FREIGHT CAR REPAIR YARDS.

(a) Freight Car Repair Yards should be composed of short tracks of a capacity of about fifteen cars each, arranged in pairs; the tracks of each pair spaced 16 ft. apart centers, and the pairs spaced 40 ft. apart centers.

(b) A material supply track should be placed in the space between each pair of tracks.

(c) In calculating the capacity of repair tracks a space of 50 ft. should be allowed for each car in order to provide working room about eacn car.

(d) Part of the yard should be provided with air and water pipes with outlets 50 ft. apart for testing cars.

(e) Heavy freight car repair tracks shouid be under cover, and provided with overhead traveling cranes to facilitate heavy lifting.

TEAM DELIVERY YARDS.

CONCLUSIONS.

(a) Team Delivery Yards should be located convenient to the freight house, so that the receipt and shipment of freight may be easily under control of the freight agent's force.

(b) The tracks should be stub tracks, arranged in parallel pairs; the tracks of each pair spaced 12 ft. centers, and the pairs 52 ft. centers, and for convenience of shifting the tracks should be of about 20 cars capacity each.

(c) The yard should be provided with a crane for handling heavy freight.

(d) Ingress and egress for teams should be provided at each end of each teamway, if possible.

(e) Wagon scales should be provided handy to the team entrance of the yard, and track scales should be provided and located for convenient switching.

Respectfully submitted,

J. A. Atwood, Chief Engineer, Pittsburg & Lake Erie Railroad, Pittsburg, Pa., *Chairman.*

E. E. R. Tratman, Resident Editor, *Engineering News,* Chicago, Ill., *Vice-Chairman.*

A. B. Corthell, Terminal Engineer, New York Central & Hudson River Railroad, New York, N. Y.

E. P. Dawley, Engineer of Construction, New York, New Haven & Hartford Railroad, New Haven, Conn.

W. A. Garrett, General Manager, Cincinnati, New Orleans & Texas Pacific Railway, Cincinnati, O.

B. H. Mann, Signal Engineer, Missouri Pacific Railway, St. Louis, Mo.

J. D. Mason, Engineering Department, Chicago, Burlington & Quincy Railroad, Chicago, Ill.

I. G. Rawn, General Manager, Illinois Central Railroad, Chicago, Ill.

C. S. Sims, Assistant to President, Erie Railroad, New York, N. Y.

F. S. Stevens, Superintendent, Philadelphia & Reading Railway, Reading, Pa.

J. E. Taussig, Terminal Superintendent, Wabash Railroad, St. Louis, Mo. *Committee.*

AMENDMENTS.

(a) Hump yards should consist of receiving, classification and departure tracks, in consecutive order as enumerated.

(b) A hump yard is a desirable form of yard for receiving, classifying and making up trains, because cars can be handled through it faster and at less cost than through any other form of yard.

(c) Each receiving track should be of sufficient length to hold a maximum train.

APPENDIX 1.

THE ENOLA YARD: PENNSYLVANIA R. R.,

(From a paper by Mr. W. C. Cushing in the *Railroad Gazette.*)

The Enola yard at Fairview, Pa., which is designed to relieve Harrisburg, has standing room for about 10,705 cars. The engine yard is laid out in accordance with the typical design of the Pennsylvania R. R., and is in the center of the collection of yards, which has come to be regarded as the correct location, since it was first adopted for Conway several years ago. The water supply is furnished from large storage reservoirs on the hill above, an important departure for railroads.

The westbound receiving yard has 20 tracks of 90 cars capacity each, and the classification yard 25 tracks of 110 cars capacity each. The eastbound receiving yard has 21 tracks of 90 cars each, and the classification yard 17 tracks of 70 cars each, while there are six tracks of 70 cars each for solid trains. The large number of receiving tracks in proportion to the number of sorting tracks is noticeable. The arrangement of ladders for the classification yards is among the best used anywhere. (Fig. 13.) The large V arrangement of the hump-end of the yards is made up of two small V's, and each has its track over the hump and one around it. There are, therefore, two separate yards which can be worked by two engines side by side. The beautiful regularity of the ladders is to be commended. There is also a free track alongside the ladder, to be used by an engine for poling in derelicts when necessary.

APPENDIX 2.

GRADES FOR HUMP YARDS.

A.—GRADES SUITABLE FOR DIFFERENT CONDITIONS.

The following arrangements of grades for hump yards, operating under different conditions of traffic and in northern and southern climates, have been suggested to the Committee:

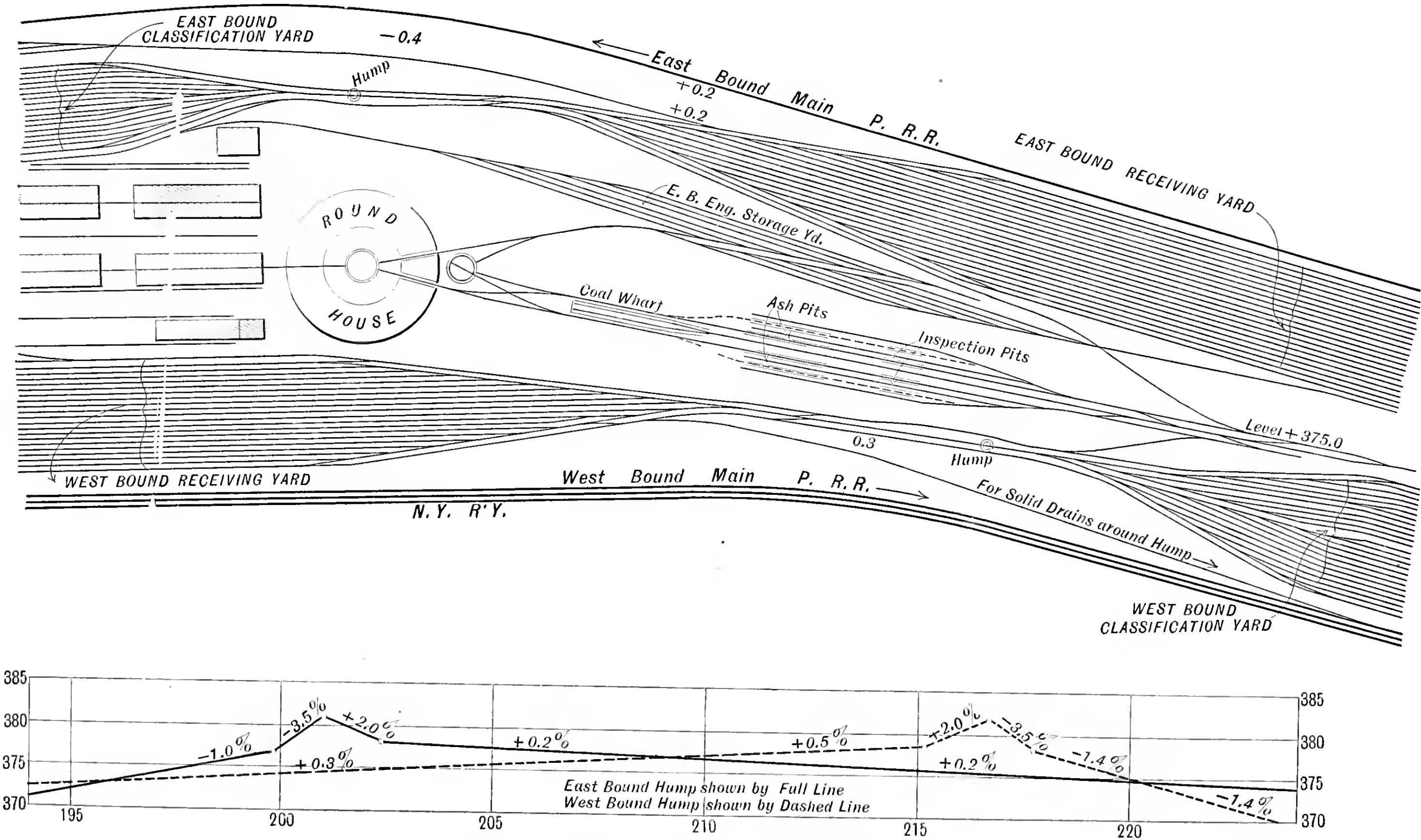


Fig. 13—Enola Yard, Fairview, Pa.—Pennsylvania Railroad.

	Northern Climate.	Southern Climate.
1. Bunching grade. Approaching summit.	75 ft. of 1.5 per cent. up grade.	75 ft. of 1.5 per cent. up grade.
2. Momentum grade (no scales on hump tracks):		
A. For loaded cars.	200 ft. of 3 per cent. down grade.	200 ft. of 2.5 per cent. down grade.
B. For empty cars.	200 ft. of 4 per cent. down grade.	200 ft. of 3.0 per cent. down grade.
3. Momentum grade (with scale on hump).	25 ft. effective of 4 per cent. followed by scales on 1 per cent. followed by easy vertical curve, say, 50 ft. in length, followed by 200 ft. of 3 per cent. down grade for loaded cars or 200 ft. of 4 per cent. down grade for empty cars.	25 ft. effective of 2.5 per cent. followed by scales on 1 per cent. followed by easy vertical curve, followed by, say, 200 ft. of 2.5 per cent. down grade for loaded cars or 200 ft. of 3 per cent. down grade for empty cars.
4. Ladder grade:		
A. For loaded cars.	0.9 per cent. throughout.	0.7 per cent. throughout.
B. For empty cars.	1.2 per cent. throughout.	1.0 per cent. throughout.
C. For yards handling both loads and empties.	1.2 per cent. throughout.	1.0 per cent. throughout.
5. Continuing grade through yard:		
A. For loaded cars.	0.3 per cent.	0.2 per cent.
B. For empty cars.	0.4 per cent.	0.3 per cent.

B.—GRADES OF EXISTING HUMP YARDS.

The following table is from a paper in the *Railroad Gazette,* May 12, 1905, by Mr. W. C. Cushing, Chief Engineer of Maintenance of Way, Southwest System, Pennsylvania Lines. Mr. Cushing's explanation of the table and his discussion of the subjects of hump grades are given below, and several profiles of yard humps are shown in Figs. 12 and 14.

"The principal characteristics bearing upon a study of proper grades of humps have been gathered in the accompanying table. Columns 5 and 8 have been added by calculation from Wellington's "Economic Theory of Railway Location," as explained at the foot of the table, to assist in the comparison, for the velocity at the foot of the grade is the important factor. Nothing has been added to these velocities for the initial velocity of the cars as they are pushed over the hump. It is fully realized that the velocities are approximate only, for there is such a vast difference in the freedom of running of cars, as between loads and empties, gondolas with coal and ore and box cars with merchandise, and between the seasons—winter and summer. It is impossible also to take account, except by experience, of the turnouts from the ladders, and the inequalities of the track. Consequently the different hump profiles are the results of tests, more than anything else. It is thought that the speeds in column 5 are not far out, but those in column 8 are probably too great. In calculating both columns, an allowance was made for rolling friction of 8 lbs. per ton, but this should undoubtedly be greater on the ladders. It is known, for instance, that cars sometimes stop on the old eastbound ladders of Conway, but as winter weather materially alters the conditions, it does not seem to be worth while to try and arrive at greater accuracy, except by experiment under both winter and summer conditions. Nevertheless, the figures given have some value for comparison, because the method of comparison is quite largely employed in yard design. If the resistances to motion were assumed to be about 13 lbs. per ton instead of 8, the car would stop half way down the Conway ladders, and this, as stated, does happen under bad weather conditions."

"But, to begin at the bottom. If the rolling friction be taken at 8 lbs. per ton, the grade of repose, or grade required to overcome this, the resistance to motion, and keep the car moving uniformly with the initial velocity, is 0.4 per cent. Therefore, the grade of the classification yard should be about 0.4 per cent., certainly not less than 0.3. We have testimony that yards with these grades are quite satisfactory, Logansport (W), Crestline, Bradford; whereas Richmond with 0.25 needs revision, by raising the hump. Mansfield is giving satisfactory results with 0.2, but its humps are higher, and the velocity greater than at Richmond. The same is the experience at Linwood. In other words, if a lesser grade than 0.3 per cent. for the classification yard must be used, on account of cost or physical obstructions, the resistance to car movement must be overcome by increased entrance velocity. Notice, for instance, the case of Altoona, where the traffic consists largely of empty cars, and the hump is about to be raised for the second time since construction. The old eastward hump at Conway had to be nearly doubled in height, because the classification yard is on a level. A second one, now being built, will have a 0.3 grade by dipping below the yard grade. The low grades of the classification yards at Chicago, Fifty-fifth Street, have necessitated the construction of high humps, which give pretty considerable velocities."

"The track irregularities, and the switch turnouts from the ladders offer increased resistances, which are met by increasing the grade on the ladders. This grade should be enough more than 0.4 per cent. to keep the car moving at the entrance velocity, as in the case of the classification yard, and experience must determine what it should be. A study of the table seems to show that the preponderance of opinion is in favor of 0.5 per cent. to 1.3 per cent. in cases where coal, ore, and minerals are the principal freight, and from 0.92 to 1.5 per cent. where the cars are largely empties, while a grade for merchandise would be somewhat between. The writer favors from $\frac{3}{4}$ to $1\frac{1}{4}$ per cent. for minerals and merchandise, and from $1\frac{1}{4}$ to $1\frac{1}{2}$ per cent. for a preponderance of empties."

"The remaining grade of importance is the first one from the summit, because all others intermediate between it and the ladder grade simply form a vertical curve to join them. The object of the first grade is to impart the required velocity so that the different cuts will separate from each other a sufficient distance to allow the switches to be thrown, and its length is dependent upon the vertical fall required to impart the velocity, and the maximum length of cuts. The number of cars in a cut is another one of the reasons why precise mathematics cannot be applied to this problem. With long cuts, the front end will be quite a distance down the slope before the whole cut begins to acquire much velocity. Although this detail in the case of the yards under discussion is not known in all cases to the writer, it is reasonable to assume that where the initial grade is short, the cuts are likewise short."

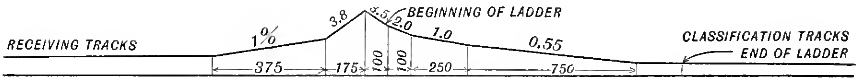
"In general, where there are no scales on the slope, and the cuts are to be short, the initial grade is steep and short, say from 3 per cent. to 4 per cent., for a distance of from 50 to 150 ft. A good grade is 3.5 per cent. for a distance of 100 ft. When the length of slope has to be from 200 to 600 ft., the grade is from 1.5 to 3 per cent., the object being to produce proper velocity."

"The introduction of scales on the slope alters the conditions, for the speed over the scales must be moderate, as already shown, say from three to six miles per hour. If the hump is any higher than is necessary to produce this speed, the car must be checked by the brakes. As cars must be weighed singly, and as the speed must be moderate, the natural place for the scales would seem to be rather near the summit, although an inspection of the table shows that some are quite far away, notably one of the Conway scales, and the two at Chicago, Fifty-fifth Street. Unless a large number of cars in each train is weighed, the summit does not appear to be a good location, because the weighing is probably done with the car at rest, which would materially delay the rest of the switching. The scale grade should probably not exceed 2.5 per cent. for a distance of 100 ft., and perhaps 2 per cent. for a distance of 50 ft. would be better. There seems to be no good reason for placing the center of the scales farther away from the summit than between 90 and 170 ft. The scale hump may be the only one, as in the case of a coal weighing yard, or it may be placed alongside the other hump, and on a separate track, for occasional weighing."

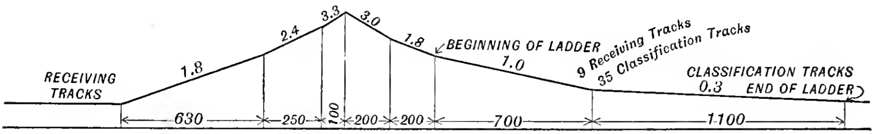
"The approach grade to the summit should not exceed that over which the full train can be pushed by one engine."

"Some operating officers request that the top of the hump be level for about 100 ft. If a flat piece be not provided, the curve of the top should at least have a pretty long radius."

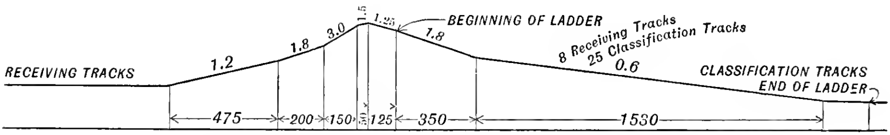
"To sum up the foregoing, the grade of the classification yard should be about 0.4 per cent., the grade of the ladders from ¾ to 1¼ per cent. for loaded cars, and from 1¼ to 1½ per cent. for empties, while, with no scales, the initial grade from the summit should be about 3.5 per cent. for a distance of 100 ft., and 1.5 to 3 per cent. when the slope is longer, but in the case of scales, the initial grade should be 2½ per cent. for a distance of 100 ft., or 2 per cent. for a distance of 50 ft."



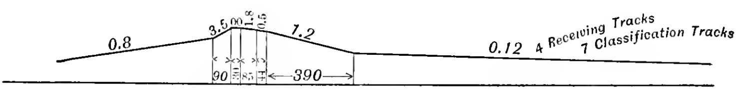
Conway—Middle Lead Hump—Pennsylvania Railroad.



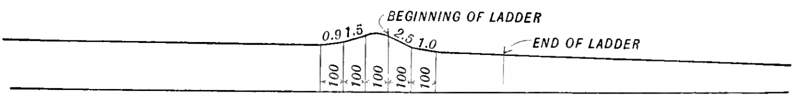
Conway—Eastbound Hump—Pennsylvania Railroad.



Conway—Westbound Hump—Pennsylvania Railroad.

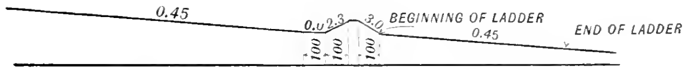


Honeypot Hump—Pennsylvania Railroad.

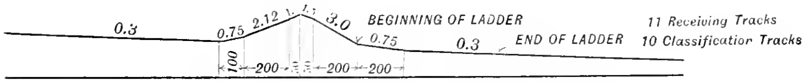


Richmond Junction Hump—Pennsylvania Railroad.

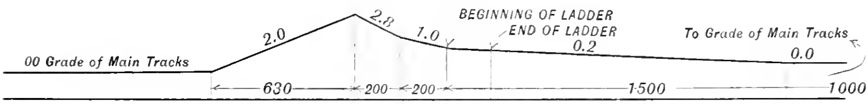
FIG. 12—A.



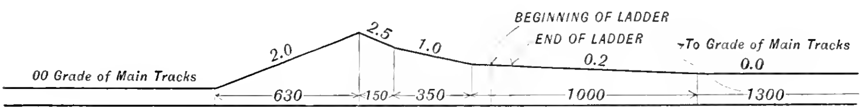
Bradford Yard Hump—Pennsylvania Railroad.



Crestline Yard Hump—Pennsylvania Lines.

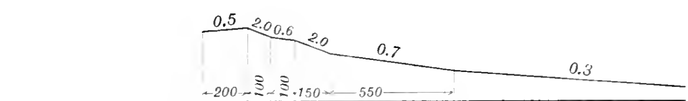


Mansfield Westbound Hump—Pennsylvania Lines.



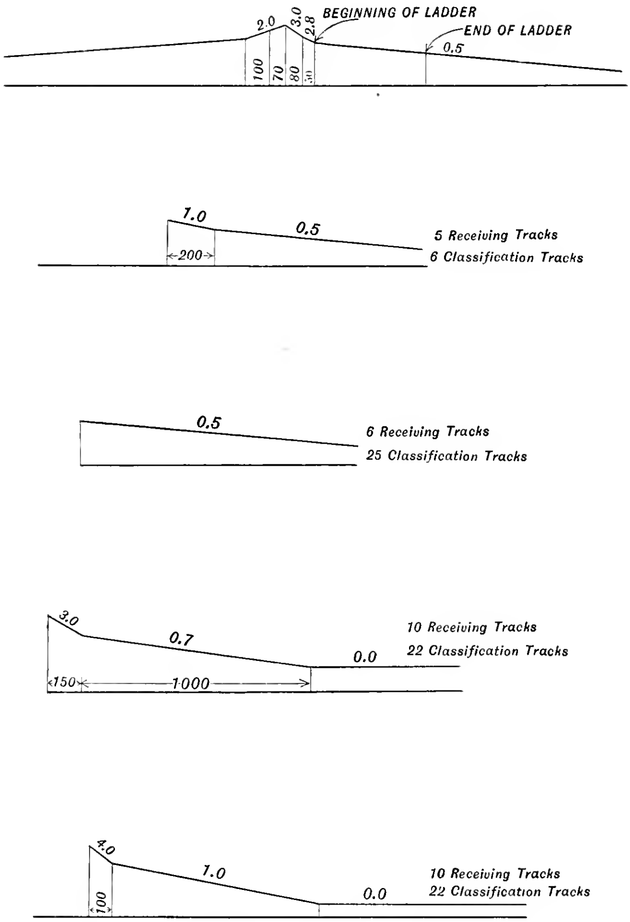
Mansfield Eastbound Hump—Pennsylvania Lines.

Chicago Westbound Hump—Pennsylvania Lines.



Haselton Hump—Pittsburg & Lake Erie Railroad.

FIG. 12—B.



New York Central & Hudson River Railroad.

FIG. 12—C.

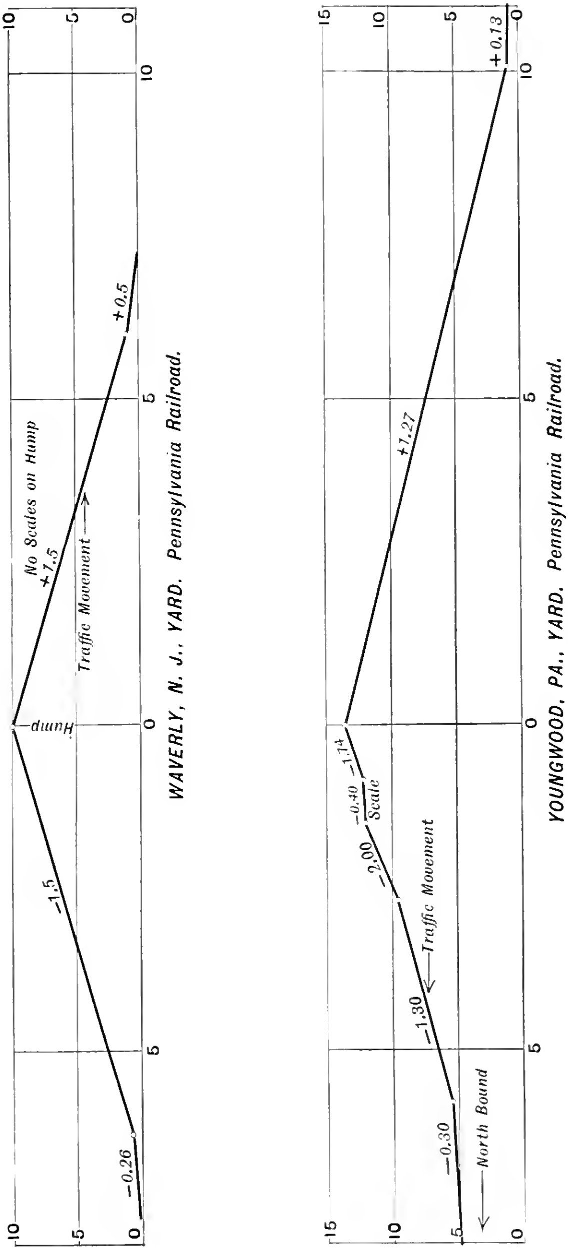

WAVERLY, N. J., YARD. Pennsylvania Railroad.
No Scales on Hump
+7.5
Traffic Movement
Hump
−1.5
−0.26
+0.5
YOUNGWOOD, PA., YARD. Pennsylvania Railroad.
+0.13
+1.27
−1.74
−0.40
Scale
−2.00
Traffic Movement
−1.30
−0.30
North Bound

FIG. 14—A.

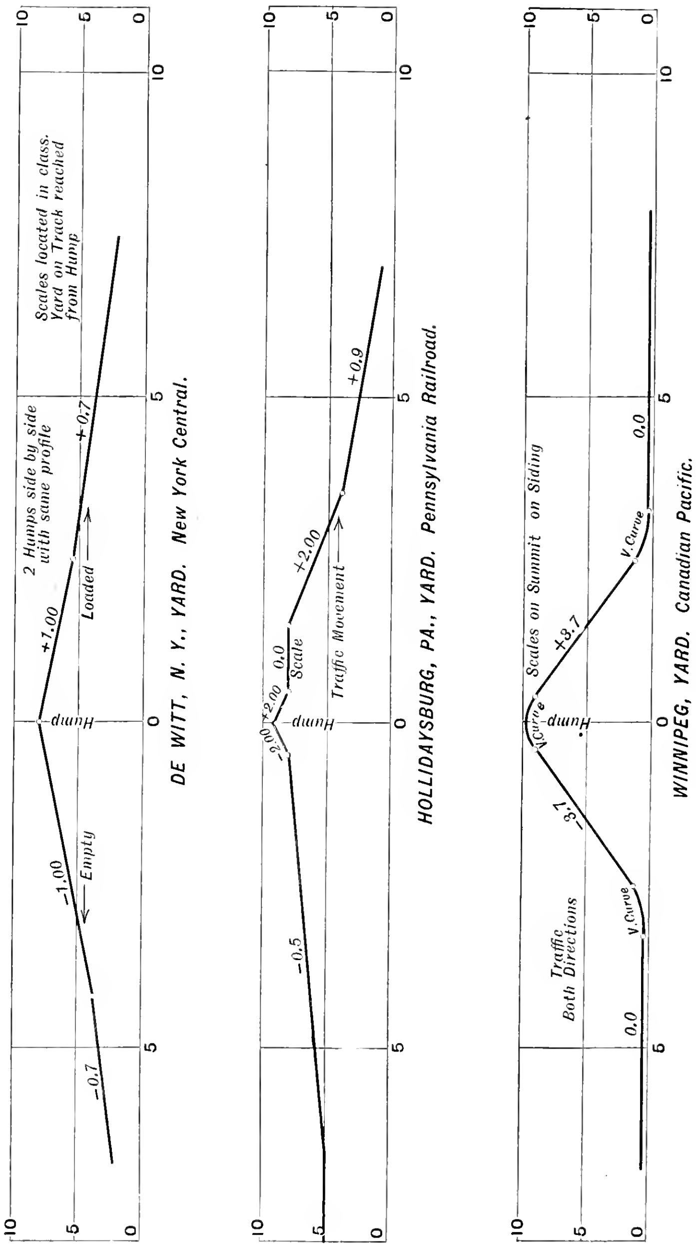

Scales located in class. Yard on Track reached from Hump
2 Humps side by side with same profile
+1.00
+0.7
Loaded
Hump
Empty
-1.00
-0.7
DE WITT, N. Y., YARD. New York Central.
+0.9
+2.00
Traffic Movement
0.0
Scale
+2.00
-2.00
Hump
-0.5
HOLLIDAYSBURG, PA., YARD. Pennsylvania Railroad.
0.0
V. Curve
Scales on Summit on Siding
+3.7
V. Curve
Hump
-3.1
Traffic Both Directions
V. Curve
0.0
WINNIPEG, YARD. Canadian Pacific.

FIG. 14—B.

TABULATED SUMMARY OF HUMP OR SUMMIT GRADES.

YARD.	First Grade from Summit.				Average Remaining Grade from First Grade to Bottom of Ladders.			Grade of Ladders. Per Cent.	Grade of Classification Yard. Per Cent.	First Grade from Scales, when any. Per Cent.	Distance from Summit to Center of Scales. Ft.	Standing Car Capacity of All Yards.	Character of Traffic.
	Grade. Per Cent.	Fall. Ft.	Horizontal Length. Ft.	Velocity at Foot. M. P. Hr.	Fall. Ft.	Horizontal Length. Ft.	Velocity at Foot of Ladders. M. P. Hr.						
1	2	3	4	5	6	7	8	9	10	11	12	13	
Enola............ E.	3.5	4.2	120	10.2	5	500	19.4	1.0	0.1	None.	....	10,705	Coal.
Enola .... W.	3.5	3.5	100	9.3	10	700	23.3	1.4	0.3	None.	....		Empties.
Altoona ..... W.	3.9	5.8	150	12.2	13.8	1,500	27	0.92	0.29	None.	....	10,500	Empties and mdse.
Harrisburg....... W.	3.6	5.4	150	11.6	14.6	1,100	25	1.5 & 1.2	0.0	None.	....	10,015	Empties and mdse.
Conway.......... E	2.5	5.5	220	11.4	15	2,800	21.9	0.5 & 0.3	0.3	0.83	250	8,967	Ore, grain and mdse.
" .... E.	3.0	6.3	210	12.4	13	2.000	24.3	1.0 & 0.3	0.0	1.80	350		Ore, grain and mdse.
" .... W.	1.8	8.6	480	13.7	8.4	1,800	19.7	0 6	0.14	1.80	220		Coal, coke and mdse.
Granville (mdse.).E	2.5	1.3	50	5.4	......	....	....	1.0	1.0	None.	....	7,842	Merchandise.
Granville (coal) .. E.	2.0	1.0	50	5.5	......	....	....	1.0	1.0	2.0	100		Coal.
Columbus......... E.	2.0	4.8	240	10.4	9	1,000	22.2	1.0	0.8	2.5	280	3,402	Mdse., grain and empties.
Columbus........ W	2.5	8.8	350	14.4	7.5	750	25.6	1.0	1.0	2.5	190		Coal, coke and mdse.
Alexandria .... N.	2.5	2.5	100	7.7	11.5	900	22.6	1.0	0.35	2.0	170	3,127	Mdse. and produce.
Alexandria .... S.	2.5	2.5	100	7.7	13.5	1,100	23.7	1.0	0.30	2.0	170		
Edgemoor .... N.	1.54	0.8	50	4.0	......	....	....	1.5	....	1.5	80	2,819	
Edgemoor......... S.	1.0	0.7	70	4.0	5.25	300	14.6	1.75	0.0	1.75	80		
Logansport....... E	2.4	3.0	125	8.4	7	800	18.7	0.5	0.04	On sum't.	....	2,124	Mdse., grain and empties.
Logansport....... W.	1.45	3.6	250	8.4	2	450	10.7	0.43	0.4	On sum't.	....		Mdse., coke and coal.
Crestline......... W.	3.0	7.5	250	13.5	2	400	16.8	0.75	0.3	None.	......	1,784	Mdse., coke and coal.
Marysville........ E.	2.5	6.5	260	12.4	12	1,000	27.4	1.2	0.0	2.5	110	1,756	
Marysville....... W.	2.0	4.6	230	10.2	8.4	700	22.7	1.2	0.36	None.	....		
Scully............. E.	2.5	2.5	100	7.7	13	1,000	20.5	1.3	0.5	2.5	150	1,740	Coal.
Bradford .... W.	3.0	2.4	80	7.6	3.2	700	10.6	0.45	0.45	None.	....	1,715	Coal, mdse. and empties.
Ebenezer .... N.	1.75	14 9	850	18	0.0	0	18	1.75	0.57	1.75	120	1,620	
Chicago, 55th St. E.	3.0	4.5	150	10.5	3.5	700	14.9	0.5	0.17	0.5	330	1,278	Mdse., grain and empties.
Chicago, 55th St.. W.	3.0	4.5	150	10.5	3.5	700	14.9	0.5	0.5 & 0.05	0.5	400		Mdse. and coal.
Honey Pot........ W.	2.0	0.8	40	4.2	5	500	13.4	1.0	0 12	1.2	90	1,194	Coal.
Sheridan......... E.	1 67	2.5	150	7.3	6	700	16.8	0.74	1 0	1 55	170	1,103	Coal.
Richmond........ W.	2.5	2.5	100	7.7	2	400	11.0	0.25	0.25	None.	....	745	Merchandise.
Linwood .... W.	3.0	3	100	8.5	4	400	16.8	1.0	0.0	On sum't.	0	656	Merchandise.
Mansfield .... E.	2 5	3.2	130	8.7	4	600	15.3	0.2	0.2	1.0	250	630	Mdse. and empties.
Mansfield......... W.	2.5	5	200	10.9	2.5	400	15.9	0.2	0.2	None.	....		Mdse. and coal.
Chic., Clear.. N. & S.	2.5	5	200	10.9	19.8	2.200	28.5	0.9	0.0	None.	....	14,000	Not in use.
Youngwood...... W.	1.74	1.4	80	5.4	......	....	....	1.3	0.3	2.0	120	....	Coal and coke.
Hollidaysburg.......	2.0	1.0	50	5	......	....	....	2.0	0.9	2.0	100	....	Coal.
Waverly	1.5	9	600	13.6	......	....	....	1.5	0.5	None.	....	....	
DeWitt...... E. & W.	1.0	2.5	250	6 5	......	....	....	....	....	None.	....	....	
Winnipeg... E. & W	3.7	11.1	300	16.7	......	....	....	....	0.0	On sum't.	0	....	
Elkhart........... E.	4.3	12.9	300	18.1	......	....	....	....	0.16	....	....	....	
Elkhart .... W.	5.0	15	300	19.7	......	....	....	....	0.18	....	....	....	

In calculating columns 5 and 8, the following data were used: A single loaded car weighing 150,000 lbs. = 75 tons; rolling friction = 8 lbs. per ton; grade acceleration = f = 20 x rate of grade per cent. (Wellington, p. 340); grade of repose, or grade to balance resistance to motion = 0.4%. Wellington's "Railway Location," p. 335, Table 118. No initial velocity included in column 5.

DISCUSSION.

The President:—The chairman of the Committee not being present, the vice-chairman, Mr. Tratman, will present the report.

Mr. E. E. R. Tratman (Engineering News):—The principal features of this report are the conclusions on hump yards. The definitions and conclusions previously submitted are given with very few alterations; they have been considered so many times at previous meetings that I do not think it is necessary to give time to them now. The Committee confined its attention almost entirely to the question of hump yards. It was concluded that this was the coming type of yard, and we were asked to get all the information we could, both as to construction and operation. This information is presented very fully in the report. I should judge that it would be the best plan to take up the hump yard conclusions, one by one, and invite discussion or criticism of the individual conclusions.

The President:—The Secretary will read the conclusions, and as they are read, the members can discuss them.

The Secretary:—"(a) A hump yard is the best form of yard for receiving, classifying and making up trains, because cars can be handled through it faster, with less damage and at less cost than through any other form of yard."

The President:—The first conclusion of the Committee is that a hump yard is the best form of yard for certain purposes.

Mr. Geo. H. Bremner (Chicago, Burlington & Quincy):—The hump yard is not the best form of yard for all purposes. It is where there is a large amount of switching and classifying, but where there is a small yard and a medium amount of switching, a hump yard is frequently an expensive yard to handle, and does not come into play as well as the old-style yard for that purpose.

The President:—If there is no further discussion, the conclusion (a) will be considered adopted.

The Secretary:—"(b) Hump yards should consist of receiving, classification and departure tracks, in consecutive order as enumerated.

"(c) Receiving tracks should be of sufficient length to hold a maximum train."

Mr. R. C. Barnard (Pennsylvania Lines):—"Receiving tracks should be of sufficient length to hold a maximum train" is misleading, I think. I suggest that be made to read, "each receiving track."

The President:—The Committee accepts that alteration.

Mr. E. C. Brown (Union Railroad):—I object to that. I think it unnecessary that all the tracks in the yard should be capable of holding a maximum train. It is often advisable to have shorter tracks, especially where the traffic varies. I think this should be modified to read "at least a portion of the tracks should be capable of holding maximum trains."

The President:—Do you make that in the form of a motion, Mr. Brown?

Mr. Brown:—Yes, sir.

(The motion was lost.)

Mr. Edwin F. Wendt (Pittsburg & Lake Erie):—It seems to me that all that needs is this: "As a general rule, the receiving tracks should be of sufficient length to hold a maximum train."

The Secretary:—"(d) Receiving tracks should be sufficient in number to hold a number of trains arriving in quick succession. The number will depend on the amount and character of traffic handled, and upon the relative location of the yard with respect to other yards and connections.

"(e) If it is possible, the grades of the receiving tracks should be such that one engine could push the maximum train over the hump.

"(f) No definite recommendation can be made for the length and number of classification tracks, except to say that they need not be full train length, except when used as departure tracks. Local conditions will govern.

"(g) Departure tracks must be full train length and of sufficient number to provide ample standing room for trains while being tested for air and while waiting for engines.

"(h) The departure yard should be provided with an air hose and air brake testing plant.

"(j) Grades after leaving the summit should be such as to carry the cars to their proper destination in the yard.

"(k) Where the cars to be classified are largely empty or light cars, the following grades are recommended for average conditions: 75 ft. of 1.5 per cent. up grade, approaching summit; 300 ft. of 2.5 per cent. grade from the summit down; thence down through the several switches in the yard, 1.0 per cent.; thence down through the remainder of the yard, 0.5 per cent.

"(l) Where the cars to be classified are largely loaded or heavy cars, the following grades are recommended for average conditions: 75 ft. of 1.5 per cent. up grade, approaching the summit; 300 ft. of 2 per cent. grade from the summit down; thence down through the several switches in the yard, 0.7 per cent.; thence down through the remainder of the yard, 0.3 per cent.

"(m) Where the traffic and climatic conditions require it, the grades should be made steeper in winter and restored again in the spring.

"(n) When required, scales should be located at such a distance from the summit (75 ft. is recommended) that when the car to be weighed reaches the scales it will be properly spaced from the following cars and running slowly enough to render correct weighing easy.

"(o) For average conditions it is recommended that a No. 9 frog be the sharpest used for classification yards, making the angle of the body track with the ladder that of a No. 7 frog."

The President:—If there is no objection, these conclusions will stand as adopted by the Association. The next item is "Freight Car Repair Yards."

The Secretary:—"(a) Freight Car Repair Yards should be composed of short tracks of a capacity of about fifteen cars each, arranged in pairs; the tracks of each pair spaced 16 ft. apart centers, and the pairs spaced 40 ft. apart centers.

"(b) A material supply track should be placed in the space between each pair of tracks.

"(c) In calculating the capacity of repair tracks a space of 50 ft. should be allowed for each car in order to provide working room about each car.

"(d) Part of the yard should be provided with air and water pipes with outlets 50 ft. apart for testing cars.

"(e) Heavy freight car repair tracks should be under cover, and provided with overhead traveling cranes to facilitate heavy lifting."

The President:—Is there any discussion upon this subject? If there are no objections, the conclusions on freight car repair yards will stand as approved. The next item, which has not been acted upon in the past, is team delivery yards. The Secretary will read the conclusions on this subject.

The Secretary:—"(a) Team Delivery Yards should be located convenient to the freight house, so that the receipt and shipment of freight may be easily under control of the freight agent's force.

"(b) The tracks should be stub tracks, arranged in parallel pairs: the tracks of each pair spaced 12 ft. centers, and the pairs 52 ft. centers, and for convenience of shifting, the tracks should be of about 20 cars capacity each.

"(c) The yard should be provided with a crane for handling heavy freight.

"(d) Ingress and egress for teams should be provided at each end of each teamway, if possible.

"(e) Wagon scales should be provided handy to the team entrance of the yard, and track scales should be provided, and located for convenient switching."

The President:—The subject is open for discussion.

Prof. C. Frank Allen (Massachusetts Institute of Technology):—The practice prevails to a considerable extent of having the tracks in sets of three. I am not sufficiently familiar with the work to be able to express an opinion in the matter, but will be very glad if there are any gentlemen here who have had experience in that matter if they will state it. Some excellent engineers are altogether in favor of constructing in sets of three.

The President:—This refers to team delivery yard?

Prof. Allen:—Yes, sir. It gives a somewhat better opportunity for delivering extra cars and switching empties into the tracks, and it is not altogether difficult, if necessary, to load through the center track. I have not the matter sufficiently well in mind to make an argument in the matter, but thought possibly there might be some others here who had some experience with it.

The President:—If there is no further discussion, the conclusions in regard to team delivery yards will stand as approved.

Mr. A. S. Baldwin (Illinois Central):—If it is not too late, I would like to go back to freight car repair yards. I intended to make a suggestion when that section was considered, but it escaped me at the time. Paragraph (e) reads: "Heavy freight car repair tracks should be under cover, and provided with overhead traveling cranes to facilitate heavy lifting." I would suggest the omission of the word "heavy." The idea conveyed is that a freight car repair track would be provided with overhead covering only under such circumstances, whereas I believe there is true economy in providing a covering for all freight car repair tracks. It is a common thing, in passing by a freight car repair yard, during a storm, to find that all the men under the cars are at one side. They work at a disadvantage in cold and snowy weather, unless there is a covering over the repair yard. I believe a great economy is effected by a cheap shed over freight car repair tracks, and I would therefore suggest that the word "heavy" be omitted in paragraph (e). I would suggest that the section read: "Freight car repair tracks should be under cover. Where they are for heavy repairs, they should be provided with traveling cranes to facilitate lifting."

(The motion was lost.)

Mr. Baldwin:—In view of the vote just taken, I would like to hear some argument against the omission of the word "heavy."

Mr. A. W. Johnston (New York, Chicago & St. Louis):—My reason for voting "no" is that I take the Committee meant by the term "heavy freight car repairs" such repairs as required the cars to be sent on a special track, which is a track usually apart from those where light freight car repairs are made. If we take out the word "heavy," and have the paragraph apply to all freight car repairs, we go on record as including a covering for tracks where the simplest repairs are made.

Mr. Wendt:—I voted "no" because in our practice we repair cars at many points, that is, we make light repairs at several points, and it would be quite impracticable to cover all repair tracks. It is our practice to send the freight cars which require heavy repairs to our repair shops, but the light repairs are always made out in the open in our country. I have in mind a line that will repair two hundred cars in one day; the cars need but slight attention, yet they must be shifted into a light repair yard and detained twenty-four hours. It seems to me quite unnecessary to cover these tracks. If we did, such buildings would run into large sums of money. I think that the Committee means that it is economical to construct buildings for the protection of the men where heavy repairs are being made, which requires considerable time, and for which freight car repair shop cranes are economical.

Mr. Baldwin:—The discussion is probably out of order, in that the vote has been taken, but I would ask Mr. Wendt if he ever got from his Master Mechanic any statement of time actually lost by the repair men in bad weather? I did recently, and I found that it footed up to a large sum in the season, and my idea in this suggestion was for outside tracks to have an umbrella shed of cheap construction. Where you speak of the use of "overhead traveling cranes to facilitate heavy lifting," the idea conveyed is that of a large repair shop; but the point I was discussing was that of covering your cars which are just put out for ordinary repairs. I will suggest that it is a matter which should be looked into, because I think a little investigation will show that at certain seasons of the year, particularly in the spring and fall, when there is a great deal of rain, that there is a large amount of time lost by the repairmen on account of not being supplied with a shelter, particularly in snowy and stormy weather.

Mr. A. Montzheimer (Elgin, Joliet & Eastern):—I have not read the report carefully, and the point I am about to make may have been brought out, but I would ask what is the latest practice in placing tracks, that is, as to distance from center to center for yards?

The President:—We would like to hear from the members as to the practice existing on their roads.

Mr. Montzheimer:—I understand some yards have 12 and 12½ ft. centers, but that distance does not give the necessary clearance, especially where coal cars with bulging sides are handled, and the tracks are slightly out of surface.

Mr. Chas. S. Churchill (Norfolk & Western):—I think this point has been covered in past meetings and 13 ft. was established by the work of this same Committee. It is the practice of many roads, I know, to use 13 ft. as the standard space for double track. I think that 13 ft. was made to apply also to yards as far as practicable.

Mr. C. H. Ewing (Philadelphia & Reading):—I do not know what action was taken at previous meetings, but it seems to me that 13 ft. is entirely too great a space for yard tracks and requires too much room, especially where you have thirty or forty classification tracks. Twelve feet and one inch has been our practice, and we have found it sufficient.

Prof. W. D. Pence (Purdue University):—The Manual of Recommended Practice, recently issued, on page 128, has this recommendation, which was adopted by the Association: "Body Tracks.—These should be spaced 11 ft. 6 in. to 13 ft. centers; and where they are parallel to the main track or other important running track they should be spaced not less than 16 ft. center to center from said track."

The President:—That was the action of the Association two years ago; there was quite a lengthy argument and discussion at that time on the subject. Are there any of the operating officials having had experience with hump yards who would like to make any remarks as to their working—their advantages and disadvantages?

Mr. Johnston:—Since you raise the question of hump yards, Mr. President, I will ask this question. I have had no experience with hump yards myself, but the Committee has given the conclusion and we have committed ourselves to it, that a hump yard is an absolutely safe yard, because cars can be handled through it faster, with less damage and with less cost than through any other form of yard. I know that the question of damage to freight cars is an ever-present one to the operating man, and the claim department people say that the claims are now more numerous than ever before, and it is alleged that part of it is due to damage in hump yards. The Committee must be in possession of information that leads them to believe that hump yards do cause less damage, and if so I would like to know something about it myself.

Mr. Tratman:—The Committee had this question up and made special inquiry of some fifteen or twenty yards. In only one case was it stated that there was more damage operating on the hump system than by the other system. Inquiry developed that in this one case the statement was written during the absence of the Superintendent, who later wrote that personally he was satisfied there was less damage. This of course implies proper care and discipline. In switching on the flat, either by tail switching or poling, cars may be—and often are—handled in such a way as to smash sills and draft rigging, drive the load through the end of the car, and so forth; no system of switching can prevent that. But under the same conditions of ordinary care in operation there seems to be no room for doubt that for busy yards the classification switching can be done more quickly and with less damage to cars and their contents by the gravity-summit system than by any other system.

Mr. Johnston:—They might not have stated there was more damage, but is it a fact that there was less damage? The fact remains irrespective of the character of switching, that the claims arising out of rough handling is increasing steadily on all railroads, and I am so informed by our claim department. We know that in fast switching without humps there is more damage done. I do not think this Association should go on record in a conclusion that the use of hump yards causes less damage. I think the question had better be left open, or omitted altogether, because I do not see what relation that question has in itself to the superiority of yards, in so far as the arrangement is concerned.

The President:—This discussion relates to conclusion (a). These conclusions were adopted in the form in which they were presented by the Committee, and the chair will entertain a motion to reconsider that conclusion. The point Mr. Johnston brings up is very interesting, and if it is not necessary to state it in the language used in the conclusion, it would be more conservative, at least, to leave that portion of the conclusion out. The conclusion now reads: "(a) A hump yard is the best form of yard for receiving, classifying and making up trains, because cars can be handled through it faster, with less damage and at less cost than through any other form of yard." Do you wish your suggestion to take the form of a motion, Mr. Johnston?

Mr. Johnston:—I move, to get the matter properly before the convention, that we leave out the words "with less damage." I also move to change the expression "is the best form" to read "is a desirable form of yard."

Mr. L. C. Fritch (Illinois Central):—I think it is improper to have the word "receiving" in there, for the reason that cars are not "received" into a hump yard. Cars are only "classified" in a hump yard; therefore, I would amend the motion by leaving out the word "receiving."

Mr. Johnston:—I will accept the amendment.

Prof. Allen:—That suggestion carries more with it, because the next section reads, "Hump yards should consist of receiving, classification and departure tracks, in consecutive order, as enumerated." I do not know to how great an extent the amendment affects the rest of the proposition, but it certainly affects the next paragraph (b).

Mr. Brown:—The very same clause says, "should consist of receiving, classification and departure tracks."

Mr. L. C. Fritch:—Paragraph (b) should also have the word "receiving" left out. A hump yard is a classification yard pure and simple.

Prof. Pence:—Does not this really hinge on the question of what the word "hump" means? For example, any yard which has the hump as a ruling feature would be called a hump yard, and the receiving part of the yard would be part of the entire plant for the receiving, classifying and handling of trains.

Mr. Tratman:—The use of the word in that case refers to the entire yard system, or the "general yard," but it would be an awkward expression to say "any general hump yard." The only preferable change that might be made would be to say "any general yard operated on the hump system should consist of receiving and classification tracks." The term "hump yard" in this case is a general term applied to the whole yard, from the receiving end to the departure end.

Mr. Churchill:—I suggest that the Committee be asked to give a definition of the hump yard, to correspond with the statement just made. They have definitions for other yards, but have left out the definition for the hump yard.

Prof. Pence:—If Mr. Churchill will refer to page 84 of the report I think he will find the definition he speaks of.

The President:—The motion now stands that conclusion (a) be altered to read as follows: "A hump yard is a desirable form of yard for classifying and making up trains, because cars can be handled through it faster and at less cost than through any other form of yard."

(The motion was carried.)

Mr. T. H. Hickey (Michigan Central):—While under the head of freight car repair yards, if in order, I would like to inquire if there is any provision to protect men under box cars when doing work on repair tracks; that is, from engines switching on the track where men might be engaged under the cars.

The President:—Before taking up the question raised by Mr. Hickey, we should not depart from the consideration of paragraph (b) under hump yards, provided that in the opinion of the members it is affected by paragraph (a). It was suggested that the omission of the word "receiving" in paragraph (a) would necessitate omitting the same word in paragraph (b). Paragraph (a) provides that "hump yards should consist of receiving, classification and departure tracks, in consecutive order as enumerated." The suggestion is made that the word "receiving" should be left out.

Mr. McDonald:—I would like to inquire how conclusion (a) stands now. My understanding is that simply the words "with less damage" were stricken out.

The President:—The words quoted were stricken out, and the phraseology changed to read "is a desirable form." The word "receiving" was also stricken out.

Prof. Allen:—I did not understand Mr. Johnston's motion to include that. I understood the Secretary's motion referred to the word "receiving."

The President:—Mr. Johnston accepted the amendment. Do you wish to reconsider it?

Prof. Allen:—Yes, sir.

The President:—You voted in the affirmative?

Mr. McDonald:—I voted in the affirmative under a misapprehension, and will move to reconsider.

(The motion to reconsider the action on conclusion (a) was carried.)

The President:—The original motion is now before the house for consideration.

Prof. Allen:—It seems to me that this matter might be straightened out if we should follow the language in paragraph (b) and put in paragraph (a) a statement that hump yards shall be considered as consisting of receiving, classification and departure yards, in consecutive order as enumerated. Then the whole thing holds good.

The President:—The chair will ask Mr. Johnston to restate his motion, to clear up any misapprehension.

Mr. Johnston:—It included solely the change of the first expression to read "is a desirable form of yard," with the words "with less damage" stricken out, and leaving in the word "receiving." The Secretary made a motion, which I accepted, to omit the word "receiving."

The President:—The conclusion, in its amended form, would read as follows: "A hump yard is a desirable form of yard for receiving, classifying and making up trains, because cars can be handled through it faster and at less cost than through any other form of yard." That is the motion before the house. Discussion is in order.

Mr. McDonald:—I suggest that the two changes be put before the convention separately. Possibly some members might approve of one change and not the other.

The President:—Will you put that in the form of an amendment, Mr. McDonald?

Mr. McDonald:—I move that we first take a vote on the change in the first line, in which it says that it is a desirable form, instead of the best.

Mr. Johnston:—I do not see why we should say that a certain form is the best form. The whole science is in a progressive state. It is a desirable yard to-day, but I do not believe we should say it is the best yard. If it is, we cannot improve on it.

Mr. Bremner:—I second the motion of Mr. McDonald. I want to say in this connection that we built one hump yard, a fairly large yard, where we had a large amount of switching, and in the course of about one year the amount of switching in that yard decreased, and we found it was cheaper to do away with the hump yard and we did so. That was in our St. Paul yard. We do the switching in St. Paul by the straight method, although the hump is there. We have not always found it the most desirable yard for smaller yards; for large yards we have found it the most desirable. I would make the suggestion—and later on will make a motion—that for *large* yards the hump yard is the most desirable.

Mr. Baldwin:—I think the term "hump yard" is somewhat too comprehensive, and that is the cause of this discussion. If it could be changed so as to read, "A hump track is a desirable feature of a yard used for receiving, classifying and making up trains," I think it would be simpler. You can have a hump track in any yard, and have all characters of tracks in it; you can have a receiving yard, classifying yard, etc., and I do not think that the hump should necessarily give the name to the yard as a whole.

The President:—The motion before us is that the first part of conclusion (a) be changed to read, "A hump yard is a desirable form of yard for receiving, classifying and making up trains, because cars can be handled through it faster, with less damage and at less cost than through any other form of yard."

(The motion was carried.)

The President:—The next motion is that in the last line of the conclusion (a) the words "with less damage" be stricken out.

(The motion was carried.)

Mr. Bremner:—May I make a motion that we amend this by saying "for *large* yards."

Mr. Churchill:—My point is on the same question. I think the Committee has not covered it in any definition which they make of the hump yard. I did not discover the word "hump" after the word "summit" when I first spoke. The Committee's intention is, it seems to me, through the entire page 82, to regard a hump yard as a group consisting of receiving tracks, a hump, and tracks beyond the hump, and they are all well described here. If that total of three parts makes up a hump yard, as it really does, then the definition should cover that, and if not, we are correct in leaving in the words "receiving and classification" in conclusion (a) and the same words in conclusion (b), and in that sense I think we should simply have a modification of the definition to make all these articles on page 82 quite clear.

Mr. L. C. Fritch:—In operating parlance, a hump yard is commonly known as a classification yard, in which cars are assorted and classified. If you speak of a hump yard, you refer to the part used for that purpose. If you visit the yards, you will find that they refer to the "eastbound hump" and "westbound hump," speaking of that particular part which is used for classification, and I think it is a mistake to speak of "receiving" in the hump yard, as cars are not received in that yard.

Mr. Barnard:—I think Mr. Baldwin's idea is a good one and should be considered.

The President:—Will you put your suggestion in the form of a motion, Mr. Baldwin?

Mr. Baldwin:—I move that the beginning of conclusion (a) be changed so as to read, "A hump track is a desirable track for a yard that is used for receiving, classifying and making up trains, because cars can be handled through it faster and at less cost than through any other form of yard." The hump is a feature of the yard. Mr. Fritch brings that point out. It does not necessarily give the name to the whole yard. Does Mr. Bremner call his yard a hump yard since he stopped using it?

Mr. Bremner:—No.

Mr. Baldwin:—The hump is there yet.

Mr. Ewing:—It seems to me it would be unwise to separate the hump feature as the distinguishing characteristic of the yard. When we speak of the "eastbound hump" and "westbound hump" yard, we refer to the series of yards on each side, whether for westbound traffic or eastbound traffic. I think the whole matter can be straightened out by substituting in the definition the word "classification" for the word "movement." The definition would then read, "A yard in which the classification of cars is produced by pushing them over a summit," etc. There are many car movements that are not made by pushing them over a summit. This change would make the hump feature the classification one, and then I think we will be regular all the way through.

Mr. L. C. Fritch:—I do not think the word "track" will cover it, for the reason that in many yards there is more than one track over the hump. In the Chicago Clearing Yard there are several tracks over the hump, and therefore I do not consider the word "track" comprehensive enough to cover the point.

Mr. W. M. Camp (Railway and Engineering Review):—Is it not true that in any hump yard the classification tracks lie on the slope of the hump, at least partially? If that is the case, the word "track," in the singular, which Mr. Baldwin embodies in his motion, does not apply. It seems to me that we cannot separate the classification track from the hump. You can, however, separate the receiving and departure tracks, but the Committee undoubtedly meant that they shall be auxiliary to this arrangement. I ask the Committee if they intended that the receiving and departure tracks shall be on the hump or on the slopes of the hump?

Mr. F. S. Stevens (Philadelphia & Reading):—I understand Mr. Camp wishes information as to the track passing over the hump. So far as I know, in all the classification yards I have ever seen, it is a thoroughfare track, that is, there is a second track which is a thoroughfare track. The track that passes over the hump, on which the classification is made, is the track which is connected to the ladders of the receiving yard on one side and the classification yard on the other.

Mr. Camp:—Further down in this report it provides that the several grades of hump shall extend down through the several switches in the yard, so that it seems to me the classification tracks lie on the slope of the hump, according to that.

Mr. Stevens:—The second track or thoroughfare track, which passes over the hump, is the one used to facilitate the movement of cars by the use of an engine in exceedingly cold weather, or when for some other reason the cars will not run.

Prof. Allen:—It seems to me that we need to do one of two things—either to define a hump yard as including receiving, classification and departure tracks, or else cut out entirely all reference to the receiving tracks; if the latter course be pursued, then this report in its present form will have to be done away with—referred back to the Committee—so that certain parts shall be cut out bodily. Hump yards are comparatively new, and this Association can determine what they mean, and it seems to me there would be no mistake made whatever to modify paragraph (b) to read, "Hump yards shall be considered as consisting of receiving, classification and departure tracks, in consecutive order as enumerated." In that case all we have here would become consistent. The other course is to cut out a considerable portion of what there is in these conclusions. I should be glad to make a motion to this effect when in order.

Mr. L. C. Fritch:—If the Committee had used the words "gravity yard," there, it would have simplified the whole matter. Gravity yard is the yard taken as a whole, wherein the principle of gravity is used; but to define a hump yard as a yard for receiving, classifying and making up trains is to use one particular point of the yard for these three purposes, which is not the case in common practice and as commonly understood.

Mr. Baldwin:—I would be perfectly willing to accept an amendment such as calling this a gravity yard, but I think this report as it now stands is inconsistent. There is a good deal which is described under the term "hump yard" which would be applicable to any yard, and the substance of the matter is that a hump can be a feature of any yard. There are certain particular portions of the yard regulated and governed by the hump. As regards Mr. Fritch's point, that the receiving track should not be considered as a part of the yard, this report still goes on to say that the grades of the receiving tracks are a part of the yard, because it says if it is possible the grades of the receiving tracks shall be such that one engine can push the maximum train over the hump, and thereby you see the receiving track is made a portion of the hump yard. It occurs to me, if the Committee could take this report back and give a definition which referred to the gravity portion of the yard alone, that it would be clear.

The President:—Are you ready for the question on Mr. Baldwin's motion?

Mr. Churchill:—Before that motion is put, I want to say that I think the work of this Committee on hump yards is excellent. We have something very valuable in this report, and I would dislike to see anything done to destroy its usefulness. The Committee has made it very clear that all these items on page 82 refer to a system of tracks and include both the receiving side and the classifying side. It is just as important that the grade on the receiving track be within certain limits as it is that the grade over the hump be within certain limits, or that the grade on the classifying side be within certain limits. If we do not keep all these three within proper limits, the hump is a failure. We cannot afford to let anything go out from this Association which is not complete in every part of it; and therefore I would dislike to see anything cut out of page 82 except what has been cut out. The simple change of a definition, or the enlargement of a definition will make everything clear, and the Association has decided heretofore that definitions be left with the Committee. We should regard this whole page as describing a system complete in itself, and I trust that we will therefore leave it alone.

Mr. L. C. Fritch:—I would like to suggest as a solution of the difficulty, that we put conclusion (b) first, making conclusion (b) conclusion (a), which will then read that a hump yard shall consist of certain things, and then put in the present conclusion (a), which will be in proper order, and it could stand. You will then know what it refers to. I will make that an amendment to Mr. Baldwin's motion.

Mr. Baldwin:—I will accept that as a substitute for my motion.

The President:—It is moved that conclusion (b) take the place of conclusion (a), and that conclusion (a) be retained in its form as amended on the motion of Mr. Johnston.

(The motion was carried.)

The President:—Before dismissing the Committee, the chair would like to have an expression from the members as to what direction the investigation of the Committee should take this coming year. At the last annual convention the suggestion was made that this Committee report upon hump yards, and they have produced this report which the

Association has adopted. It was a valuable suggestion and one that was timely, and if any member present has anything to suggest as to the line of work this Committee should undertake during the coming year, it will assist the Board of Direction in outlining its program.

Prof. Allen:—The Committee has spent so much time on work of this sort, I would ask if they have some suggestions to make themselves?

Mr. Tratman:—The chairman of the Committee recently invited suggestions for the work of 1906, and my suggestions in response to this were as follows: (1) Design and operation of poling yards; (2) design of and facilities for division yards; (3) locomotive facilities at division yards; (4) freight handling machinery at yards and terminals (including rail-and-water terminals); (5) arrangements and facilities for small yards and at small stations; (6) yard arrangements and facilities at passenger terminals.

Mr. Montzheimer:—I would like to see some investigation made as to the best method of draining surfaces of large terminal yards.

Mr. L. C. Fritch:—I think the Committee should go further into the subject of hump yards. This is one of the live questions in operation, and we depend upon the engineers to build the yards. I think the most important question in connection with hump yards is the matter of grades. In the course of an investigation of a number of hump yards we found that where the grade is heaviest immediately after leaving the summit, and therefore the acceleration is greatest at the start, in that yard the switching is done most rapidly. I think the Committee should determine the exact grades which should be used through the classification yard, how far it should extend, whether entirely through the yard or only part way. I do not think the suggestions of the Committee on that point at present are complete. They say the grade shall take cars to destination, but the destination may be at the end of the classification yard or just within the limits at the upper end, and that is a matter which should be definitely determined. I think they ought to give us definite data on the various kinds of grades to use, classifying the grades to be used in the hump yard, such as the "approaching grade," from the receiving yard to the summit, should be one grade; then the "velocity grade," running from the summit down; then the "assisting grade," connecting with the velocity grade and running into the receiving grade; and then the "yard grade." These grades should be specified and the best practice determined and recommendations made on these lines. Then I think they should also investigate the matter of "poling yards," the yard intermediate between the "flat" yard and the "hump" yard, to determine the relative economy of the poling yard and the hump yard. I also believe the Committee should give us some data on the cost of the use of hump yards, that is, the cost of switching and at what point it becomes economical to close up the hump yard and use a level yard.

Mr. Wendt:—It is an open question when to build a scale on a hump or on the grade following the hump in the classification yard. The question involves one of location, and it seems to me that the Committee might follow this up with profit to the members. I can conceive of conditions which would make it entirely improper to put any scale at the hump. This question was recently discussed by a writer in Engineering News, and it has occurred to me that the Committee might do some investigating along this line.

Mr. McDonald:—Has anything been done on the subject of providing shelter for the repairing of freight cars, which was referred to in the discussion?

The President:—There was discussion on the subject, but there was no action taken. Have the members any suggestions to make on that?

Mr. L. C. Fritch:—The Committee could get some information from the investigations made by Mr. Baldwin on the Illinois Central. We found it to be more economical to furnish umbrella sheds—not exactly umbrella sheds, but sheds covering three, four or five tracks—than it was not to furnish them, because of the extra amount of labor secured from the car repair men. Our practice is to use old sills taken from the cars in building the sheds. We have now a large number gathered at different points, and we figure it is economical to use a shed to cover the cars, even where ordinary repairs are made, as Mr. Baldwin stated.

Prof. Allen:—I was about to suggest that the matter be left in the hands of the Board of Direction. I suppose if no motion is made, that will be the course.

The President:—The suggestions that have been made are being recorded and will be taken up by the Board of Direction in planning the work of the Committee during the year.

Mr. Baldwin:—I suggest that the Committee obtain some actual data from the different roads as to how much time, in a certain period, is lost by the men engaged in car repairs, through bad weather, and formulate some recommendation in their report as to when and under what circumstances a road would be justified in providing sheds for the cars while slight repairs are being made.

Mr. G. D. Hicks (Nashville, Chattanooga & St. Louis):—Another item to be considered is the loss of the use of the cars while waiting to be repaired, which amounts to a considerable sum. If the weather should be bad for two or three days, the cars would be held up for that length of time, and the road would lose the use of them.

Mr. Ewing:—I would supplement what has been said by including the handling of switches in hump yards.

Mr. Wendt:—There is another very live subject in connection with yards, and especially hump yards, and that is the question of electric lighting. I do not understand that we have ever taken any action on that subject, and if it is in order for this Committee—and I think it is—

to report upon that subject, it would be well for them to give us some conclusions in regard to lighting these large classification yards.

The President:—If there are no further suggestions, the report of the Committee will be received as amended and the Committee relieved with the thanks of the Association.

REPORT OF COMMITTEE NO. XV.—ON IRON AND STEEL STRUCTURES.

To the Members of the American Railway Engineering and Maintenance of Way Association:

In accordance with instructions set forth in Bulletin No. 63, your Committee on Iron and Steel Structures begs to submit a revision of the specifications presented to the Association at the last annual meeting.

In response to our circular letter issued by the Secretary of the Association dated October 4, several valuable discussions have been received. We have endeavored to conform to the suggestions offered as far as possible; and have profited by these discussions, and by the valuable work of the individual members of the Committee, as we hope will be apparent in the specifications now laid before you.

Part I, which was referred back to the Committee, has been very thoroughly studied and completely revised. Part II has been somewhat rearranged and many paragraphs rewritten with the idea of improving its make-up and phraseology, but without much change of meaning.

New paragraphs, and those which have been revised are referred to by footnotes. Paragraphs 31, 32, 66, 89, 150, 151, 152, and 153, of the 1905 edition, have been omitted and their substance covered in other places; 69, 77, 88 and 165 have been omitted as not essential.

For comparison, the paragraphs of the 1905 edition which have been revised are reprinted on right-hand pages.

An alternate scheme of impact and unit strains is presented as a minority report by three of our members. It is submitted for the consideration of the Association. It is manifestly impracticable to incorporate the two schemes in a single definite set of rules for designing bridges, although both result in satisfactory structures.

CONDENSED STATEMENT OF MEETINGS.

The Boston members of the Committee met three times during the past year, at which Messrs. Snow, Brown and Worcester were present. At one of these meetings, Mr. C. C. Schneider was also present.

The Chicago members—Messrs. Loweth, Brunner, Cartlidge, Robinson and Page—met twice during the year, holding one meeting on November 28th, and the second meeting on December 1st. At the second meeting, Mr. C. D. Purdon was also present.

The meetings of the General Committee were held at Niagara Falls on June 19th and December 20th. There were present, Messrs. Snow, Loweth, Brunner, Cartlidge, Crandall, Page, Purdon, Robinson, Schneider, Worcester and Brown; all members being present except Messrs. Mills, Greiner and Hawxhurst.

RECOMMENDED PRACTICE IN CONTRACTING FOR STEEL RAILROAD BRIDGES.

REVISED 1906.

First.—That it is preferable for railroads to furnish general detailed plans and specifications of structural work to bidders, complete enough to show the exact character of the work; but if such plans cannot be furnished, the alternative to be full specifications similar to those on pages 6 to 24, accompanied by outline plans and all information concerning the work.

Second.—That it is preferable to invite bids on a pound price basis; and, if desired, alternate bids may be asked for the work, f. o. b. cars, and for the work erected. That a lump sum bid is inadmissible unless general detailed plans and specifications are furnished.

Third.—That it is preferable to invite bids for as large groups of bridges as can be defined consistently with the first recommendation, but when required to anticipate future requirements, it is not necessary for the railroad to submit designs if the nature of the work is known to the bidder by reason of having previously done work for the railroad or if standard designs of similar structures are submitted to the bidders.

Fourth.—That whenever a bridge is to be erected on a line where traffic is to be maintained, it is recommended that the work be done by the railroad force; but on small railroads where suitably organized and equipped forces for such work may not be justified, the large bridges, and in some cases all bridges, may be erected by contract.

Fifth.—That it is preferable in all cases that the Railroad Company furnish and lay the floor timber.

1906.

GENERAL SPECIFICATIONS FOR STEEL RAILROAD BRIDGES.

PART FIRST—DESIGN.

I. GENERAL FEATURES.

*1. The material in the superstructure shall be structural steel, except rivets, and as may be otherwise specified. **Kind of Material.**

*2. On a straight line, the clear height of through bridges shall not be less than 21 ft. above top of rails for a width of 6 ft. over a single track, and the clear width shall be not less than 7 ft. from the center line of the track between the heights of 4 and 17 ft. above the rails. The width shall be increased to provide the same minimum clearance on curves, for a car 80 ft. long, 14 ft. high, and 60 ft. center to center of trucks, allowance being made for curvature and superelevation of rails. **Clearance.**

3. The width center to center of girders and trusses shall in no case be less than one-twentieth of the effective span, nor less than is necessary to prevent overturning under the assumed lateral loading. **Spacing Trusses.**

*4. Ends of deck plate girders and track stringers of skew bridges at abutments shall be square to the track, unless a ballasted floor is used. **Skew Bridges.**

*5. Wooden tie floors shall be secured to the stringers and shall be proportioned to carry the maximum wheel load, with 100 per cent. impact, distributed over three ties, with fiber strain not to exceed †2,400 lbs. per sq. in. Ties shall not be less than 10 ft. in length. They shall be spaced with not more than 6 in. openings; and shall be secured against bunching. **Timber Floors.**

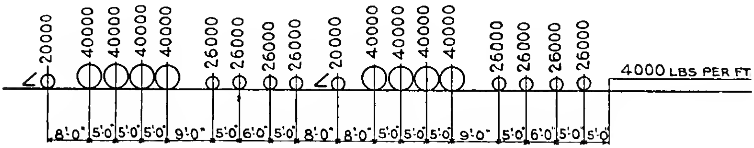
II. LOADS

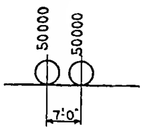
*6. The dead load shall consist of the estimated weight of the entire suspended structure. Timber shall be assumed to weigh 4½ lbs. per ft. B. M.; ballast 100 lbs. per cu. ft. and rails and fastenings 150 lbs. per linear ft. of track. **Dead Load.**

* 1905 specifications revised.
†See amendment, page 205.

Moving Load.

*7. The live load, for each track, shall consist of two typical engines followed by a uniform load, according to Cooper's series,† or a system of loading giving practically equivalent strains. The minimum loading to be Cooper's E-40, as shown in the following diagrams:



and 

the diagram that gives the larger strains to be used.

Heavier Loading.

8. Heavier loadings shall be proportional to the above diagrams on the same spacing.

Impact.

*9. The dynamic increment of the live load shall be added to the maximum computed live load strains and shall be determined by the formula $I = S \dfrac{300}{L + 300}$

where

†I = impact to be added to the live load strains.

S = computed maximum live load strain.

L = loaded length of track in feet producing the maximum strain in the member. For bridges carrying more than one track, the aggregate length of all tracks producing the strain shall be used.

Impact shall not be added to strains produced by longitudinal, centrifugal and lateral or wind forces.

Lateral Load.

*†10. All spans shall be designed for a lateral force of 600 lbs. per linear ft. of the loaded chord, and 200 lbs. per linear ft. of the unloaded chord; these forces being considered as moving.

Wind Load.

*11. Viaduct towers shall be designed for a force of 50 lbs. per sq. ft. on one and one-half times the vertical projection of the structure unloaded; or 30 lbs. per sq. ft. on the same surface plus 400 lbs. per linear ft. of structure applied 7 ft. above the rail for assumed wind load on train when the structure is either fully loaded or loaded on either track with empty cars assumed to weigh 1,200 lbs. per linear ft., whichever gives the larger strain.

* 1905 specifications revised.
†See amendment, page 205.

*12. Viaduct towers and similar structures shall be designed for a longitudinal force applied to the rail of †two-tenths of the live load. Longitudinal Force.

*†13. Structures located on curves shall be designed for the centrifugal force of the live load acting at a height of 6 ft. above the rail; and at a speed to be determined by the engineer for each case. Centrifugal Force.

III. UNIT STRAINS AND PROPORTION OF PARTS.

14. All parts of structures shall be so proportioned that the sum of the maximum strains shall not exceed the following amounts in pounds per square inch, except as modified in paragraphs 20 to 23: Unit Strains.

15. Axial tension on net section .... 16,000 Tension.

16. Axial compression on gross section .... $16{,}000 - 70\frac{l}{r}$ Compression.

where "l" is the length of member in inches and "r" is the least radius of gyration in inches.

*17. Bending: on extreme fibers of rolled shapes, built sections and girders; net section 16,000
on extreme fibers of pins .... 24,000 Bending.

*18. Shearing: shop driven rivets and pins 12,000
field driven rivets and turned bolts .... †19,000
plate girder webs; gross section .... 10,000 Shearing.

*19. Bearing: shop driven rivets and pins 24,000
field driven rivets and turned bolts .... †18,000
granite masonry and Portland cement concrete 600
sandstone and limestone 400
expansion rollers; per linear inch .... $600\,d$
where "d" is the diameter of the roller in inches. Bearing.

*†20. Members subject to alternate strains of tension and compression shall be proportioned for the strains giving the largest section. The connections shall be proportioned for the sum of the strains. Alternate Strains.

21. Wherever the live and dead load strains are of opposite character, only 70 per cent. of the dead load strain shall be considered as effective in counteracting the live load strain. Counter-Strains.

*22. Members subject to both axial and bending strains shall be proportioned so that the combined fiber strains will not exceed the allowed axial strain. Axial and Bending Strains Combined.

* 1905 specifications revised.
†See amendment, page 205.

Lateral and Other Strains Combined.

*†23. For strains produced by lateral, longitudinal or wind forces combined with those from live and dead load, the unit strains may be increased 25 per cent. over those given above; but the section shall not be less than required for the live and dead load alone.

Net Section at Rivets.

*24. In proportioning tension members the diameter of the rivet holes shall be taken ⅛-in. larger than the nominal diameter of the rivet.

Rivets.

*25. In proportioning rivets, the nominal diameter of the rivet shall be used.

Net Section at Pins.

26. Pin-connected riveted tension members shall have a net section through the pin-hole at least 25 per cent. in excess of the net section of the body of the member, and the net section back of the pin-hole, parallel with the axis of the member, shall be not less than the net section of the body of the member.

Proportioning Plate Girders.

*27. Plate girders shall be proportioned either by the moment of inertia of their net section; or by assuming that the flanges are concentrated at their centers of gravity; in which case one-eighth of the gross section of the web, if properly spliced, may be used as flange section.

Compression Flange.

*28. The gross section of the compression flanges of plate girders shall not be less than the gross section of the tension flanges; nor shall the strain per sq. in. in the compression flange of any beam or girder exceed $16{,}000 - 200 \frac{l}{b}$, where l = unsupported distance and b = width of flange.

Flange Rivets.

*†29. The number of plate girders shall be connected to the web with a sufficient number of rivets to transfer the total shear at any point in a distance equal to the depth of the girder at that point combined with any load that is applied directly on the flange. The wheel loads, where the ties rest on the flanges, shall be assumed to be distributed over three ties.

Depth Ratios.

*†30. Pony trusses and plate girders shall preferably have a depth not less than one-tenth of the span, and rolled beams used as girders shall preferably have a depth of not less than one-twelfth of the span. When these ratios are decreased, proper increase shall be made to the section to avoid excessive deflection.

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* 1905 specifications revised.
†See amendment, page 206.

IV. DETAILS OF DESIGN.

GENERAL REQUIREMENTS.

*31. Structures shall be so designed that all parts will be accessible for inspection, cleaning and painting. Open Sections.

*32. Pockets or depressions which would hold water shall have drain holes, or be filled with waterproof material. Water Pockets.

33. Main members shall be so designed that the neutral axis will be as nearly as practicable in the center of section, and the neutral axes of intersecting main members of trusses shall meet at a common point. Symmetrical Sections.

*†34. Rigid counters are preferred; and where subject to reversal of strain shall preferably have riveted connection to the chord. Adjustable counters shall have open turnbuckles. Counters.

35. The strength of connections shall be sufficient to develop the full strength of the member, even though the computed strain is less, the kind of strain to which the member is subjected being considered. Strength of Connections.

*36. The minimum thickness of metal shall be ⅜-in. except for fillers. Minimum Thickness.

†37. The minimum distance between centers of rivet holes shall be three diameters of the rivet; but the distance shall preferably be not less than 3 in. for ⅞-in. rivets and 2½ in. for ¾-in. rivets. The maximum pitch in the line of strain for members composed of plates and shapes shall be 6 in. for ⅞-in. rivets and 5 in. for ¾-in. rivets. For angles with two gage lines the maximum shall be twice the above in each line, with rivets staggered, and where two or more plates are used in contact, rivets not more than 12 in. apart in any direction shall be used to hold the plates well together. In tension members composed of two angles in contact, a pitch of 12 in. will be allowed for riveting the angles together. Pitch of Rivets.

38. The minimum distance from the center of any rivet hole to a sheared edge shall be 1½ in. for ⅞-in. rivets and 1¼ in. for ¾-in. rivets, and to a rolled edge 1¼ and 1⅛ in., respectively. The maximum distance from any edge shall be eight times the thickness of the plate, but shall not exceed 6 in. Edge Distance.

39. The diameter of the rivets in any angle carrying calculated strain shall not exceed one-quarter the width of the leg in which they are driven. In minor parts ⅞-in. rivets may be used in 3-in. angles, and ¾-in. rivets in 2½-in. angles. Maximum Diameter.

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* 1905 specifications revised.
†See amendment, page 206.

Long Rivets.

40. Rivets carrying calculated strain and whose grip exceeds four diameters shall be increased in number at least one per cent. for each additional $\frac{1}{16}$-in. of grip.

Pitch at Ends.

41. The pitch of rivets at the ends of built compression members shall not exceed four diameters of the rivets for a length equal to one and one-half times the maximum width of member.

Compression Members.

*†42. In compression members the metal shall be concentrated as much as possible in webs and flanges. The thickness of each web shall be not less than one-thirtieth of the distance between its connections to the flanges. Cover plates if used shall have a thickness not less than one-fortieth of the distance between rivet lines.

Minimum Angles.

*43. Flanges of girders and built members without cover plates shall have a minimum thickness of †one-tenth the width of the outstanding leg.

Tie-Plates.

*44. The open sides of compression members shall be provided with lattice and shall have tie-plates as near each end as practicable. Tie-plates shall be provided at intermediate points where the lattice is interrupted. In main members the end tie-plates shall have a length not less than the distance between the lines of rivets connecting them to the flanges, and intermediate ones not less than one-half this distance. Their thickness shall not be less than one-fiftieth of the same distance.

Lattice.

45. The minimum width of lattice bars shall be 2½ in. for ⅞-in. rivets, 2¼ in. for ¾-in. rivets, and 2 in. if ⅝-in. rivets are used. The thickness shall not be less than one-fortieth of the distance between end rivets, for single lattice and one-sixtieth for double lattice. Shapes of equivalent strength may be used.

Rivets in Flanges.

46. Five-eighths-inch rivets shall be used for latticing flanges less than 2½ in. wide and ¾-in. rivets for flanges from 2½ to 3½ in. wide; ⅞-in. rivets shall be used in flanges 3½ in. and over, and lattice bars with two rivets shall be used for flanges over 5 in. wide.

Angle of Lattice.

47. The inclination of lattice bars with the axis of the member shall be not less than 45 degrees, and when the distance between rivet lines in the flanges is more than 15 in., if single rivet bar is used, the lattice shall be double and riveted at the intersection.

Spacing of Lattice.

*48. Lattice bars shall be so spaced that the portion of the flange included between their connection shall be as strong as the member as a whole.

* 1905 specifications revised.
† See amendment, page 206.

49. Abutting joints in compression members when faced for bearing shall be spliced on four sides sufficiently to hold the connecting members accurately in place. All other joints in riveted work, whether in tension or compression, shall be fully spliced. **Faced Joints.**

50. Pin holes shall be reinforced by plates where necessary, and at least one plate shall be as wide as the flanges will allow and be on the same side as the angles. They shall contain sufficient rivets to distribute their portion of the pin pressure to the full cross-section of the member. **Pin Plates.**

51. Forked ends on compression members will be permitted only where unavoidable; where used, a sufficient number of pin plates shall be provided to make the jaws of twice the sectional area of the member. At least one of these plates shall extend to the far edge of the farthest tie-plate and the balance not less than 6 in. beyond the near edge of the same plate. **Forked Ends.**

*52. Pins shall be long enough to insure a full bearing of all the parts connected upon the turned body of the pin. They shall be secured by chambered nuts or be provided with washers if solid nuts are used. The screw ends shall be long enough to admit of burring the threads. **Pins.**

53. Members packed on pins shall be held against lateral movement. **Filling Rings.**

54. Where members are connected by bolts, the turned body of these bolts shall be long enough to extend through the metal. A washer at least ¼-in. thick shall be used under the nut. Bolts shall not be used in place of rivets except by special permission. Heads and nuts shall be hexagonal. **Bolts.**

†55. Where splice plates are not in direct contact with the parts which they connect, rivets shall be used on each side of the joint in excess of the number theoretically required to the extent of one-third of the number of each intervening plate. **Indirect Splices.**

†56. The number of rivets in fillers between parts carrying strain shall be governed by paragraph 55; the excess rivets, where possible, to be outside of the connected part, so as to make tight fillers. **Fillers.**

*57. Provision for expansion to the extent of ⅛-in. for each 10 ft. shall be made for all bridge structures. Efficient means shall be provided to prevent excessive motion at any one point. **Expansion.**

*58. Spans of 80 ft. and over resting on masonry shall have turned rollers or rockers at one end; and those of less length shall be arranged to slide on smooth surfaces. **Expansion Bearings.**

* 1905 specifications revised.
†See amendment, page 207.

Fixed Bearings.

59. Movable bearings shall be designed to permit motion in one direction only. Fixed bearings shall be firmly anchored to the masonry.

Rollers.

*60. Expansion rollers shall be not less than **6 in.** in diameter. They shall be coupled together with substantial side bars, which shall be so arranged that the rollers can be readily cleaned.

Bolsters.

*61. Bolsters or shoes shall be so constructed that the load will be distributed over the entire bearing; spans of 80 ft. or over shall preferably have hinged bolsters at each end.

Wall Plates.

*62. Wall plates may be cast or built up; and shall be so designed as to distribute the load uniformly over the entire bearing. They shall be secured against displacement.

Anchorage.

*63. Anchor bolts for viaduct towers and similar structures shall be long enough to engage a mass of masonry the weight of which is at least one and one-half times the uplift.

Inclined Bearings.

64. Bridges on an inclined grade without pin shoes shall have the sole plates beveled so that the masonry and expansion surfaces may be level.

FLOOR SYSTEMS.

Floor Beams.

65. Floor beams shall preferably be square to the trusses or girders. They shall be riveted directly to the girders or trusses or may be placed on top of deck bridges.

Stringers.

66. Stringers shall preferably be riveted to the webs of all intermediate floor beams by means of connection angles not less than $\frac{7}{16}$-in. thick. Shelf angles or other supports provided to support the stringer during erection shall not be considered as carrying any of the reaction.

End Spacers for Stringers.

*67. Where end floor beams cannot be used, stringers resting on masonry shall have cross frames near their ends. These frames shall be riveted to girders or truss shoe where practicable.

BRACING.

Rigid Bracing.

68. Lateral, longitudinal and transverse bracing in all structures shall be composed of rigid members.

Portals.

*69. Through truss spans shall have riveted portal braces rigidly connected to the end posts and top chords. They shall be as deep as the clearance will allow.

* 1905 specifications revised.

*70. Intermediate transverse frames shall be used at each panel of through spans having vertical truss members where the clearance will permit. Transverse Bracing.

*71. Deck spans shall have transverse bracing at each end proportioned to carry the lateral load to the support. End Bracing.

*72. The minimum sized angle to be used in lateral bracing shall be 3½ by 3 by ⅜-in. Not less than three rivets through the end of the angles shall be used at the connection. Minimum Bracing.

*73. Lateral bracing shall be far enough below the flange to clear the ties. Bracing to Clear Ties.

*74. The struts at the foot of viaduct towers shall be strong enough to slide the movable shoes when the track is unloaded. Tower Struts.

PLATE GIRDERS.

*75. If desired plate girder spans over 50 ft. in length shall be built with camber at a rate of $\frac{1}{16}$-in. per 10 ft. of length. Camber.

76. Where flange plates are used, one cover plate of top flange shall extend the whole length of the girder. Top Flange. Cover.

*77. There shall be web stiffeners, generally in pairs, over bearings, at points of concentrated loading and at points required by the formula: Web Stiffeners.

$$D = \frac{t}{40}(12{,}000 - s)$$

Where D = clear distance, between stiffeners or flange angles.

t = thickness of web.

s = shear per sq. in.

The stiffeners at ends and at points of concentrated loads shall be proportioned by the formula of paragraph 16, the effective length being assumed as one-half the depth of girders. End stiffeners and those under concentrated loads shall be on fillers and have their outstanding legs as wide as the flange angles will allow and shall fit tightly against them. Intermediate stiffeners may be offset or on fillers and their outstanding legs shall be not less than one-thirtieth of the depth of girder plus 2 in.

78. Through plate girders shall have their top flanges stayed at each end of every floor beam, or in case of solid floors, at distances not exceeding 12 ft., by knee braces or gusset plates. Stays for Top Flanges.

* 1905 specifications revised.

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TRUSSES.

Camber. *79. Truss spans shall be given a camber by making the panel length of the top chords, or their horizontal projections, longer than the corresponding panels of the bottom chord in the proportion of ⅛-in. in 10 ft.

Rigid Members. *†80. The hip verticals and similar members and generally the two end panels of bottom chords of pin trusses shall be rigid.

Eye-bars. 81. The eye-bars composing a member shall be so arranged that adjacent bars shall not have their surfaces in contact; they shall be as nearly parallel to the axis of the truss as possible, the maximum inclination of any bar being limited to one inch in 16 ft.

Pony Trusses. *82. Pony trusses shall be riveted structures, with double webbed chords, and shall have all web members latticed or otherwise effectively stiffened.

* 1905 specifications revised.
†See amendment, page 207.

PART SECOND—MATERIALS AND WORKMANSHIP.

V. MATERIAL.

Process of Manufacture.

83. Steel shall be made by the open-hearth process.

Schedule of Require-ments.

84. The chemical and physical properties shall conform to the following limits:

Elements Considered.	Structural Steel.	Rivet Steel.	Steel Castings.
Phosphorus, max.... Basic.....	0.04 per cent.	0.04 per cent.	0.05 per cent.
Phosphorus, max.... Acid......	0.08 "	0.04 "	0.08 "
Sulphur, maximum..............	0.05 "	0.04 "	0.05 "
Ultimate tensile strength. Pounds per square inch	Desired 60,000	Desired 50,000	Not less than 65,000
Elong., min. % in 8", Fig. 1.	1,500,000* / Ult. tensile str'gth	1,500,000 / Ult. tensile str'gth	
" " " 2", " 2	22		18
Character of Fracture......	Silky	Silky	Silky or fine granular
Cold Bends without Fracture	180° flat†	180° flat‡	90° d = 3t.

*See paragraph 93. †See paragraphs 94 95 and 96. ‡See paragraph 97.

The yield point, as indicated by the drop of beam, shall be recorded in the test reports.

Allowable Variations.

*†85. If the ultimate strength varies more than 4,000 lbs. from that desired, a retest may be made on the same gage, at the option of the inspector, which, to be acceptable, shall be within 5,000 lbs. of the desired ultimate.

Chemical Analyses.

86. Chemical determinations of the percentages of carbon, phosphorus, sulphur and manganese shall be made by the manufacturer from a test ingot taken at the time of the pouring of each melt of steel, and a correct copy of such analysis shall be furnished to the engineer or his inspector. Check analyses shall be made from finished material, if called for by the purchaser, in which case an excess of 25 per cent. above the required limits will be allowed.

* 1905 specifications revised.
†See amendment, page 207.

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Form of Specimens.

87. Plates, Shapes and Bars: Specimens for tensile and bending tests for plates, shapes and bars shall be made by cutting coupons from the finished product, which shall have both faces rolled and both edges milled to the form shown by Fig. 1; or with both edges parallel; or they may be turned to a diameter of ¾-in. for a length of at least 9 in., with enlarged ends.

88. Rivets: Rivet rods shall be tested as rolled.

89. Pins and Rollers: Specimens shall be cut from the finished rolled or forged bar, in such manner that the center of the specimen shall be one inch from the surface of the bar. The specimen for tensile test shall be turned to the form shown by Fig. 2. The specimen for bending test shall be 1 in. by ½-in. in section.

90. Steel Castings: The number of tests will depend on the character and importance of the castings. Specimens shall be cut cold from coupons molded and cast on some portion of one or more castings from each melt or from the sink heads, if the heads are of sufficient size. The coupon or sink head, so used, shall be annealed with the casting before it is cut off. Test specimens to be of the form prescribed for pins and rollers.

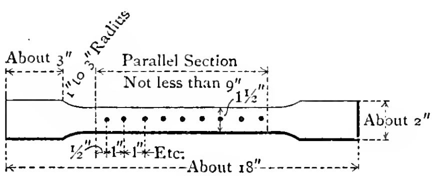

Fig. 1.

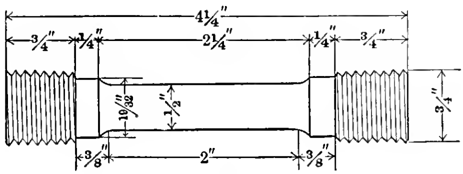

Fig. 2.

Annealed Specimens.

91. Material which is to be used without annealing or further treatment shall be tested in the condition in which it comes from the rolls. When material is to be annealed, or otherwise treated before use, the specimens for tensile tests representing such material shall be cut from properly annealed or similarly treated short lengths of the full section of the bar.

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92. At least one tensile and one bending test shall be made from each melt of steel as rolled. In case steel differing ⅜-in. and more in thickness is rolled from one melt, a test shall be made from the thickest and thinnest material rolled. **Number of Tests.**

93. For material less than $\frac{5}{16}$-in. and more than ¾-in. in thickness the following modifications will be allowed in the requirements for elongation: **Modifications in Elongation.**

(a) For each $\frac{1}{16}$-in. in thickness below $\frac{5}{16}$-in., a deduction of 2½ will be allowed from the specified percentage.

(b) For each ⅛-in. in thickness above ¾-in., a deduction of 1 will be allowed from the specified percentage.

*(c)

94. Bending tests may be made by pressure or by blows. Plates, shapes and bars less than one inch thick shall bend as called for in paragraph 84. **Bending Tests.**

95. Full-sized material for eye-bars and other steel one inch thick and over, tested as rolled, shall bend cold 180 degrees around a pin, the diameter of which is equal to twice the thickness of the bar, without fracture on the outside of bend. **Thick Material.**

96. Angles ¾-in. and less in thickness shall open flat, and angles ½-in. and less in thickness shall bend shut, cold, under blows of a hammer, without sign of fracture. This test will be made only when required by the inspector. **Bending Angles.**

97. Rivet steel, when nicked and bent around a bar of the same diameter as the rivet rod, shall give a gradual break and a fine, silky uniform fracture. **Nicked Bends.**

98. Finished material shall be free from injurious seams, flaws, cracks, defective edges or other defects, and have a smooth, uniform and workmanlike finish. Plates 36 in. in width and under shall have rolled edges. **Finish.**

99. Every finished piece of steel shall have the melt number and the name of the manufacturer stamped or rolled upon it. Steel for pins and rollers shall be stamped on the end. Rivet and lattice steel and other small parts may be bundled with the above marks on an attached metal tag. **Stamping.**

* (c) 1905 specification omitted.

Defective Material.

100. Material which, subsequent to the above tests at the mills, and its acceptance there, develops weak spots, brittleness, cracks or other imperfections, or is found to have injurious defects, will be rejected at the shop and shall be replaced by the manufacturer at his own cost.

Allowable Variation in Weight.

101. A variation in cross-section or weight of each piece of steel of more than 2½ per cent. from that specified will be sufficient cause for rejection, except in case of sheared plates, which will be covered by the following permissible variations, which are to apply to single plates:

When Ordered to Weight.

102. Plates 12½ lbs. per sq. ft. or heavier:

(a) Up to 100 in. wide 2½ per cent. above or below the prescribed weight.

(b) One hundred inches wide and over, 5 per cent. above or below.

103. Plates under 12½ lbs. per sq. ft.:

(a) Up to 75 in. wide, 2½ per cent. above or below.

(b) Seventy-five inches and up to 100 in. wide, 5 per cent. above or 3 per cent. below.

(c) One hundred inches wide and over, 10 per cent. above or 3 per cent. below.

When Ordered to Gage.

104. Plates will be accepted if they measure not more than 0.01 in. below the ordered thickness.

105. An excess over the nominal weight, corresponding to the dimensions on the order, will be allowed for each plate, if not more than that shown in the following table, one cu. in. of rolled steel being assumed to weigh 0.2833 lb.:

Thickness Ordered.	Nominal Weights	Width of Plate			
		Up to 75″	75″ and up to 100″	100″ and up to 115″	Over 115
¼-inch	10.20 lbs.	10 per cent.	14 per cent.	18 per cent.	....
5/16 "	12.75 "	8 "	12 "	16 "	....
⅜ "	15.30 "	7 "	10 "	13 "	17 per cent.
7/16 "	17.85 "	6 "	8 "	10 "	13 "
½ "	20.40 "	5 "	7 "	9 "	12 "
9/16 "	22.95 "	4½ "	6½ "	8½ "	11 "
⅝ "	25.50 "	4 "	6 "	8 "	10 "
Over ⅝ "	....	3½ "	5 "	6⅛ "	9 "

VI. SPECIAL METALS.

Cast-Iron.

106. Except where chilled iron is specified, castings shall be made of tough gray iron, with sulphur not over 0.10 per cent. They shall be true to pattern, out of wind and free from flaws and excessive shrinkage.

If tests are demanded, they shall be made on the "Arbitration Bar" of the American Society for Testing Materials, which is a round bar, 1¼ in. diameter and 15 in. long. The transverse test shall be made on a supported length of 12 in. with load at middle. The minimum breaking load so applied shall be 2,900 lbs., with a deflection of at least $\frac{1}{10}$-in. before rupture.

107. Wrought-iron shall be double-rolled, tough, fibrous and uniform in character. It shall be thoroughly welded in rolling and be free from surface defects. When tested in specimens of the form of Fig. 1, or in full-sized pieces of the same length, it shall show an ultimate strength of at least 50,000 lbs. per sq. in., an elongation of at least 18 per cent. in 8 in., with fracture wholly fibrous. Specimens shall bend cold, with the fiber, through 135 degrees, without sign of fracture, around a pin the diameter of which is not over twice the thickness of the piece tested. When nicked and bent, the fracture shall show at least 90 per cent. fibrous. Wrought-Iron Bars.

VII. INSPECTION AND TESTING AT THE MILLS.

108. The purchaser shall be furnished complete copies of mill orders, and no material shall be rolled, nor work done, before the purchaser has been notified where the orders have been placed, so that he may arrange for the inspection. Copies of Mill Orders.

109. The manufacturer shall furnish all facilities for inspecting and testing the weight and quality of all material at the mill where it is manufactured. He shall furnish a suitable testing machine for testing the specimens, as well as prepare the pieces for the machine, free of cost. Facilities for Inspection.

110. When an inspector is furnished by the purchaser to inspect material at the mills, he shall have full access, at all times, to all parts of mills where material to be inspected by him is being manufactured. Access to Mills.

VIII. WORKMANSHIP.

111. All parts forming a structure shall be built in accordance with approved drawings. The workmanship and finish shall be equal to the best practice in modern bridge works. General.

112. Material shall be thoroughly straightened in the shop, by methods that will not injure it, before being laid off or worked in any way. Straightening Material.

113. Shearing shall be neatly and accurately done and all portions of the work exposed to view neatly finished. Finish.

Size of Rivets. 114. The size of rivets, called for on the plans, shall be understood to mean the actual size of the cold rivet before heating.

Rivet Holes. *115. When general reaming is not required the diameter of the punch shall not be more than $\frac{1}{16}$-in. greater than the diameter of the rivet; nor the diameter of the die more than ⅛-in. greater than the diameter of the punch. Material more than ¾-in. thick shall be sub-punched and reamed or drilled from the solid.

Punching. *116. All punching shall be accurately done. Holes mismatching more than $\frac{1}{16}$-in. shall be corrected with reamers. Drifting to enlarge unfair holes will not be allowed. Poor matching of holes will be cause for rejection.

Sub-punching and Reaming. *117. Where general reaming is required the punch used shall have a diameter not less than $\frac{3}{16}$-in. smaller than the nominal diameter of the rivet. Holes shall then be reamed to a diameter not more than $\frac{1}{16}$-in. larger than the nominal diameter of the rivet.

Reaming After Assembling. *118. Reaming shall be done with twist drills, after the pieces forming one built member are assembled and firmly bolted together. If necessary to take the pieces apart for shipping and handling, the respective pieces reamed together shall be so marked that they may be reassembled in the same position in the final setting up. No interchange of reamed parts will be allowed.

Burrs. *119. The outside burrs on reamed holes shall be removed.

Edge Planing. *120. Sheared edges or ends shall, when required, be planed at least ⅛-in.

Assembling. 121. Riveted members shall have all parts well pinned up and firmly drawn together with bolts before riveting is commenced. Contact surfaces to be painted (see 149).

Lattice Bars. 122. Lattice bars shall have neatly rounded ends, unless otherwise called for.

Web Stiffeners. 123. Stiffeners shall fit neatly between flanges of girders. Where tight fits are called for, the ends of the stiffeners shall be faced and shall be brought to a true contact bearing with the flange angles.

Splice Plates and Fillers. 124. Web splice plates and fillers under stiffeners shall be cut to fit within ⅛-in. of flange angles.

Web Plates. 125. Web plates of girders, which have no cover plates, shall be flush with the backs of angles or project above the same not more than

* 1905 specification revised.

⅛-in., unless otherwise called for. When web plates are spliced, not more than ¼-in. clearance between ends of plates will be allowed.

*126. Connection angles for floor beams and stringers shall be flush with each other and correct as to position and length of girder. In case milling is required after riveting, the removal of more than $\frac{1}{16}$-in. from their thickness will be cause for rejection. Connection Angles.

127. Rivets shall be driven by pressure tools wherever possible. Pneumatic hammers shall be used in preference to hand driving. Riveting.

128. Rivets shall look neat and finished, with heads of approved shape, full and of equal size. They shall be central on shank and grip the assembled pieces firmly. Recupping and calking will not be allowed. Loose, burned or otherwise defective rivets shall be cut out and replaced. In cutting out rivets, great care shall be taken not to injure the adjacent metal. If necessary, they shall be drilled out. Rivets.

129. Wherever bolts are used in place of rivets which transmit shear, the holes shall be reamed parallel and the bolts turned to a driving fit. A washer not less than ¼-in. thick shall be used under nut. Turned Bolts.

130. The several pieces forming one built member shall be straight and fit closely together, and finished members shall be free from twists, bends or open joints. Members to Be Straight.

131. Abutting joints shall be cut or dressed true and straight and fitted close together, especially where open to view. In compression joints depending on contact bearing, the surfaces shall be truly faced, so as to have even bearings after they are riveted up complete and when perfectly aligned. Finish of Joints.

*132. Holes for floor beam and stringer connections shall be subpunched and reamed with twist drills to a steel templet one inch thick. Unless otherwise allowed, all other field connections shall be assembled in the shop and the unfair holes reamed; and when so reamed the pieces shall be match-marked before being taken apart. Field Connections.

*†133. Eye-bars shall be straight and true to size, and shall be free from twists, folds in the neck or head, or any other defect. Heads shall be made by upsetting, rolling or forging. Welding will not be allowed. The form of heads will be determined by the dies in use at the works where the eye-bars are made, if satisfactory to the engineer, but the manufacturer shall guarantee the bars to break in the body when tested Eye-Bars.

* 1905 specifications revised.
†See amendment, page 207.

to rupture. The thickness of head and neck shall not vary more than $\frac{1}{16}$-in. from the thickness of the bar. (See 160.)

Boring Eye-Bars.

*134. Before boring, each eye-bar shall be properly annealed and carefully straightened. Pin holes shall be in the center line of bars and in the center of heads. Bars of the same length shall be bored so accurately that, when placed together, pins $\frac{1}{32}$-in. smaller in diameter than the pin holes can be passed through the holes at both ends of the bars at the same time without forcing.

Pin Holes.

*135. Pin holes shall be bored true to gages, smooth and straight; at right angles to the axis of the member and parallel to each other, unless otherwise called for. The boring shall be done after the member is riveted up.

Variation in Pin Holes.

136. The distance center to center of pin holes shall be correct within $\frac{1}{32}$-in., and the diameter of the hole not more than $\frac{1}{50}$-in. larger than that of the pin, for pins up to 5-in. diameter, and $\frac{1}{32}$-in. for larger pins.

Pins and Rollers.

137. Pins and rollers shall be accurately turned to gages and shall be straight and smooth and entirely free from flaws.

Screw Threads.

138. Screw threads shall make tight fits in the nuts and shall be U. S. standard, except above the diameter of 1⅜ in., when they shall be made with six threads per inch.

Annealing.

139. Steel, except in minor details, which has been partially heated, shall be properly annealed.

Steel Castings.

140. All steel castings shall be annealed.

Welds.

141. Welds in steel will not be allowed.

Bed Plates.

142. Expansion bed plates shall be planed true and smooth. Cast wall plates shall be planed top and bottom. The cut of the planing tool shall correspond with the direction of expansion.

Pilot Nuts.

*143. Pilot and driving nuts shall be furnished for each size of pin, in such numbers as may be ordered.

Field Rivets.

*144. Field rivets shall be furnished to the amount of 15 per cent. plus ten rivets in excess of the nominal number required for each size.

Shipping Details.

145. Pins, nuts, bolts, rivets and other small details shall be boxed or crated.

Weight.

146. The weight of every piece and box shall be marked on it in plain figures.

* 1905 specifications revised.

147. Payment for pound price contracts shall be by scale weight. No allowance over 2 per cent. of the total weight of the structure as computed from the plans will be allowed for excess weight. Finished Weight.

IX. SHOP PAINTING.

148. Steel work, before leaving the shop, shall be thoroughly cleaned and given one good coating of pure linseed oil, or such paint as may be called for, well worked into all joints and open spaces. Cleaning.

149. In riveted work, the surfaces coming in contact shall each be painted before being riveted together. Contact Surfaces.

150. Pieces and parts which are not accessible for painting after erection, including tops of stringers, eye-bar heads, ends of posts and chords, etc., shall have a good coat of paint before leaving the shop. Inaccessible Surfaces.

151. Painting shall be done only when the surface of the metal is perfectly dry. It shall not be done in wet or freezing weather, unless protected under cover. Condition of Surfaces.

152. Machine-finished surfaces shall be coated with white lead and tallow before shipment or before being put out into the open air. Machine-Finished Surfaces.

X. INSPECTION AND TESTING AT THE SHOPS.

153. The manufacturer shall furnish all facilities for inspecting and testing the weight and the quality of workmanship at the shop where material is manufactured. He shall furnish a suitable testing machine for testing full-sized members if required. Facilities for Inspection.

*154. The purchaser shall be notified well in advance of the start of the work in the shop in order that he may have an inspector on hand to inspect material and workmanship. Starting Work in Shop.

155. When an inspector is furnished by the purchaser, he shall have full access, at all times, to all parts of the shop where material under his inspection is being manufactured. Access to Shop.

156. The inspector shall stamp each piece accepted with a private mark. Any piece not so marked may be rejected at any time, and at any stage of the work. If the inspector, through an oversight or otherwise, has accepted material or work which is defective or contrary to the specifications, this material, no matter in what stage of completion, may be rejected by the purchaser. Accepting Material or Work.

* 1905 specifications revised.

Shop Plans.

*157. The purchaser shall be furnished complete shop plans.

Shipping Invoices.

*158. Complete copies of shipping invoices shall be furnished to the purchaser with each shipment.

XI. FULL-SIZED TESTS.

Test to Prove Workmanship.

*159. Full-sized tests on eye-bars and similar members, to prove the workmanship, shall be made at the manufacturer's expense, and shall be paid for by the purchaser at contract price, if the tests are satisfactory. If the tests are not satisfactory, the members represented by them will be rejected.

Eye-Bar Tests.

*160. In eye-bar tests, the fracture shall be silky, the elongation in 10 ft., including the fracture, shall be not less than 15 per cent; and the ultimate strength and true elastic limit shall be recorded. (See 133.)

Respectfully submitted,

J. P. Snow, Bridge Engineer, Boston & Maine Railroad, Boston, Mass., *Chairman.*

C. F. Loweth, Engineer and Superintendent Bridges and Buildings, Chicago, Milwaukee & St. Paul Railway, Chicago, Ill., *Vice-Chairman.*

John Brunner, Assistant General Superintendent, North Works, Illinois Steel Company, Chicago, Ill., *Secretary.*

M. F. Brown, Chief Engineer, Boston Bridge Works, Boston, Mass.

C. H. Cartlidge, Bridge Engineer, Chicago, Burlington & Quincy Railroad, Chicago, Ill.

C. L. Crandall, Professor of Railroad Engineering, Cornell University, Ithaca, N. Y.

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Robt. Hawxhurst, Jr., Consulting Engineer, Tacoma, Wash.

Chas. M. Mills, Principal Assistant Engineer, Elevated Railroad and Subway, Philadelphia, Pa.

A. D. Page, Engineer Bridges and Buildings, Chicago, Rock Island & Pacific Railway, Chicago, Ill.

C. D. Purdon, Engineer Maintenance of Way, St. Louis & San Francisco Railway, St. Louis, Mo.

A. F. Robinson, Bridge Engineer, Santa Fe Railway System, Chicago, Ill.

C. C. Schneider, Consulting Engineer, Philadelphia, Pa.

J. R. Worcester, Consulting Engineer, Boston, Mass.

Committee.

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* 1905 specifications revised.

AMENDMENTS.

5. Wooden tie floors shall be secured to the stringers and shall be proportioned to carry the maximum wheel load, with 100 per cent. impact, distributed over three ties, with fiber strain not to exceed 2,000 lbs. per sq. in. Ties shall not be less than 10 ft. in length. They shall be spaced with not more than 6-in. openings and shall be secured against bunching.

9. Amend fifth line to read as follows: "*I* equals impact or dynamic increment to be added to line-load strains."

10. All spans shall be designed for a lateral force on the loaded chord of 200 lbs. per linear foot plus 10 per cent. of the specified train load on one track, and 200 lbs. per linear foot on the unloaded chord; these forces being considered as moving.

12. Viaduct towers and similar structures shall be designed for a longitudinal force applied to the rail of 20 per cent. of the live load.

13. Structures located on curves shall be designed for the centrifugal force of the live load acting at a height of 6 ft. above the rail, proper account being taken of the superelevation, the speed and superelevation to be determined by the engineer for each case.

18.	Shearing: shop driven rivets and pins	12,000
	field driven rivets and turned bolts	10,000
	plate girder webs; gross section	10,000
19.	Bearing: shop driven rivets and pins	24,000
	field driven rivets and turned bolts	20,000
	granite masonry and Portland cement concrete	600
	sandstone and limestone	400
	expansion rollers; per linear inch	600*d*
	where "*d*" is the diameter of the roller in inches.	

20. Members subject to alternate strains of tension and compression shall be proportioned for the strains giving the largest section. If the alternate strains occur in succession during the passage of one train, as in stiff counters, each strain shall be increased by 50 per cent. of the smaller. The connections shall in all cases be proportioned for the sum of the strains.

28. For strains produced by longitudinal and lateral or wind forces combined with those from live and dead load and centrigual forces, the unit strain may be increased 25 per cent. over those given above; but the section shall not be less than required if the longitudinal and lateral or wind forces be neglected.

29. The flanges of plate girders shall be connected to the web with a sufficient number of rivets to transfer the total shear at any point in a distance equal to the effective depth of the girder at that point combined with any load that is applied directly on the flange. The wheel loads, where the ties rest on the flanges, shall be assumed to be distributed over three ties.

30. Trusses shall preferably have a depth of not less than one-tenth of the span. Plate girders and rolled beams, used as girders, shall preferably have a depth of not less than one-twelfth of the span. If shallower trusses, girders or beams are used, the section shall be increased so that the maximum deflection will not be greater than if the above limiting ratios had not been exceeded.

34. Rigid counters are preferred; and where subject to reversal of strain shall preferably have riveted connections to the chords. Adjustable counters shall have turnbuckles.

37. The minimum distance between centers of rivet holes shall be three diameters of the rivet; but the distance shall preferably be not less than 3 in. for ⅞-in. rivets and 2½ in. for ¾-in. rivets. The maximum pitch in the line of strain for members composed of plates and shapes shall be 6 in. for ⅞-in. rivets and 5 in. for ¾-in. rivets. For angles with two gage lines and rivets staggered the maximum shall be twice the above in each line. Where two or more plates are used in contact, rivets not more than 12 in. apart in either direction shall be used to hold the plates well together. In tension members composed of two angles in contact, a pitch of 12 in. will be allowed for riveting the angles together.

42. In compression members the metal shall be concentrated as much as possible in webs and flanges. The thickness of each web shall be not less than one-thirtieth of the distance between its connections to the flanges. Cover plates shall have a thickness not less than one-fortieth of the distance between rivet lines.

43. Flanges of girders and built members without cover plates

shall have a minimum thickness of one-twelfth of the width of the outstanding leg.

55. Where splice plates are not in direct contact with the parts which they connect, rivets shall be used on each side of the joint in excess of the number theoretically required to the extent of one-third of the number for each intervening plate.

56. Rivets carrying strain and passing through fillers shall be increased 50 per cent. in number; and the excess rivets, when possible, shall be outside of the connected member.

80. Hip verticals and similar members, and the two end panels of the bottom chords of single track pin-connected trusses up to 300 ft. spans shall be rigid.

84. Change second line, second column, from 0.08 to 0.06.

85. If the ultimate strength varies more than 4,000 lbs. from that desired, a retest shall be made on the same gage, which, to be acceptable, shall be within 5,000 lbs. of the desired ultimate.

126. Connection angles for floor beams and stringers shall be flush with each other and correct as to position and length of girder. In case milling of all such angles is needed or is required after riveting, the removal of more than 1-16 in. from their thickness will be cause for rejection.

133. Eye-bars shall be straight and true to size, and shall be free from twists, folds in the neck or head or any other defect. Heads shall be made by upsetting, rolling or forging. Welding will not be allowed. The form of heads will be determined by the dies in use at the works where the eye-bars are made, if satisfactory to the engineer, but the manufacturer shall guarantee the bars to break in the body when tested to rupture. The thickness of head and neck shall not vary more than 1-16 in. from that specified. (See 160.)

APPENDIX.

DISCUSSION OF COMPRESSION FORMULAS.

By John Brunner, Assistant General Superintendent, North Works, Illinois Steel Company.

During the discussion at the annual convention last spring (1905), several of the speakers raised objections to the adoption of the straight-line compression formula recommended by the Committee on Iron and Steel Structures, and as the first part of the specifications have been referred back to the Committee for reconsideration, it is the proper time to again open up the question of the merits of the various compression formulas.

The compression formulas in use are largely based on the numerous tests that have been made on compression members, either duplicate of, or similar to, the compression members used in structures which have been built.

A collection of the data from these tests shows that the ultimate strength of compression members varies greatly, due to the non-uniformity of the material and workmanship, and the more or less eccentric application of the forces on the members during the tests, and other sources.

There is no doubt that the forces, acting on the compression members in actual use in structures, are applied much more eccentrically and irregularly and for this reason are more destructive than those applied in the testing machine, and that the ultimate strength of the members, under such adverse conditions, if it could be recorded, would be less and would show a greater variation than for the members broken in the testing machine. Take, for example, the top chords in trusses with parallel chords. The ends of the chord sections at their splices are usually milled square to the axis of the chords. The trusses are given a camber in most cases so large that the deflection under full load is not sufficient to counteract it. The milled ends of the chords are, in calculating the required section, assumed to be in contact throughout and to transfer the strain from one chord section to another through this assumed contact surface. In actual service, the contact surface is limited to the lower part of the milled ends, until either the material at the lower edge is strained so as to take a permanent set, or the chord is deflected upwardly.

Posts, to which the ends of shallow floor beams are riveted, are thrown by the deflection of the floor beams out of the straight line in which they have been assumed to act as columns. In bridges with two trusses supporting two tracks, and three trusses supporting two tracks with only one track loaded, the rigid bracing and floor system will bend all the compression members out of their normal position during the deflection of the structure under the eccentric loading and produce large secondary strains. These secondary strains cannot be accurately determined and are, except in perhaps a few cases, entirely disregarded in designing bridges of ordinary spans.

That they affect compression members more than tension members is clear for the reason that after a member has been deflected from its normal position or shape, compression strains will assist the secondary bending strains to further deflect the member, while tension strains will resist the secondary bending strains against further deflection of the member. It is also clear that a combination of the compression strains with the secondary bending strains is more dangerous for compression members with a large value of $\frac{l}{r}$ than for compression members with a smaller value of $\frac{l}{r}$.

In adopting a formula for use in proportioning compression members such a formula should be selected as will give a section of sufficient strength under the conditions existing when the structures are in service, and not a formula that applies to theoretical conditions only.

Engineers have found, from experience, that it is not safe to use the formulas devised above a certain relation between the length of the member and its radius of gyration, and have placed this limit at $\frac{l}{r} = 100$ for main members and $\frac{l}{r} = 120$ for lateral members, prohibiting in their specifications the use of columns with the relation $\frac{l}{r}$ above these limits.

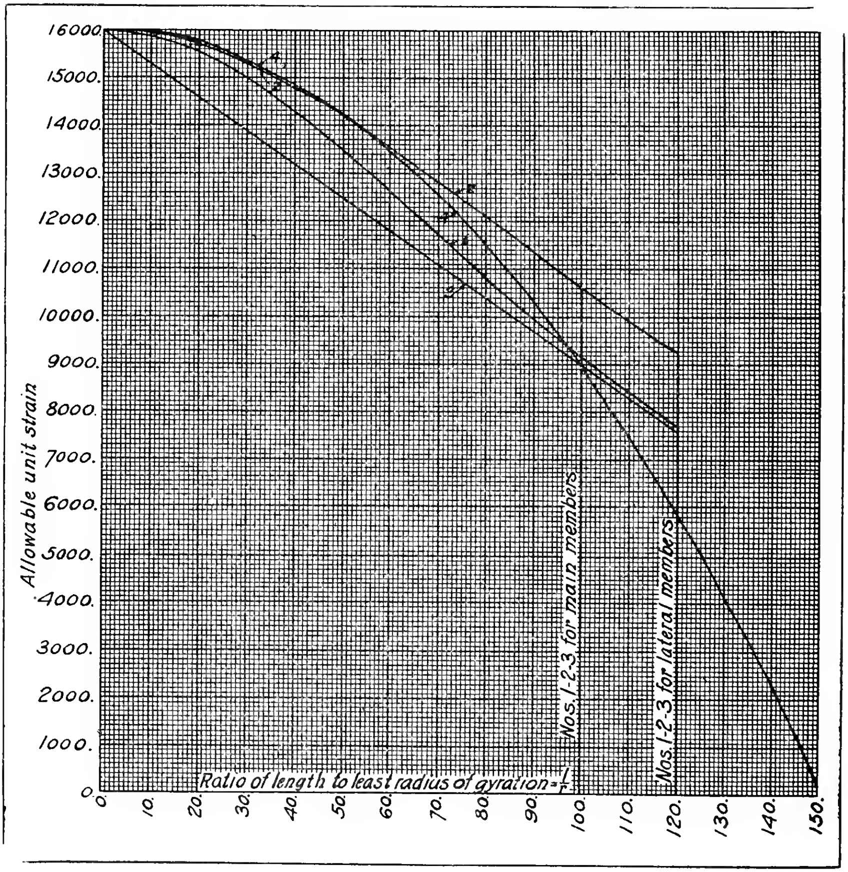
It looks as if these formulas are not as well adapted for practical use as is desired, as there seems to be no good reason for assuming that the column can safely carry a strain of several thousand pounds per square inch according to the formula under and at the above limits, but is not safe for any strain above these limits. It seems more reasonable to devise a formula that could be followed for all values of $\frac{l}{r}$ up to a point where the formula itself would give a limit. Such a formula was proposed by the late Prof. J. B. Johnson and can be found in his book, "The Theory and Practice of Modern Framed Structures," paragraph 137, of the edition of 1900.

It is the form of $p = f - b \frac{l^2}{r^2}$

where p = the strength of the material in compression at the elastic limit.
f = the elastic limit.
b = a coefficient.
l = the length of column.
r = the least radius of gyration.

Substituting the base unit strain recommended by the Committee instead of "p" and assuming 0.7 for the co-efficient, the formula would have this form: $p = 16{,}000 - 0.7 \frac{l^2}{r^2}$

For comparison, this form of the formula, together with the formula recommended by the Committee last year, and forms of the Gordon-Rankin formula used in the American Bridge Company's specifications



and the Atchison, Topeka & Santa Fe Railway System specifications, have been plotted and are shown on the accompanying diagram.

The formula recommended by the Committee has been cut short at $\frac{l}{r} = 100$ for main members and $\frac{l}{r} = 120$ for lateral members to follow the practice of those who have used the straight-line formula for a number of years in their designing.

The formulas are numbered on the diagram as follows:

No. 1—American Bridge Company's Specifications: $\dfrac{16{,}000}{1 + \dfrac{l^2}{13{,}500\, r^2}}$

No. 2—Atchison, Topeka & Santa Fe Railway System Specifications for pin connected members: $\dfrac{16{,}000}{1 + \dfrac{l^2}{20{,}000\, r^2}}$

No. 3—The formula recommended by the Committee last year, but limited to $\frac{l}{r} = 100$ for main members and $\frac{l}{r} = 120$ for lateral members: $16{,}000 - 70\frac{l}{r}$.

No. 4—A revision of the formula proposed by J. B. Johnson: $16{,}000 - 0.7\frac{l^2}{r^2}$.

A SYSTEM OF UNIFORM LIVE LOADS FOR RAILROAD BRIDGES, AND A FORMULA FOR SHEARING STRESS IN WEBS AND SPACING OF STIFFENERS OF PLATE GIRDERS.

By A. W. Buel, Associate Bridge Engineer, Western Pacific Railway

As a substitute for the system of live loads for railroad bridges consisting of two typical engines, followed by a uniform load per foot of track, the writer offers the following suggestion for discussion:

A live load per linear foot of track equal to

$$\frac{T}{\sqrt[3]{S} + \sqrt[6]{S}}$$

in which T, the index of the loading desired, has a value equal to the weight on each driving axle in pounds, and S is the length of the span in feet.

The values of T, approximately corresponding to the usual loadings of the Cooper series, are as follows:

$T = 40{,}000$, for Cooper's E-40,
$T = 45{,}000$, for Cooper's E-45,
$T = 50{,}000$, for Cooper's E-50,
$T = 55{,}000$, for Cooper's E-55.

The table submitted herewith gives the value of $\sqrt[3]{S} + \sqrt[6]{S}$ for spans from 10 to 500 feet, and the live load per foot of track for the $T = 50{,}000$ loading. This table also shows the equivalent uniform loads for Cooper's E-50, for moment and shear, and the average, or mean, equivalent loads of the two.

From this table it will be seen that while the loading proposed is greater than the equivalent uniform load for moments of the Cooper series, for spans from 10 to 120 ft. in length, by from 9.2 to 17.5 per cent., it is only 2.0 per cent. greater for spans of 350 ft.

Compared with Cooper's equivalent load for shear, it is from 0.4 of one per cent. to 3.5 per cent. greater for spans from 40 to 80 ft., the higher value being for spans of 60 ft. For spans of 10 to 30 ft., it is from 7.6 to 2.0 per cent. less than Cooper's equivalent uniform load for shear, and for spans of 90 to 120 ft. it is from 0.4 of one per cent. to 3.3 per cent. less. For a span of 350 ft. it is practically identical for shear.

If we compare the proposed loading with the average of Cooper's equivalent uniform loads for both moment and shear, the excess of the former, in per cent., is as follows:

For a span of 10 ft., 1.7 per cent. excess
For a span of 20 ft., 0.8 per cent. excess
For a span of 30 ft., 5.0 per cent. excess
For a span of 40 ft., 8.0 per cent. excess
For a span of 50 ft., 9.5 per cent. excess
For a span of 60 ft., 10.0 per cent. excess
For a span of 70 ft., 8.6 per cent. excess
For a span of 80 ft., 7.6 per cent. excess
For a span of 90 ft., 6.9 per cent. excess
For a span of 100 ft., 5.5 per cent. excess
For a span of 110 ft., 4.1 per cent. excess
For a span of 120 ft., 2.5 per cent. excess
For a span of 350 ft., 1.0 per cent. excess

While these excesses are considerable for spans up to 110 ft., they are no more than the difference between the typical wheel loadings and the probable actual loadings. Taking into account the close agreement between the proposed loading and Cooper's equivalent uniform loads for shear, and the fact that the material excesses, compared with Cooper's equivalent uniform loads for moment, are confined to spans of 120 ft. and under, it is not unreasonable to expect it to give satisfaction in practice.

As most spans for which it gives excess moments would be plate girders, for which, in the past, many roads have required that "no part

TABLE OF UNIFORM LIVE LOADS PER LINEAR FOOT OF TRACK FOR SPANS FROM 10 FEET TO 500 FEET.

Span in Feet, "S"	$\sqrt[3]{S}$	$\sqrt[6]{S}$	$\sqrt[3]{S}+\sqrt[6]{S}$	Equivalent Uniform Load for Cooper's E-50. For Moment.	For Shear.	Average of Equivalent Load for Shear and Moment.	Uniform Live Load per Foot of Track. $\frac{50,000}{\sqrt[3]{S}+\sqrt[6]{S}}$
10	2.1544	1.4678	3.6222	12,250	15,000	13,625	13,804
15	2.4662	1.5704	4.0366	....	....	....	12,387
20	2.7144	1.6475	4.3619	10,313	12,500	11,410	11,463
25	2.9240	1.7100	4.6340	....	....	....	10,790
30	3.1072	1.7627	4.8699	9,125	10,500	9,815	10,267
35	3.2711	1.8086	5.0797	....	....	....	9,843
40	3.4200	1.8493	5.2693	8,200	9,400	8,800	9,489
45	3.5569	1.8860	5.4429	....	....	....	9,186
50	3.6840	1.9194	5.6034	7,613	8,700	8,160	8,923
55	3.8030	1.9501	5.7531	....	....	....	8,691
60	3.9149	1.9786	5.8935	7,225	8,200	7,715	8,484
65	4.0207	2.0052	6.0259	....	....	....	8,298
70	4.1213	2.0301	6.1514	6,975	8,000	7,490	8,128
75	4.2172	2.0536	6.2710	....	....	....	7,973
80	4.3089	2.0758	6.3847	6,750	7,800	7,275	7,831
85	4.3968	2.0969	6.4937	....	....	....	7,700
90	4.4814	2.1169	6.5983	6,600	7,600	7,100	7,578
95	4.5629	2.1361	6.6990	....	....	....	7,464
100	4.6416	2.1544	6.7960	6,438	7,500	6,970	7,357
110	4.7914	2.1889	6.9803	6,425	7,360	6,895	7,163
120	4.9324	2.2209	7.1533	6,412	7,240	6,825	6,990
130	5.0658	2.2507	7.3165	....	....	....	6,834
140	5.1925	2.2787	7.4712	....	....	....	6,692
150	2.3133	2.3051	7.6184	....	....	....	6,563
160	5.4288	2.3300	7.7688	....	....	....	6,436
170	5.5397	2.3536	7.8933	....	....	....	6,334
180	5.6462	2.3762	8.0224	....	....	....	6,233
190	5.7489	2.3977	8.1466	....	....	....	6,138
200	5.8480	2.4183	8.2663	....	....	....	6,049
225	6.0822	2.4662	8.5484	....	....	....	5,849
250	6.2996	2.5099	8.8095	....	....	....	5,676
275	6.5030	2.5501	9.0531	....	....	....	5,523
300	6.6943	2.5873	9.2816	....	....	....	5,387
325	6.8753	2.6221	9.4974	....	....	....	5,265
350	7.0473	2.6547	9.7020	5,050	5,150	5,100	5,154
400	7.3700	2.7150	10.0850	....	....	....	4,960
500	7.9400	2.8170	10.7570	....	....	....	4,650

of the web shall be considered as resisting flange stresses," and as with this loading plate girders should be proportioned by their moment of inertia, plate girder spans so designed under this loading would be very little heavier than we have been building. The fact that it gives heavier loadings for short spans than for long spans, as compared with the Cooper series of wheel loads, will not generally be considered an objection, and the writer does not believe serious criticism will be advanced against the relatively heavier loadings for floor systems.

With almost identical loads for spans of 350 ft., it drops off so that for spans of 500 ft. the loading is about 10 per cent. less than Cooper's, and this, the writer believes, is as it should be.

Herewith is presented a diagram showing graphically several formulas for shear in plate girder webs and spacing of stiffeners.

The Thacher-Rankine formula is Rankine's formula, with Thacher's constants and with *d* measured horizontally or vertically instead of on an angle of 45 degrees, and is, perhaps, one of the oldest, and has, possibly been more generally used than any of the others. This does not include impact.

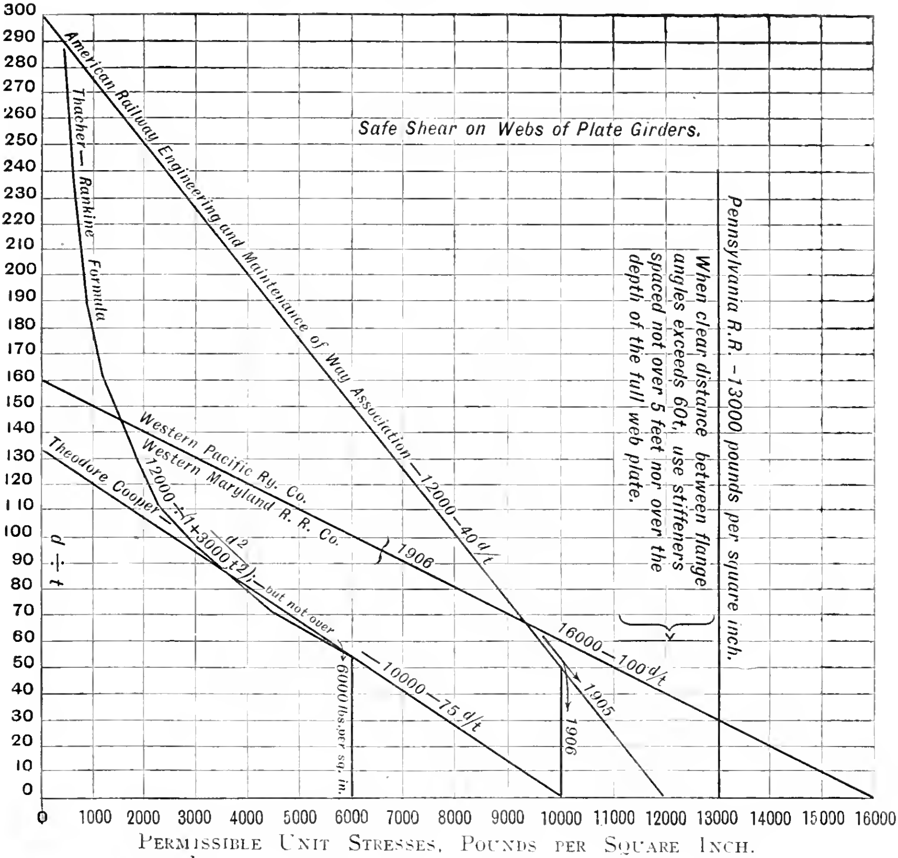
The Pennsylvania Railroad permits a maximum shearing stress on *net* section of web plates, including impact, of 13,000 lbs. per sq. in., which does not seem unreasonable. The rule for the spacing of stiffeners, however, has no relation to the allowed stress per sq. in., which is constant, and, for the average values of $\frac{d}{t}$, permits a stress per sq. inch about twice as great as that of any other specification illustrated on the diagram.

Cooper's straight-line formula corresponds, very closely, with the older formula—$12{,}000 \div \left(1+\frac{d^2}{3{,}000\,t^2}\right)$,—for all values of $\frac{d}{t}$ from 40 to 100. The writer believes Cooper's formula $\left(10{,}000 - 75\,\frac{d}{t}\right)$ is, everything considered, the best yet proposed where impact is not included. With impact included, for which case it was not intended to apply, Cooper's formula would give excessive webs and stiffeners, and should be modified.

The formula recommended by the Committee of the American Railway Engineering and Maintenance of Way Association—$12{,}000 - 40\,\frac{d}{t}$—gives stiffener spaces so much greater than either of the older formulas most generally used, that its recommendation or adoption as "standard" does not appear to be wise or conservative. It is better than the purely empirical rule of the Pennsylvania Railroad, but the formula $12{,}000 \div \left(1+\frac{d^2}{3{,}000\,t^2}\right)$ was based on a rational theory, and Cooper's formula gives nearly the same results and is more practical in application. It is not clear why 12,000 is used as the base of the Committee's formula, when 16,000 is the base for both tension and compression.

The formula here proposed—$16{,}000 - 100\,\frac{d}{t}$—has been tentatively adopted by the Western Maryland Railroad and the Western Pacific Railway. It starts with the same base of 16,000 lbs. per sq. in., as is used for tension and compression, and includes impact, the same as the Committee's formula.

It is reduced by $100\,\frac{d}{t}$, so that for $\frac{d}{t}=30$, the allowed stress is 13,000 lbs. per sq. in., at which point it crosses the empirical line of the Pennsylvania Railroad. For values of $\frac{d}{t}$ under 30, no good reason is apparent why the higher stress per square inch should not be permitted, especially as impact is included in the total stress.



When $\frac{d}{t}$ is about 67, the line crosses that of the Committee's formula, with an allowed stress of about 9,800 lbs. per sq. in. This is near the lower limit of the values of $\frac{d}{t}$ for webs of plate girders that will occur in ordinary cases.

When $\frac{d}{t}$ is greater than 67, the proposed formula will require somewhat closer stiffener spaces than those of the Committee's formula, but not so close as the older Thacher-Rankine or Cooper's formulas, notwithstanding the fact that impact is not included in the latter.

The formula proposed, with impact added to the total shear, saves, on an average, one pair of stiffeners for each 30 linear feet of girder, as compared with the Thacher-Rankine formula with no impact added.

An inspection of the diagram and the comparisons given above will show that the formula here proposed—$16{,}000 - 100\frac{d}{t}$—gives results between the extremes of past and present practice, and that it is both conservative and rational.

MINORITY REPORT.

To the Members of the American Railway Engineering and Maintenance of Way Association:

We, the undersigned, minority members of the Committee, join in the approval of the preceding specifications, with the following exceptions:

(1) We cannot approve the impact formula as submitted, involving the use of a single unit stress for both static and live loads.

The method of proportioning bridges, which was based on the assumption that the moving load has twice the effect on a structure of an equal amount of static load is so generally in use by prominent engineers that it is to our minds unreasonable to infer that it is incorrect and bad practice.

The impact formula proposed by the majority members, before being adopted finally and promulgated to the profession as the only one worthy of use, should be either mathematically or experimentally proven. This we claim has not been done, and it certainly has not been done to our satisfaction at least.

The proposed formula does not adequately account for the effect of heavy static loads involved by the use of ballasted floors, or other causes.

(2) The specifications do not directly state what the live loading for each track shall be in the case of double-track bridges.

(3) We do not approve the proposed method of determining when stiffeners on plate girders shall be used, and their spacing when used.

The minority members feel that the question of impact should be given the same consideration as other disputed points, some of which are of at least no greater importance.

The specifications as above written provide for the use of either concentrated or uniform live loads; they permit the use of plain punched; punched and reamed, or drilled work, at the option of the engineer; they recognize the use of both pin-connected and riveted work, with no qualification as to limiting length of span. Girders may be proportioned either by the moment of inertia of their sections or by assuming that the flange areas are concentrated at their centers of gravity.

In view of the recognition of the necessity for the exercise of individual preference in the foregoing instances, it seems to the undersigned a matter of common justice and fairness that the important impact question be not made more narrow and binding than those just mentioned.

We further believe that the very commonly used method involving unit stresses on a sliding scale for varying proportions of live and static load be recognized in the specification along with and of equal prominence with the method approved by the majority.

The undersigned have no impact formula to recommend as a body. We believe that the impact question is one which should not be settled at the present time. The Committee itself, as a whole, is prepared to recommend to the Association the carrying out of impact tests, and this in itself is proof that although a recommendation has been made for an impact formula, the question is still unsettled, even in the minds of the Committee.

The minority members urge that these tests ought to be made and believe that a reasonable impact formula can be determined from such experiments. Whatever may be the result of these tests, no pre-conceived notions will stand in the way of our approval, providing always that they be made properly, and not with an idea of substantiating a pre-determined formula.

We, the undersigned, suggest that the specifications be returned to the Committee with instructions that clauses providing for the use of unit stresses proportional to the relative amounts of live and static loads be added, and that such additional clauses be given equal prominence in the specifications with the present one.

Respectfully submitted,

C. D. Purdon, Engineer Maintenance of Way, St. Louis & San Francisco Railroad, St. Louis, Mo.

A. F. Robinson, Bridge Engineer, Atchison, Topeka & Santa Fe Railway System, Chicago, Ill.

C. H. Cartlidge, Bridge Engineer, Chicago, Burlington & Quincy Railway, Chicago, Ill.

DISCUSSION.

Mr. C. H. Cartlidge (Chicago, Burlington & Quincy—by letter) :—The writer being in the position of dissent from the finding of the majority of the Committee, desires to explain that his dissent applies only to the portion under the heading "Live Loads and Unit Strains." So strong is his belief, however, that there is a considerable number of engineers in the Association who are not entirely satisfied with the impact formula advocated in the Committee report, that he ventures to lay before the members of the Association a statement of his reasons for dissent.

The writer believes that the Schneider formula for impact is really only another form of the long-used provision for the dynamic effect of moving loads, and the dimensions of bridges resulting from its use are not materially different from those resulting from the specifications of a majority of the more prominent roads. The writer believes, moreover, that there is a difference between impact and the dynamic effect of moving trains, terms which are generally used interchangeably.

Under the Schneider formula, the live load is, theoretically, reduced to a static load, and this is a very elegant provision for the moving load effect. The omission of any provision for the true impact, or "hammer blow" of the drivers, seems erroneous.

It is well-known that the large majority of locomotives are necessarily so counterbalanced that at anything above moderate speeds there is, at each revolution of the driving wheel, an increase and subtraction from its total load on the rail. This amounts in certain engines to from thirty to forty per cent., and exists as an actual load, in addition to the dead weight on the driving wheels. This should be taken account of quite as much as the static weight of the wheel.

This impact effect does not exist on both rails of the track at the same time, though the alternations are very rapid at high speeds. It will readily be seen that the members nearest the rail will be most affected by this impact and that it will travel to the various members in about the following order: First to the rails, then the ties, stringers, floorbeams and truss members; a part of its effect being gradually absorbed by the mass of the structure, and by the elasticity of the material composing it.

In order to represent this action, the writer proposes to impose upon each driver, on one rail only, an allowance of fifty per cent. of its static weight; this allowance to be known as "Impact" and this impact to be treated as an additional load, and moved with the driving wheels to produce the greatest effect on members under consideration.

The increase to fifty per cent. from the thirty to forty per cent.

mentioned is suggested because of the unknown quantities involved by the roughness of track and the rolling and nosing of heavy engines.

The live and static loads having been adopted, and their strains computed, such unit strains should be employed as will allow for the varying proportions of static to live load strains.

The writer believes that it is impossible to design bridges with a single unit strain for dead and live loads, and design them consistently. The effect of a moving load, due to its sudden application, is commonly believed to be twice as great in magnitude as its static effect.

It seems most rational to the writer to take into account all the effects of moving loads as far as they can be estimated and for resulting strains employ a unit strain of half what is deemed safe for static strains. This process will involve very little labor of computation, and resulting strains are what they seem to be on the strain sheet.

This will no doubt seem a harking back to old methods, but, when the various types of structures to be designed are considered, some having extremely heavy ballasted floors, and some having none, but carrying the rails directly on the steel work, it is evident that those having the heavier dead load should be allowed to undergo greater unit strains.

The typical loading proposed by the Committee is entirely adequate, but I propose that for impact allowance there be added to each driver, on one side of one engine, fifty per cent. of its weight. The computations resulting from this may appear somewhat complicated at first, but they are not so, and anyone who has had to deal with concentrated load systems will readily devise short and quick methods of taking care of this impact allowance.

It is to be hoped that, although there be no proof of the correctness of the writer's position in this matter, this may lead to further and fuller discussion of a really important question by the members of the Association, and that the Association as a whole will not commit itself to any impact formula based on insufficient data.

It is also hoped that all members who are not disposed to agree with the majority of the Committee will discuss the question either by letter or orally in the convention.

Mr. Ralph Modjeski (Consulting Engineer—by letter):—I desire to make some remarks on the General Specifications for Steel Railroad Bridges of 1905 prepared by the Committee on Iron and Steel Structures.

Paragraph 10: It would be desirable to introduce some formula to provide for the effect of unbalanced locomotives on short spans. This effect is sometimes sufficiently great to bend the rails and therefore cannot be neglected in designing bridges.

Paragraph 19: There is considerable doubt in my mind as to whether there should be a difference made between the unit strains allowed for shop and field rivets. A hand-driven shop rivet may be a great deal worse than a field rivet driven with an air hammer. There seems to be no difference between field rivets and shop rivets when both kinds are driven with a pneumatic hammer. If the same unit were adopted in the specifications restricting, perhaps, somewhat the field riveting to insure better workmanship, it would simplify the calculations considerably, besides there may be cases where a shop riveted connection is gradually replaced by field rivets as the former become loose, in which case the number of rivets would not be sufficient under the specifications.

Paragraph 21: I believe that the requirement for provision for alternate strains is a good one, except that I would suggest some manner of transition between the cases where only the largest section is taken and those where total sections of area for both alternate stresses are taken; for instance, taking a stiff diagonal next to the center panel, under these specifications it would be uncertain whether only the section giving the largest strain should be taken or whether the member should be proportioned for a total sectional area equal to the sum of areas required for each strain. There is some uncertainty about the expression "if the alternate strains occur in *immediate* succession."

Paragraph 33: "When these ratios are decreased proper increase shall be made to the flange sections." It does not seem clear to me what the "proper" increase would be.

Paragraph 34: It would seem impossible to comply with this requirement in case of closely packed eyebar heads, for instance.

Paragraph 39: I think it objectionable to use thinner metal than 3/8-in. in railroad bridges, except for fillers. I believe a proper specification would be for bridges designed for Cooper's E-50 loading to stipulate that material shall be 7/16-in. thick for all parts carrying calculated strain and 3/8-in. for other parts.

Paragraph 43: There should be a limitation to the length of rivets driven either by hand or by pneumatic hammer. This length should be shorter than the length allowed for rivets driven by direct power.

Paragraph 45: I see no objection to using cover plates as thin as 1/50 or even 1/60 of the distance between rivet lines provided the entire section of these cover plates is not figured as part of the working area.

Paragraph 47: I found the following rule a good one to use in determining the length of tie-plates or compression members: The tie-plates and the rivets connecting them to the webs should be sufficiently strong to transmit one-half of the strain of the entire member from one web to the other. I offer this as a suggestion and think a similar rule could be formulated to make the tie-plate question more definite.

Paragraph 48: As the specifications are for railroad bridges only I would suggest barring out 5/8-in. rivets entirely. In fact, it would be still better to adhere to 7/8-in. rivets as a minimum, barring out 3/4-in. rivets as well. There is a good deal of room for study and experiment as to the lattice bars. I think that there is generally a great deal of metal wasted in lattice bars because we lack the necessary data, and having to go by precedent only we wish to be on the safe side.

Paragraph 63: I would suggest using nothing less than 6-in. and preferably 9-in. rollers.

Paragraph 69: I would suggest that all wall plates be set on rust cement, as it is impossible to determine in all cases whether they get full bearing when placed directly on masonry. I do not favor the use of Portland cement mortar for that purpose.

Paragraph 91: I have on previous occasions expressed my objections to dropping out the requirement for the yield point or elastic limit. I see no use in recording it if it is not to be used as a requirement. I have also expressed my objections to the quality of steel specified. The steel which I use in my work has an ultimate strength of 62,000 to 70,000 lbs. and an elastic limit of not less than 37,000 lbs. In work specified recently for the Columbia River bridge the ultimate strength will be 62,000 to 70,000 lbs. and elastic limit not less than 35,000 lbs. and the cold specimens will be bent as follows:

Up to and including ¾-in. in thickness bend 180 degrees flat.

From ¾ to 1 in. bend 180 degrees around a pin of a diameter equal to one-half the thickness of the piece bent.

One inch and over bend around a pin of a diameter equal to three-fourths of the thickness of the piece.

I am of the opinion that the specification as prepared by the Committee provides for an inferior grade of steel, the unfortunate argument having been used that it is the natural product of the mill. The pig-iron is still a more natural product of the furnaces, and still we would not use it for bridge work.

Paragraph 102: This requirement is entirely too easy to comply with, especially if the low grade of steel as called for in the Committee's specifications is used. This requirement should be 180 degrees flat. From experience I know that this can be obtained without much difficulty.

Paragraph 122: I am strongly in favor of reaming of all material, or if soft metal be used, of punching of all material, but there are objections to having some holes reamed and other holes punched on the same work. An exception to this might be made in the case of lattice bars.

Paragraph 138: I would suggest to strike out "wherever possible," as I think the work should be designed in such a manner as to make this always possible.

Paragraph 139: I would change the word "5-in." to "6-in."

Paragraph 141: In my experience 10 per cent. of excess of field rivets is not sufficient, and I always specify 20 per cent.

Paragraph 146: In accordance with my previous suggestion as to placing of the wall plates on masonry, it seems preferable to leave the castings with a rough bottom instead of planing them.

Paragraph 150: Even in reamed work I do not consider the planing off of shearing edges essential except in working sections.

Paragraph 158: The coating of finished surfaces seems to me should not apply to milled or faced ends of stringers, floor beams and compression members. This paragraph could possibly be modified as follows:

"Machine finished surfaces, except ends of riveted members, shall be coated, etc."

Paragraph 164: I do not know what amendment will be presented at the next convention, but as the requirements for full-sized tests stand now they seem very deficient as far as the eyebars are concerned. It is essential to test full-sized eyebars because of the various manipulations to which they are subjected.

In response to an invitation from a member of the Committee, Mr. Theodore Cooper, Consulting Engineer, New York, N. Y., furnishes the following comments:

Your letter of inquiry is very opportune, as I am now preparing a new edition of my Railroad Bridge Specifications.

Impact Formulas: Some thirty years ago I became much interested in the subject of dynamic deflection of girders and studied the tests made by the Parliamentary Commission (about 60 years ago) and all the later tests made in France and Germany, with all the theoretical discussions thereon, and have kept a general watch on all actual tests made from time to time. In addition, I have had opportunities for some personal observations. My general conclusions are that, as long as the train stays on the track, the worst impacts are due to, first, bad rail joints; second, to the jump of the rolling-stock at the entrance of a bridge, due to change in elasticity of the roadbed (hence a great demand for an end-floor beam instead of resting any part on the rigid abutment walls).

Of course, unbalanced rolling-stock, flat or imperfect wheels, etc., act to increase the loads, but the most important impact outweighing all the others is the impact due to a derailed engine or train.

The early American bridge builders, to provide for this, adopted the rule of using twice as great a factor for the live as for the dead load. Now, while I do not believe a moving load has twice the effect of a dead load, I do consider this old rule, which certainly has done us good service, clearer of comprehension and better suited to the purpose than the formula you mention.

Common Specifications: I do not believe it desirable or possible to get up one common specification. Different experiences and special studies of existing work frequently bring out new requirements that may appear useless or unnecessary to others. For unity of ideas and harmonious agreement, there must be sacrifices and compromises. I never could accept the idea, now so prevalent, that a majority vote can settle intelligently any scientific question of difference of view. Advancement in any branch of human knowledge must stop, if, like the trade-union idea, the views and desires of the majority are to be the limitations.

That the more experienced Bridge Engineers could reduce their specifications nearer to a common basis is no doubt possible, each, however, holding to their own on all points where they could not agree. This is what Mr. C. C. Schneider and I did in 1901.

I have stated for some years that if the two associations could get up a common specification for materials (I assumed it would be up to the best practice of the day) I would insert it in my next edition.

The weakness of my eyes for some months past has prevented me from keeping in touch with the action of these associations, but recently I have examined their conclusions somewhat critically, and was extremely disappointed. I should be stultifying my whole experience and career by adopting the material they have selected. I have handled and worked the commonest and best wrought-iron, the hardest of crucible steel (St. Louis Bridge) and in 1880 ("Use of Steel for Bridges," Am. Soc. C. E. Proceedings) took a stand against the use of high steel and in favor of the steel that has become known as "medium steel."

For years this material has been largely used, and I personally have never had any difficulty in getting it, without friction.

That there are, in the execution of any work, certain occasions when the engineer must use his professional experience and common-sense to determine after consideration of the facts whether he can avoid taking the "pound of flesh" or not without detriment to the work, only emphasizes the necessity of the engineer having the above qualities. No specification, however lenient, can obviate the necessity for experience and common-sense.

It has appeared to me that, behind the general desire for a common specification, there are two especially dangerous features, tending to degrade all the standards: First—For unanimity, it will be necessary to lower the standards so that the poorer or less progressive manufacturers can be placated. Second—Lower the standards, so the perfunctory inspector or inexperienced engineer will not be bothered to use any judgment.

I have been subject to much correspondence in the past from those apparently having work, under my specifications, asking the most elementary questions or seeking a determination of some simple question, requiring a minimum amount of common-sense. No specification at all is the only thing that would relieve such cases.

Low Steel: I cannot accept or advise the acceptance of this material as the final outcome of our experience with structural steel. It is unfit for eye-bars, and is no more suitable for other work than medium steel. I have been in favor, if it was possible, of establishing one grade of structural material, but only on the assumption that the best and not the poorest would be selected.

Some years ago, at the request of certain manufacturers of soft steel, which was unquestionably better than iron, I inserted a clause for soft steel in my specifications with lower allowed strains than for medium steel. If I insert the low steel of the associations, it must be with a reduction of ten per cent. in the allowed strains.

In important structures, the Bridge Engineer could not accept this material, when the demands are all for higher material and when we are looking hopefully forward to the possible nickel or other high-class material for the great spans of the future.

It is pretty clear to my mind that the bridges of the future must be better, not poorer, than we have been getting. Due weight should be given by the younger members of our profession to this fact, viz., much of the incompetency and ignorance shown in much of the bridge work of the past has been hidden under the excuse that the defects were due to the rapidly increasing train loads.

Now that we have reached a point where the maximum train load will never be surpassed, errors in design, material or workmanship must come squarely back to the responsible engineer.

It may temporarily appear best to the greater number to lower the standards, but in my opinion it is a grave error.

Mr. R. G. Manning (American Bridge Company—by letter):—I note that the specifications for steel railway bridges have not been formally adopted and are subject to revision at the convention in March, 1906. I wish to say that on the whole these specifications are practical, clear and definite, and will probably become quite universal in their use, but would like to offer a few suggestions which may be considered if desired.

Having had several years' experience in the manufacture and detailing of bridges, and coming in contact with many specifications and inspectors, I find there are a few points which are always raised when it comes to carrying out the work, and which are usually settled in about the same way, and it would seem that if specifications eliminated these points it would save considerable annoyance and trouble. Some of the points are as follows:

Paragraph 35 provides for satisfactory drain holes for pockets or depressions which will hold water, or they shall be filled with acceptable waterproof material. I do not believe it is possible to provide satisfactory drain holes, as they soon fill up and do not perform their duty. Would it not be better to omit this clause and specify the pockets to be filled with acceptable waterproof material to be furnished by the railroad company?

Paragraph 82 calls for the spacing of rivets and stiffeners not to exceed 5 in. This will make it difficult for most modern shops where multiple punches are used. The spacing of the rivets in the end stiffeners and at floor beam connections is usually made 3-in., and for the intermediate stiffeners every other rivet is omitted, leaving the rivets 6-in. spacing and the rivets in horizontal lines throughout the web, which is necessary for the use of the multiple punch. The 5-in. spacing will make it impossible to use the multiple punch for most webs where stiffeners occur. This limit should be made not to exceed 6 in.

Under paragraphs 122, 150 and 151 it seems confusion will arise on account of the indefiniteness of whether general reaming will be required by the specifications. Many engineers will simply call for their work to be done in accordance with this specification. Would it not be better if paragraph 122 were made to cover the reaming as would be used under the ordinary class of work, and not say anything about the general reaming; then under a heading something like this: "Additional Specifications for Reaming," there specify that if additional requirements are desired for reaming and planing other than that called for by the general specifications, the plans and invitations must state just what is desired, so that it will be perfectly definite what is required unless special mention is made of it.

Under the heading of "General Reaming" this specification would require everything even to the minor details to be reamed. Even where this is called for and the matter is taken up, the minor details are invariably waived.

I have also found that the specifications for sheared edges, as called for in your paragraph 150, causes considerable confusion. Your specification would require the ends of all small details, such as hitch angles, lateral plates, tie-plates, fillers, ends of lateral angles and many other parts to be planed where it is not usually intended. These are points also which are usually waived when the question is taken up.

The question of planed edges does not mean much after you eliminate that which is done in the ordinary practice of first-class work to-day, viz.: Ends of all chord sections are milled, ends of all floor beams and stringers are usually milled, and when these are taken out, the important members are taken care of except perhaps web plates. Ordinarily web plates have a large edge distance, say 2 in. or more, and do not really necessitate planing and it is seldom required. This leaves the planing, so far as important parts are concerned, to a very few pieces, or where it is required in gusset plates and the like for appearances. We believe the best results would be obtained if a clause for planing the sheared edges would be something like this: "Sheared edges will be required to be planed only when called for on the plans submitted."

My thought in the above is that when this workmanship will be required the case will be special and the engineer in charge will know what he desires and why, and can easily call for it. This is also true of the general reaming.

Paragraph 129 is also indefinite as to the milling of beams and stringers. For built up stringers in this class of work, the ends are either milled to exact length before connection angles are put on, and this milled edge used as a surface to fit the connecting angles to, or they are milled after the connection angles are riveted on. This is especially true of stringers. Why not call for the stringers and floor beams to be milled to length and give the option to the shop as to which way they will do it?

Under paragraph 134 a clause covering the usual practice in the tension chord splice of riveted trusses should be added, viz.: "In splicing tension members where a part of the main section is extended to form a part of the splice, making it impossible to mill the member after it is riveted up, an opening not to exceed ⅜-in. will be allowed at the joint."

Paragraph 135 calls for floor girder connections to be reamed to iron templets. This part is all right, as the floor beam connections are usually reamed to an iron templet. The rest of the paragraph would call for assembling of the work in the shop, which in many cases is impossible and seldom required and it is not necessary. Chord sections are usually assembled, reamed and match-marked. Lateral connections and minor details where connections are short, hardly require it.

The connection of diagonals in riveted work is a little more important but all that is necessary and usually required, is to apply wooden templets to both connections to see that the holes match. We believe a paragraph which states just what is wanted and yet conforms to the general practice, would be more satisfactory, viz.: "Floor connections reamed to iron templet, chord section assembled, match-marked and reamed in place. Main diagonal connections reamed to templet and templet applied to satisfy the inspector that the workmanship is first class. Lateral connections and minor field connections merely checked up by the inspector."

My thought in these suggestions is to make a specification which, when it is referred to without any qualifying clauses, will be perfectly clear as to what is required in every detail. If anything more is desired by the customer, have him specify it in his tender for the work, which will make the entire specification clear and complete. These additional requirements can be embodied in the specification in such a way that they will not be a part of the specification unless specifically referred to. Most of the general specifications try to cover everything that is likely to be required for the most complex case, and the result is that there are always a number of indefinite points unsettled for nearly every order, even where the plans submitted call for what is desired, and should the general specifications require more than the customer intended the inspector will always question these points, which may not be brought up until the work is at such a stage in the shop that it must be stopped until these points are settled. In most of these cases the manufacturer clearly understands what is desired but must stop to settle the point, and in my years of experience it is usually settled according to the interpretation of the manufacturer.

When we put drawings into the shop we aim to so specify everything that there can no question arise in the minds of the shopmen as to the interpretation of the plans. You have nearly attained this point in your specification, and it is possible to make it still more complete in this respect by making a few alterations as suggested above, although I have not attempted to cover all the points and have taken up the questions relating to the shop work and shop drawings only.

A clause in the specification which would say that the work should be manufactured in the shop in accordance with the approved plans, and where the specifications thereon differed from the general specifications the plans should be followed, would avoid many difficulties. The only thing the shop has to govern its work is the plans, and they should have everything on them pertaining to the specifications which refer to the shop work, in order to carry out the intent of the specification.

I hope I have made myself clear as to the intent of the suggestions and trust I will be pardoned for making them, but my experience and practice in this respect may be of use to the Committee, and I write this mainly to help to get the best results possible.

O. E. Selby (Bridge Engineer Cleveland, Cincinnati, Chicago & St. Louis Railway—by letter):—As a somewhat belated response to the Committee's circular letter of October 4, 1905, asking for expressions of opinion on different clauses of the specifications for steel railroad bridges, the writer wishes to present some comparisons of impact formulas and unit stresses, bearing on clauses 10, 16 and 17. Pressure of work has prevented getting the data for this together sooner, but it may be of interest still.

Practically all specifications recognize and take into account the differences between fixed and moving loads, and by means of impact formulas or variable unit stresses, or both, attempt to provide against the greater destructive effects of the moving loads. Moving loads differ from fixed loads in their effects on a structure in two distinct ways: first, by reason of their more or less frequent application and removal, and, second, by reason of their more or less sudden application and removal. A fixed load slightly less than the elastic limit will not produce permanent set, but a load slightly more than half the elastic limit, if applied instantaneously, would produce permanent set. Again a load slightly below the elastic limit, if applied and removed frequently, will produce permanent set, and a load very much below the elastic limit, if applied and removed a very great number of times, no matter how gradually, will produce permanent set.

A load applied to a railroad bridge by a moving train is not applied instantaneously—far from it—but is applied more or less suddenly, depending on the speed of the train and the distance which it has to travel from the time when a member begins to receive its load until it receives its maximum load.

This suddenness of application is properly provided for by adding to the live-load stresses a percentage for impact depending on the length traveled by the load in producing the maximum stress. What this percentage should be is a disputed question, because there seem to be no experimental facts which determine it.

The so-called fatigue of metal caused by frequency of application is properly provided for by allowing lower unit stresses for live than for dead loads. How much the difference should be is also a disputed question, but on the assumption that a load equal to half the elastic limit, if applied an infinite number of times, would produce the same effect as a quiescent load equal to the elastic limit, and it seems rational and safe to allow only one-half as high unit stresses for live loads as for dead loads.

Now, here are two distinct and separate effects which should be taken care of in two separate ways.

Cooper's specifications allow for the fatigue by doubling the unit stress for dead load, but make no allowance for impact. Other specifications allow for impact by some rule or other, but ignore the fatigue. The Committee's specification, by use of a constant (and high) unit stress with an impact formula which for moderate span lengths nearly doubles the live load stresses (or halves the unit stresses), attempts to combine the two allowances in one operation.

The road with which the writer is connected uses an impact formula $\left(I = S \frac{10}{L + 10}\right)$ which gives moderate additions, and seems rational and sufficient when strictly impact is considered. The fatigue is taken care of by allowing only half as great unit stresses for live as for dead loads.

The proof of the value of the different practices is in the results, and in order to compute results I have prepared the following table which shows for the different formulas the comparative results in the proportions of the flanges of girders and truss spans of various lengths from 6 ft. to 300 ft. The tabular quantities given in columns 4, 5, 6, 7 and 8 are those obtained by dividing the total center bending moments plus impact percentage, if any, by the allowed unit stress. The quantities in the different columns are strictly comparable, as they have only to be divided by the effective depth to give the required tension flange area.

Column 2 gives the assumed dead load per foot for one girder used with all formulas in the table. Column 3 gives the center bending moments for Cooper's loading E-60, which is used for the live-load stresses for all except column 7. Column 4 contains the results by Big Four practice, using the impact formula $I = S \frac{10}{L + 10}$, with a unit stress of 10,000 lbs. for live load and 20,000 lbs. for dead load, the area required being most conveniently determined by adding to the live-load stress one-half of the dead-load stress and dividing by the unit 10,000. Column 5 contains the results from the Committee's specification; the formula for impact being $I = S \frac{300}{L + 300}$ and the unit stress for both live and dead load being 16,000. Column 6 gives the results from using the impact formula $I = L \frac{L}{L + D}$, in which L = live load and D = dead load, together with a unit stress of 16,000 lbs. This formula depends on the relative proportions of live and dead load and only indirectly on the length of span.

In this case the live load (Cooper's E-50) used by the road employing the formula has been increased 20 per cent. to compare with that used in the other columns. The results are surprisingly close to those obtained in column 5 from the Committee's formula.

Column 7 is based on the specifications of a prominent system, increasing, however, their specified loading 20 per cent. to correspond with the E-60 loading used for the others. In this case there is no addition for impact, but the unit stress is variable and depends on the relative proportions of live and dead load. Column 8 gives the practice of another prominent Western system also raised 20 per cent. to compare with column 4 using the E-60 loading. In this case no impact is added and the unit stress is variable between 8,000 and 9,000 for different span lengths. The comparison for this road was not carried beyond 100 ft. spans because the writer has no information as to the unit stresses used above that length. If this variation of unit stress were extended below 20 ft. and above 100 ft. at the same rate of variation it would amount to using the impact formula $I = S \frac{620 - L}{620 + L}$ with the constant unit stress 15,500. This impact formula is the same as the "300" formula for a 20-ft. span and reduces to zero for a 600-ft. span.

Columns 9, 10, 11 and 12 contain the differences and percentages of difference between the quantities in column 4 and those in columns 5, 6, 7 and 8. Where the quantities in column 4 are smaller than those compared with, the differences are marked minus.

The most noticeable result of inspection of columns 9, 10, 11 and 12 is the very large excess of column 4 for short spans of say 30 ft. and under. These comparisons are for bending moments and flange sections, but a similar comparison for shears gave results in percentages so nearly identical with these that it was not thought necessary to repeat the table. This means that for short spans I-beams, floor-system counters, etc., designing by the specifications used in column 4 would give heavier results where strength and mass are desirable. The conspicuous defect in the old methods of dimensioning is the light and weak floor systems produced by them. This is constantly evident to one who has to do with figuring old structures for modern loads.

In practically all cases the excessive stresses which condemn a structure occur in the floor beams, stringers, hip verticals or counters, and many girders and trusses which are in themselves strong enough have to go because of these weak details. Therefore it seems important to design

Comparison of Impact Formulas in Combination with Unit Stresses.

1	2	3	4	5	6	7	8	9		10		11		12	
Span	Dead Load per Foot one girder	Live Load Moment Cooper's E 60	$\frac{L+\frac{1}{2}D}{10}$	$\frac{L_1+D}{16}$	$\frac{L_2+D}{16}$	$\frac{L_3+D}{U_1}$	$\frac{L_4+D}{U}$	(4) minus (5)	Per Cent of (5)	(4) minus (6)	Per Cent of (6)	(4) minus (7)	Per Cent of (7)	(4) minus (8)	Per Cent of (8)
6	280	45.0	7.4	5.7	5.6	2.3	5.8	1.7	30.6	1.8	32.1	5.1	228.0	1.6	27.6
8	300	60.0	9.5	7.6	7.5	3.8	7.8	1.9	25.1	2.0	26.7	5.7	149.3	1.7	21.8
10	320	84.4	12.9	10.6	10.6	5.7	11.1	2.2	21.0	2.3	21.7	7.2	126.4	1.8	16.2
12	350	120.0	17.8	15.1	15.0	8.0	15.8	2.7	17.6	2.8	18.7	9.8	123.5	2.0	12.7
15	400	187.5	26.8	23.6	23.6	12.0	24.9	3.2	13.7	3.2	13.6	14.8	122.8	1.9	7.6
20	450	309.4	42.4	38.9	38.7	20.9	41.5	3.5	9.0	3.7	9.6	21.5	102.5	0.9	2.2
25	500	457.5	60.8	57.4	57.4	32.3	61.6	3.3	5.8	3.4	5.9	28.5	88.0	- 0.8	- 1.3
30	533	615.7	80.0	77.2	77.4	46.0	83.2	2.8	3.6	2.6	3.4	33.9	73.7	- 3.2	- 3.8
35	557	784.5	100.2	98.3	98.6	62.0	106.2	1.9	1.9	1.6	1.6	38.1	61.5	- 6.0	- 5.7
40	575	983.4	123.8	122.9	123.3	81.0	133.1	0.9	0.7	0.5	0.4	42.8	52.8	- 9.3	- 7.0
45	590	1200.9	149.4	149.7	150.1	101.6	162.4	- 0.3	-0.2	- 0.7	-0.5	47.8	47.1	-13.0	- 8.0
50	600	1426.3	175.8	177.3	179.2	125.3	192.7	- 1.5	-0.8	- 3.4	-1.9	50.5	40.3	-16.9	- 8.8
60	617	1949.4	236.7	240.7	245.9	178.7	261.9	- 4.1	-1.7	- 9.2	-3.7	58.0	32.4	-25.2	- 9.7
70	665	2560.3	308.4	315.2	324.2	245.4	344.1	- 6.8	-2.2	- 15.8	-4.9	63.0	25.7	-35.7	-10.4
80	763	3240.7	390.6	400.6	410.7	319.8	440.0	-10.0	-2.5	- 20.1	-4.9	70.8	22.1	-49.4	-11.2
90	895	4005.7	485.9	499.6	511.1	407.6	553.5	-13.6	-2.7	- 25.2	-4.9	78.3	19.2	-67.6	-12.2
100	1000	4829.8	591.2	606.4	616.2	507.5	675.5	-15.2	-2.5	- 25.0	-4.1	83.7	16.5	-84.3	-12.5
125	1100	7494.6	912.4	933.3	966.4	797.4		-20.9	-2.2	- 54.0	-5.6	115.0	14.4		
150	1200	10584.5	1293.4	1313.5	1373.7	1164.6		-20.1	-1.5	- 80.3	-5.8	128.8	11.1		
175	1300	14025.3	1727.2	1741.3	1831.4	1595.4		-14.1	-0.8	-104.2	-5.7	131.8	8.3		
200	1400	17786.2	2213.3	2216.1	2349.1	2097.5		- 2.8	-0.1	-135.8	-5.8	115.8	5.5		
250	1600	26457.0	3372.5	3336.8	3572.3	3344.9		35.7	1.1	-199.8	-5.6	27.6	0.8		
300	1800	36555.0	4785.9	4692.7	5021.0	4947.5		93.3	2.0	-235.1	-4.7	-161.6	-3.3		

D = Dead Load Moment

L = Live Load Moment Col. 3 with impact $\frac{10}{S+10}$

L_1 = Live Load Moment Col. 3 with impact $\frac{300}{S+300}$

L_2 = Live Load Moment Col. 3 with impact $L\frac{L}{L+D}$

L_3 = Live Load Moment for 6000 lbs. per ft. of track with 6000 lbs single excess.

L_4 = Live Load Moment Col. 3.

U = 8000 for spans 20 feet and under

" = 9000 for span 100 feet

" = Interpolated amounts for intermediate spans.

$U_1 = 8000\left(1+\frac{minimum}{maximum}\right)$

new structures so as to avoid this, and that is certainly attained by using the formula of column 4. Compared with the Committee's formula the results for spans under 45 ft. are from nothing to 30 per cent. heavier and the increase varies uniformly as the spans become shorter, and the hammer effect of the load becomes greater. Above 45 ft. the results of the two formulas are remarkably close together, those from column 4 being uniformly a little lower (maximum 2½ per cent.) and giving, to that extent, economy of weight in the long spans.

The formula of column 6 gives, as before remarked, substantially the same results as the Committee's formula for spans below 50 ft., and above that length the variation does not exceed 5 per cent., and that variation is in the direction of less economy in weight for the formula of column 6. Other things being equal, the labor of applying this formula should discourage its use.

The differences between column 4 and column 7 are very great and they show that floor systems designed by the method of column 7 would have all the defects of lightness found with the old methods of designing.

The writer cannot believe but that in actual practice with the road in question considerable additions not shown in their printed specifications are made to the sections, otherwise here are two systems in the same territory, one of which would use for a 20-ft. panel in a through truss span a stringer with twice the flange area that the other would use. This is too wide a variation in practice and one or the other must be wrong.

The rapidly diminishing scale of percentages in column 11 shows the very great lack of economy in the use of the formulas of column 7 for long spans, as well as the lack of mass for short spans. With improved manufacture and uniformity of steel we can with increasing confidence use higher unit stresses for quiescent loads in long spans which have mass enough not to be disturbed by the moving loads. In long spans the dead load predominates and economy in weight being important, it is most easily obtained by using as high unit stresses for dead load as may be consistent. Recent practice tends in that direction. To point to an extreme case, note the high unit stresses used in the Quebec bridge.

The results in column 8 agree quite closely with the Committee's formula up to 40-ft. spans. Above that they become increasingly heavier.

While the results from the "300" formula (aside from the lightness in short panels) seem to be uniform and good practice, the writer is convinced that this is empirical rather than derived from reasoning, and is aware that so well-established a formula will require more than argument to discredit it, but an impact formula which is also trying to fill the place of a fatigue formula is being over-worked.

For a 300-ft. span the "300" formula gives an addition of 50 per cent., which ought to be taken to indicate that the dynamic effect of the moving load is half that of a load applied with infinite quickness. Now, a freight train of maximum weight moving at 40 miles per hour requires five seconds to cover a 300-ft. span, and this is far from 50 per cent. of instantaneousness. Again for a 20-ft. span this formula assumes a destructive effect 94 per cent. of that of an instantaneously applied load. What few experimental data there are indicate that ordinary moving loads produce no such effect as this, and the formula simply disguises a reduction of unit stress on account of frequency of application by calling it an addition for impact.

The convenience of designing by the formulas of column 4 is great. It is only necessary to add together the live load and half the dead-load stresses in thousands of pounds, then the pointing off of one decimal place gives at once the area required for tension members or the required section modulus for beams. For compression members proportioned by the Gordon formulas it is very easy to take one-fifth of the tabular quantity given for the ratio $\frac{L}{R}$ in the handbooks under the head "ultimate strength of columns—medium steel."

The inconsistency of the "300" formula becomes apparent when an attempt is made to use it in figuring old structures or designing new ones for low speed points where it is desired to reduce the impact allowance. The high live-load unit stress requires the large impact allowance to go with it to make its use safe, and if the impact allowance is much reduced or omitted the unit stress becomes too high.

With the "10" formula the impact allowance may be reduced or done away with and the 10,000-lb. unit stress remains safe for live load, no matter how frequently applied.

For figuring old structures for actual existing loads it is most simple to add impact by the "10" formula and then rule out structures which show unit stresses greater than twice those specified for new structures. The safety of this rule has been demonstrated by some years of use.

R. D. Coombs (Bangor & Aroostook—by letter):—Recommended practice in contracting, etc., paragraph 5, Bulletin 71.

While it is preferable that the railroad company furnish the floor timber, it is not evident to the writer that they should necessarily lay the floor. In many cases the bridge crew could handle floor timber along with the steel work with a minimum of handling. The character of work obtained should be merely a matter of standards and inspection.

2. The writer thinks it is within the province of the Committee to reconcile the different clearance diagrams in regard to their lower corners. This portion of the diagram is not covered by the clause given.

Cooper's 1901 Specifications, if adhered to, requires unnecessarily wide through-plate girder spans, while the diagrams allowed by many roads would not permit the passage of certain makes of snow plow. Though the use of snow plows is not general, the increasing clearance needed for modern cars and their steps demands some attention.

4. The writer would insert the word "generally" after "shall," as under this clause it would be impossible to obtain a satisfactory design for shallow bridges of great skew on account of the increased span.

Pars. 5, 9, and 15 to 19 (also 10, which seems to include wind and vibration). Apparently the Committee use a large impact and then a high unit stress to offset it. It would appear to the writer more logical to fix the working unit stress at a certain fraction (approximately one-third) of the elastic limit, and then give the most accurate values possible to all loadings. It seems reasonable to consider that the low unit assumed above will cover the fatigue of the metal; or the unit stress could be increased and a fatigue formula *added*.

31. Would it not be more in accordance with the facts to insert the word "possible" after "parts?" Lower chord eyebar heads and the interior of some panel points in riveted truss spans can hardly be called accessible, though existant under most specifications.

32. The writer would add "or both, as may be required."

It is better for the railroad company to fill such pockets as column footings with concrete, the drain holes being useful during shipment or storage.

36. It seems that 5/16-in. material need not be forbidden in details of minor parts. Such material seems to the writer more consistent for battens and lattice bars of bracing struts than 3/8-in., particularly when the main section of such member is, as is often the case, composed of 3/8-in. material. The weight of details on bracing struts is relatively too great.

41. Close spacing for twice the maximum width would be preferable, as this distance is small compared to the length of member, and there is no provision made for attaching outstanding legs.

44. In main members the end tie plates should have a length not less than the greatest width of the members, and intermediate ones not less than one-half this distance. If the governing distance were that between rivet lines, when the angles or channels were turned in, or the member were relatively narrow, the resultant battens would be too small.

49. The writer thinks that, generally, if not universally, splices should be fully riveted, as the saving in weight does not usually justify introducing a weak spot. Further, this would put a decided premium on exact bearings which is not always justified by results.

58. Spans of less than 80 ft., perhaps less than 70 ft., should have pin, or equivalent bearings, whether rollers are used or not, in order to properly distribute the load to the substructure.

60. The writer would prefer 4 in. or 4½ in. round rollers for spans of moderate length, to segmental rollers of 6 in. or more, and would suggest amending this clause as follows: "Expansion rollers shall be not less than 4 in. in diameter, or segmental rollers of 6 in., or over, may be used as required." There is some doubt whether the segmental bearings roll more than the round ones are popularly supposed to do. While it is no argument, the writer has seen segmental rollers erected in winter in the fully expanded position.

Pars. 66 and 126. It would, perhaps, be well to specify that the connection angles should not be less than 7-16-in. thick "after milling."

92. In order to obtain an accurate estimate of the material as it actually enters the structure, it would appear desirable to make tests not only on ⅜-in. and ¾-in. thickness from one melt, but also when the kind of shape varies or the size of the same shape varies very considerably.

93. If material less than ⅜-in. can only be used for fillers and such fillers are practically splice plates, they should fill the regular requirements. If they are merely spacing fillers no special requirement would seem necessary, and stock material would serve equally well.

Pars. 72 and 35. Three rivets in the minimum angle (3½x3x⅜) would not develop its full strength, except for the case of shop rivets, when the unsupported length was over eighty times its least radius of gyration and the angle was in compression.

75. To this paragraph might be added the following: "And such camber may be required by planing the abutting edges of web plates or punching splice plates to the camber, or both."

84. The quality of structural steel, as specified, appears to the writer as a step in the wrong direction. Requisite properties for both soft and medium steel should be given, as both grades have enough adherents to justify an alternative specification. The requirements stated are not very severe even for soft steel (see par. 95) and the possible variation of from 55,000 lbs. to 65,000 lbs. would permit the miscellaneous combining of both soft and medium steels.

The possible furnishing of soft steel pins is not desirable. If the "yield point" is worth anything, it is worth giving a requirement; if entirely discredited, why not make available a more accurate test? The writer would prefer the following grade of steel:

84 and 85.

Phosphorus max. basic ....0.04 per cent.
Phosphorus max. acid ....0.06 per cent.
Sulphur ....0.05 per cent.
Manganese ....0.05 per cent.
Ultimate tensile strength..........60,000 lbs. to 68,000 lbs.
(A large percentage of this should vary from 60,000 lbs. to 66,000 lbs.)
Elongation, minimum per cent. in 8 in........25 per cent.
(This should vary, with an ultimate below 64,000 lbs. from 26 per cent. to 33 per cent., and with an ultimate above 64,000 lbs. from 25 per cent. to 28 per cent.
Elongation, minimum per cent. in 8 in......25 per cent.
Character of fracture..............................**silky.**
Cold bends, up to ¾-in. thick (incl.); 180° flat.
Cold bends ¾-in. to 1 in.; 180° around one-half the thickness.
Cold bends over 1 in.; 180° around once the thickness.
Yield point........................55 per cent. ultimate.

95. The given diameter of bend is about 100 per cent. too great.

Pars. 116 and 132. Referring to these very generally used restrictions as to "unfair holes," it would be instructive to contrast the opinions of "practical" shopmen and of the purchaser's Engineer, as to what constitutes an unfair hole. The writer is of the opinion that this clause is rarely enforced.

124. Fillers under end stiffeners and at other points of concentrated loading should have a tight fit, materially increasing the actual stiffener bearing area.

139. Is this clause intended to cover the end sections of top chord, in the case of round ended or "bull nose" girders, and the bottom chord angles of "fish bellied" girders?

150. There is no provision made by which eyebar heads and other parts inaccessible after erection shall receive a second coat of paint. While this could be provided for in the field painting (which is not part of this specification) it is not certain that this is the best way to provide for such painting.

157. It would be more in accordance with the tendency of present practice to require the original tracings to be furnished to the Railroad Company, the manufacturers filing paper tracings made by some one of the negative or positive printing processes.

159. While the usual rebate of the scrap value of full sized material passing a satisfactory test is a small amount for any particular set of tests, it probably represents a considerable sum to the manufacturer in the course of a year. This might properly be made the basis of a request for tests on eyebar material as it comes from the rolls, or the tests called for under the writer's criticism of paragraph 92.

The suggestion of the Committee that a series of impact tests be made should meet with general approval.

The President:—The chairman will please make the opening statement as to the manner in which the Committee would prefer to have the report taken up.

Mr. J. P. Snow (Boston & Maine):—You will remember that last year a portion of this specification, which we call part I, was referred back to the Committee for further consideration. During the year we have studied it over pretty thoroughly and present changes which are printed on the left-hand pages of Bulletin 71, and the paragraphs of the 1905 version which were changed are printed on the right-hand page, so that you can see what alterations have been made. The complete specification, as we changed it at our meeting at Niagara in January, is shown on the left-hand pages. Since that time several important suggestions have been made to the Committee, and yesterday we worked over them and decided upon certain other changes, which we present to you as we come to them. In regard to the method of considering the report, the Committee would prefer that it be considered under the sub-headings as given, such as general features, loads, etc., considering the whole subject at once, if it is agreeable, because we can get at it so much faster.

The President:—In explanation of the report, the chair wishes to say that on the left-hand page all paragraphs having a star prefixed to them are those in which the wording or the sense has been changed from that of last year. Paragraphs in which no star occurs are embodied in the present report without change from last year. I would ask the chairman whether he wishes to take that up in sections or take it up by reading only the paragraphs that have been changed?

Mr. Snow:—I do not think it necessary to read over the paragraphs that have not been changed, as they have been before the Association two years now. However, that is for the Association to decide.

The President:—I would suggest, in order to save time and make progress, that the paragraphs prefixed with a star be read by the chairman of the Committee. The members present can follow the paragraphs with those corresponding on the opposite page. Any objection or discussion arising will take its regular course as we proceed.

Mr. Snow:—Commencing on page 6, of Bulletin 71, under the head of "General Features:" "(1) Kind of Material.—The material in the superstructure shall be structural steel, except rivets, and as may be otherwise specified."

(The paragraph was adopted.)

Mr. Snow:—"(2) Clearance.—On a straight line, the clear height of through bridges shall not be less than 21 ft. above top of rails for a width of 6 ft. over a single track, and the clear width shall be not less than 7 ft. from the center line of the track between the heights of 4 and 17 ft. above the rails. The width shall be increased to provide the same minimum clearance on curves, for a car 80 ft. long, 14 ft. high, and 60 ft. center to center of trucks, allowance being made for curvature and superelevation of rails."

Mr. T. L. Condron (Consulting Engineer):—The only question I have in mind as to paragraph 2 is as to the width of the car. Is the full width to be taken as 14 ft. or what width of car is to be assumed? This question has come up in my own office, in figuring the clearance. The length and height of the car were given. Should not the width be given?

Mr. Snow:—The central plane of the car, if the track is level, will be vertical; but if the outer rail is elevated, the central plane of the car will be inclined. We intend that there shall be seven feet from the center of the top of the car to the side clearance of the bridge. The width of the car really does not count in figuring the matter.

Mr. Condron:—You figure the full width of the bridge 14 feet distance? I mean, the space to be 14 feet wide?

Mr. Snow:—Yes, considering the superelevation. We should have the same clearance from the central plane of a car that we have on a straight line.

(The paragraph was adopted.)

Mr. Snow:—"(4) Skew Bridges.—Ends of deck plate girders and track stringers of skew bridges at abutments shall be square to the track, unless a ballasted floor is used."

(The paragraph was adopted.)

Mr. Snow:—"(5) Timber Floors.—Wooden tie floors shall be secured to the stringers and shall be proportioned to carry the maximum wheel load, with 100 per cent. impact, distributed over three ties, with fiber strain not to exceed 2,400 lbs. per sq. in. Ties shall not be less than 10 ft. in length. They shall be spaced with not more than 6 in. openings; and shall be secured against bunching." We have changed this at our recent meeting to 2,000 lbs., so that the paragraph will read, as we have changed it: "with fiber strain not to exceed 2,000 lbs. per sq. in."

(The paragraph was adopted as amended.)

Mr. A. F. Robinson (Atchison, Topeka & Santa Fe):—Shall we interrupt as each paragraph is read and have discussion or wait until the reading is finished?

The President:—Better follow the usual order.

Mr. Robinson:—I do not believe it is wise to use the low unit stress given, even with the high amount of impact, because our large ties, under heavy engines, and heavy cars, will fail just the same as the ties we have been using heretofore. It is my belief that the use of an extreme fiber stress of 2,000 lbs. per sq. in., with impact of 10 per cent., is ridiculous. I opposed the adoption of this extremely low unit stress in Committee, but was outvoted. My object in finally agreeing to this unit stress is the belief that the high first cost and high maintenance cost of decks built under these specifications will very soon force the adoption of ballasted floors on all our main line bridges. Before adopting this unit stress, our managing officers may want to count the cost. Omitting for the time being the dead load, let us see what size ties we need for the live load alone. For an extreme fiber stress not exceeding 2,000 lbs. per sq. in. and with 100 per cent. added for impact, the following sizes of ties will be required:

First—50,000-lb. axles: 8x10 in. ties for stringers spaced from 7 to 7½ ft. centers; 8x12 in. ties for stringers spaced 8 ft. centers; 8x14 in. ties for spacing of 9 and 10 ft.

Second—55,000-lb. axles: 8x10 in. ties for stringers 7 to 7½ ft. centers; 8x12 in. ties for stringers spaced 8 ft. centers; 8x14 in. ties for stringers spaced 9 ft. centers; 8x16 in. ties for stringers spaced 10 ft. centers.

Third—60,000-lb. axles; 8x10 in. ties for stringers spaced 7 ft. centers; 8x12 in. ties for stringers spaced 7½ ft. centers; 8x14 in. ties for stringers spaced 8 to 9 ft. centers; 8x16 in. ties for stringers spaced 10 ft. centers.

With a ballast floor, 6-in. creosoted timber laid solid will meet all requirements up to 8 ft. between centers of stringers, and 10-in. timber will answer for 9 to 10 ft. spacing of stringers on girders. Passenger engines with from 55,000 to 60,000 lbs. load on one or more axles are common on our trunk lines. Counting on 60,000-lb. axles and a clear space of 4 in. between ties, our open decks will cost about as follows (ties 12 ft. long considered): 7 ft. centers of stringers, $2.50 per linear foot of track; 8 ft. centers of stringers, $3.15 per foot of track; 10 ft. centers of stringers, $3.50 per foot of track. A ballasted floor of creosoted timber 14 ft. in width will cost about as follows: Creosoted timber and bolts being taken at $45 per thousand ft. B.M., and ballast at $1.00 per cu. yd. in place—for 8-ft. spacing of stringers, $4.20 per foot of track; for 10-ft. spacing of stringers, $6.70 per foot of track. With our very heavy engines and steel frame cars running at high speeds, our open deck bridges will not stand a very serious derailment. This open deck, which has become almost a lumber yard, also offers greater danger from fires. Our ballast floor will stand almost any conceivable derailment, eliminates almost all danger from fires, and is good for about 25 years of service. The saving in maintenance of a ballast floor costs no more per annum than our heavy open floors and is not open to the grave dangers accompanying the use of the latter. It seemed to me it would be almost like throwing money away to put 8x12, 14 or 16-in. timbers into our decks and leave them open so that they could get the blows from any derailed car that happened to get out of place.

The President:—Is there any discussion upon the points brought forward by Mr. Robinson? No motion having been made, the chairman will proceed.

Mr. Snow—"Section II. Loads.—(6) Dead Loads.—The dead load shall consist of the estimated weight of the entire suspended structure. Timber shall be assumed to weigh 4½ lbs. per ft. B.M.; ballast 100 lbs. per cu. ft. and rails and fastenings 150 lbs. per linear ft. of track."

(The paragraph was adopted.)

Mr. Snow:—"(7) Moving Load.—The live load, for each track, shall consist of two typical engines followed by a uniform load, according to Cooper's series, or a system of loading giving practically equivalent strains. The minimum loading to be Cooper's E-40, as shown in the diagrams, and the diagram that gives the larger strains to be used." I might add that we propose to omit the reference mark after the word "series," in the second line. It refers to nothing and means nothing.

(The paragraph was adopted.)

Mr. Snow:—"(9) Impact.—The dynamic increment of the live load shall be added to the maximum computed live load strains and shall be determined by the formula $I = S \frac{300}{L + 300}$, where I equals impact to be added to the live load strains; S equals computed maximum live load strain; L equals loaded length of track in feet producing the maximum strain in the member. For bridges carrying more than one track, the aggregate length of all tracks producing the strain shall be used. Impact shall not be added to strains produced by longitudinal, centrifugal and lateral or wind forces." In our late session we decided to change the line defining I so that it will read: "I equals impact or dynamic increment to be added to live load strains."

(The paragraph as amended was adopted.)

Mr. Snow:—We have decided to make a radical change in paragraph 10, which should read: "All spans shall be designed for a lateral force on the loaded chord of 200 lbs. per linear ft. plus 10 per cent. of the specified train load on one track, and 200 lbs. per linear ft. on the unloaded chord; these forces being considered as moving."

(The paragraph was adopted as read.)

Mr. Snow:—"(10) Wind Loads.—Viaduct towers shall be designed for a force of 50 lbs. per sq. ft. on one and one-half times the vertical projection of the structure unloaded; or 30 lbs. per sq. ft. on the same surface plus 400 lbs. per linear ft. of structure applied 7 ft. above the rail for assumed wind load on train when the structure is either fully loaded or loaded on either track with empty cars assumed to weigh 1,200 lbs. per linear ft., whichever gives the larger strain."

(The paragraph was adopted.)

Mr. Snow:—"(12) Longitudinal Force.—Viaduct towers and similar structures shall be designed for a longitudinal force applied to the rail of two-tenths of the live load." We want to change the word "two-tenths" in the last line to 20 per cent. as being more consistent with the wording of the rest of the specification.

(The paragraph as amended was adopted.)

Mr. Snow:—For paragraph 13 we have a new reading, as follows: "Structures located on curves shall be designed for the centrifugal force of the live load acting at a height of 6 ft. above the rail; proper account being taken of the superelevation. The speed and superelevation to be determined by the engineer for each case."

(The paragraph was adopted as read.)

Mr. Snow:—"Section III. Unit Strains and Proportion of Parts.—(17) Bending.—Bending: on extreme fibers of rolled shapes, built sections and girders; net section, 16,000; on extreme fibers of pins, 24,000."

(The paragraph was adopted.)

Mr. Snow:—"(18) Shearing.—Shearing: shop driven rivets and pins, 12,000; field-driven rivets and turned bolts, 9,000; plate girder webs, gross section, 10,000." We have modified the middle line to read 10,000 instead of 9,000.

(The paragraph was adopted as amended.)

Mr. Snow:—"(19) Bearing.—Bearing: shop-driven rivets and pins, 24,000; field-driven rivets and turned bolts, 18,000; granite masonry and Portland cement concrete, 600; sandstone and limestone, 400; expansion rollers, per linear inch, 600 d, where d is the diameter of the roller in inches." We have modified the second line to read 20,000 instead of 18,000.

(The paragraph was adopted as amended.)

Mr. Snow:—We have changed paragraph 20 from the printed version so as to read: "Members subject to alternate strains of tension and compression shall be proportioned for the strains giving the largest section. If the alternate strains occur in succession during the passage of one train, as in stiff counters, each strain shall be increased by 50 per cent. of the smaller. The connections shall in all cases be proportioned for the sum of the strains."

(The paragraph was adopted as read.)

Mr. Snow:—"(22) Axial and Bending Strains Combined.—Members subject to both axial and bending strains shall be proportioned so that the combined fiber strains will not exceed the allowed axial strain."

(The paragraph was adopted.)

Mr. Snow:—We have modified paragraph 23 to read: "For strains produced by longitudinal and lateral or wind forces combined with those from live and dead load and centrifugal forces, the unit strain may be increased 25 per cent. over those given above; but the section shall not be less than required if the longitudinal and lateral wind forces be neglected."

(The paragraph was adopted as read.)

Mr. Snow:—"(24) Net Section at Rivets.—In proportioning tension members the diameter of the rivet holes shall be taken ⅛-in. larger than the nominal diameter of the rivet."

(The paragraph was adopted.)

Mr. Snow:—"(25) Rivets.—In proportioning rivets, the nominal diameter of the rivet shall be used."

(The paragraph was adopted.)

Mr. Snow:—"(27) Proportioning Plate Girders.—Plate girders shall be proportioned either by the moment of inertia of their net section; or by assuming that the flanges are concentrated at their centers of gravity; in which case one-eighth of the gross section of the web, if properly spliced, may be used as flange section."

(The paragraph was adopted.)

Mr. Snow:—"(28) Compression Flanges.—The gross section of the compression flanges of plate girders shall not be less than the gross section of the tension flanges; nor shall the strain per sq. in. in the compression flange of any beam or girder exceed $16{,}000 - 200\frac{l}{b}$, where l equals unsupported distance and b equals width of flange."

(The paragraph was adopted.)

Mr. Snow:—"(29) Flange Rivets.—The flanges of plate girders shall be connected to the web with a sufficient number of rivets to transfer the total shear at any point in a distance equal to the depth of the girder at that point combined with any load that is applied directly on the flange. The wheel loads, where the ties rest on the flanges, shall be assumed to be distributed over three ties."

(The paragraph was adopted.)

Mr. Snow.—We have modified paragraph 30 so that it shall read: "Trusses shall preferably have a depth of not less than one-tenth of the span. Plate girders and rolled beams, used as girders, shall preferably have a depth of not less than one-twelfth of the span. If shallower trusses, girders or beams are used, the section shall be increased so that the maximum deflection will not be greater than if the above limiting ratios had not been exceeded."

(The paragraph was adopted as read.)

Prof. H. S. Jacoby (Cornell University):—I would like to inquire, with reference to paragraph 29, on the third line, whether "effective depth" should not be substituted for "depth." The word "depth," in connection with girders, sometimes applies to the depth of the web plate and in other cases may refer to the depth between the rivet lines. Theoretically, it is the effective depth, the distance between centers of gravity of the flanges.

Mr. Snow:—The effective depth of the girder is always the depth understood when anything is being said about the computation of a girder. It is a matter of rather small importance, but still it might be more precise if we should say "effective depth," or "depth out-to-out of angles," or something to make it definite. I do not wish to assume that the Committee would like to accept that change, but I do not think there would be any objection if the Association thinks it necessary. I am told by my colleagues that there will be no objection to inserting the word "effective" before "depth."

The President:—If there is no objection on the part of the convention, the word "effective" will be inserted in paragraph 29.

Mr. Snow:—"Section IV. Details of Design. General Requirements. (31) Open Section.—Structures shall be so designed that all parts will be accessible for inspection, cleaning and painting."

(The paragraph was adopted.)

Mr. Snow:—"(32) Water Pockets.—Pockets or depressions which would hold water shall have drain holes, or be filled with waterproof material."

(The paragraph was adopted.)

Mr. Snow:—"(34) Counters.—Rigid counters are preferred; and where subject to reversal of strain shall preferably have riveted connection to the chord. Adjustable counters shall have open turnbuckles." We have changed the words "connection" and "chord" in the second line to make them plural.

(The paragraph was adopted as amended.)

Mr. Snow:—(36) Minimum Thickness.—The minimum thickness of metal shall be ⅜-in. except for fillers."

(The paragraph was adopted.)

Mr. Snow:—We have changed paragraph 37 to read as follows: "The minimum distance between centers of rivet holes shall be three diameters of the rivet; but the distance shall preferably be not less than 3 in. for ⅞-in. rivets and 2½ in. for ¾-in. rivets. The maximum pitch in the line of strain for members composed of plates and shapes shall be 6 in. for ⅞-in. rivets and 5 in. for ¾-in. rivets. For angles with two gage lines, and rivets staggered, the maximum shall be twice the above in each line. Where two or more plates are used in contact, rivets not more than 12 in. apart in either direction shall be used to hold the plates well together. In tension members composed of two angles in contact, a pitch of 12 in. will be allowed for riveting the angles together."

(The paragraph was adopted as read.)

Mr. Snow:—"(42) Compression Members.—In compression members the metal shall be concentrated as much as possible in webs and flanges. The thickness of each web shall be not less than one-thirtieth of the distance between its connections to the flanges. Cover plates if used shall have a thickness not less than one-fortieth of the distance between rivet lines." We made a slight change in this paragraph, omitting "if used" in the line next to the last.

(The paragraph was adopted as amended.)

Mr. Snow:—"(43) Minimum Angles.—Flanges of girders and built members without cover plates shall have a minimum thickness of one-tenth the width of the outstanding leg." In the last line we have changed "one-tenth" to "one-twelfth of."

(The paragraph was adopted as amended.)

Mr. Snow:—"(44) Tie-Plates.—The open side of compression members shall be provided with lattice and shall have tie-plates as near each end as practicable. Tie-plates shall be provided at intermediate points where the lattice is interrupted. In main members the end tie-plates shall have a length not less than the distance between the lines of rivets connecting them to the flanges, and intermediate ones not less than one-half this distance. Their thickness shall not be less than one-fiftieth of the same distance."

(The paragraph was adopted.)

Mr. Snow:—"(48) Spacing of Lattice.—Lattice bars shall be so spaced that the portion of the flange included between their connections shall be as strong as the member as a whole."

(The paragraph was adopted.)

Mr. Snow:—"(52) Pins.—Pins shall be long enough to insure a full bearing of all the parts connected upon the turned body of the pin. They shall be secured by chambered nuts or be provided with washers, if solid nuts are used. The screw ends shall be long enough to admit of burring the threads."

(The paragraph was adopted.)

Mr. Snow:—In paragraph 55, which has not got a star, the word "of" in the last line should be "for." Paragraph 56, which is not starred, we decided to change so that it will read: "Rivets carrying strain and passing through fillers shall be increased 50 per cent. in number; and the excess rivets when possible shall be outside of the connected member."

(The corrections to paragraphs 55 and 56 as read were adopted.)

Mr. Snow:—"(57) Expansion.—Provision for expansion to the extent of ⅛-in. for each 10 ft. shall be made for all bridge structures. Efficient means shall be provided to prevent excessive motion at any one point."

(The paragraph was adopted.)

Mr. Snow:—"(58) Expansion Bearings.—Spans of 80 ft. and over resting on masonry shall have turned rollers or rockers at one end; and those of less length shall be arranged to slide on smooth surfaces."

(The paragraph was adopted.)

Mr. Snow:—"(60) Rollers.—Expansion rollers shall be not less than

6 in. in diameter. They shall be coupled together with substantial side bars, which shall be so arranged that the rollers can be readily cleaned."

(The paragraph was adopted.)

Mr. Snow:—"(61) Bolsters.—Bolsters or shoes shall be so constructed that the load will be distributed over the entire bearing; spans of 80 ft. or over shall preferably have hinged bolsters at each end."

(The paragraph was adopted.)

Mr. Snow:—"(62) Wall Plates.—Wall plates may be cast or built up; and shall be so designed as to distribute the load uniformly over the entire bearing. They shall be secured against displacement."

(The paragraph was adopted.)

Mr. Snow:—"(63) Anchorage.—Anchor bolts for viaduct towers and similar structures shall be long enough to engage a mass of masonry the weight of which is at least one and one-half times the uplift."

(The paragraph was adopted.)

Mr. Snow:—"(67) End Spacers for Stringers.—Where end floor beams cannot be used, stringers resting on masonry shall have cross frames near their ends. These frames shall be riveted to girders or truss shoes where practicable."

(The paragraph was adopted.)

Mr. Snow:—"(69) Portals.—Through truss spans shall have riveted portal braces rigidly connected to the end posts and top chords. They shall be as deep as the clearance will allow."

(The paragraph was adopted.)

Mr. Snow:—"(70) Transverse Bracing.—Intermediate transverse frames shall be used at each panel of through spans having vertical truss members where the clearance will permit."

(The paragraph was adopted.)

Mr. Snow:—"(71) End Bracing.—Deck spans shall have transverse bracing at each end proportioned to carry the lateral load to the support."

(The paragraph was adopted.)

Mr. Snow:—"(72) Minimum Bracing.—The minimum-sized angle to be used in lateral bracing shall be 3½ by 3 by ⅜-in. Not less than three rivets through the end of the angles shall be used at the connection."

(The paragraph was adopted.)

Mr. Snow:—"(73) Bracing to Clear Ties.—Lateral bracing shall be far enough below the flange to clear the ties."

(The paragraph was adopted.)

Mr. Snow:—"(74) Tower Struts.—The struts at the foot of viaduct towers shall be strong enough to slide the movable shoes when the track is unloaded."

(The paragraph was adopted.)

Mr. Snow:—"Plate Girders. (75) Camber.—If desired, plate girder spans over 50 ft. in length shall be built with camber at a rate of one-sixteenth-in. per 10 ft. of length."

(The paragraph was adopted.)

Mr. Snow:—"(77) Web Stiffeners.—There shall be web stiffeners, generally in pairs, over bearings, at points of concentrated loading and at points required by the formula: $d = \frac{t}{40}(12{,}000 - s)$, where d = clear distance between stiffeners in flange angles; t = thickness of web; s = shear per sq. in. The stiffeners at ends and at points of concentrated loads shall be proportioned by the formula of paragraph 16, the effective length being assumed as one-half the depth of girders. End stiffeners and those under concentrated loads shall be on fillers and have their outstanding legs as wide as the flange angles will allow and shall fit tightly against them. Intermediate stiffeners may be offset or on fillers and their outstanding legs shall be not less than one-thirtieth of the depth of girder plus 2 in."

(The paragraph was adopted.)

Mr. Snow:—"Trusses. (79) Camber.—Truss spans shall be given a camber by making the panel length of the top chords, or their horizontal projections, longer than the corresponding panels of the bottom chord in the proportion of ⅛-in. in 10 ft."

(The paragraph was adopted.)

Mr. Snow:—We have revised paragraph 80 to read: "Hip verticals and similar members, and the two end panels of the bottom chords of single track pin-connected trusses up to 300 ft. spans, shall be rigid."

(The paragraph was adopted as read.)

Mr. Snow:—"(82) Pony Trusses.—Pony trusses shall be riveted structures, with double webbed chords, and shall have all web members latticed or otherwise effectively stiffened."

(The paragraph was adopted.)

Mr. Snow:—Part II was adopted by the Association some time ago, but we have suggested a few changes.

Mr. Wm. R. Webster (Consulting and Inspecting Engineer):—I move that Part I be accepted as read.

(The motion was carried.)

Mr. Snow:—I might say in connection with these changes all through that the Committee has considered the various suggestions and discussions that have been made, and has conformed to the suggestions as far as it could see its way to do so. In paragraph 84, which is not starred, we have decided to change the elongation for steel castings, which you will find in the middle of the right-hand column, from 18 to 15 per cent.

Mr. Webster:—If paragraph 84 is open for discussion, I would like to ask the Committee if they considered the acid steel percentage equivalent to basic steel of 0.04 per cent. phosphorus, and if commercially it is about the same-priced steel, or if they consider the physical properties the same, and I would like to call attention to the fact that a good many specifications of 0.04 phosphorus in basic called for 0.06 in acid, and ask if they make any objections to reducing 0.08 to 0.06 in the acid?

Mr. Snow:—This figure 0.08 phosphorus for acid steel was adopted six years ago and has not been changed since, although the question has been somewhat discussed. The feeling, at the time it was adopted, was that acid steel with 0.08 phosphorus was good material for bridges. If we made the limit any lower at that time it would practically rule out acid steel, because it could not then be produced with 0.06 phosphorus as cheaply as basic steel with 0.04 phosphorus; and we felt that we ought not to rule out acid steel, as it was a very good material, and by some considered better than basic material. It is barely possible that the process of manufacture has so changed since that we might reduce the limit to 0.06 with perfect safety. It is easy, as I understand it now, to get acid steel with 0.06 phosphorus simply by using plenty of basic scrap in the furnace. I do not think the Committee, looking at it from the point of view of good material, would have the least objection to reducing the figure to 0.06, but I might say that this specification for material has been built up in conjunction or alongside of the specification for material which has been adopted by the Society for Testing Materials, and we have endeavored to to make them identically the same. The Committee have no objection, I am sure, to reducing the figure to 0.06, provided Mr. Webster's committee of the Society for Testing Materials will follow suit.

Mr. Webster:—That was my reason for bringing the matter up. I replied to your letter some weeks ago that I thought my committee of the Society for Testing Materials would gladly accept what this Association might do in the matter, and the subject is up for consideration by the society and will be considered at a meeting to be held in April. I will leave the matter open and will not make any motion.

Mr. Snow:—I would like to hear an expression of opinion from other members.

Mr. J. W. Schaub (Consulting Engineer):—It seems to me that the requirements for phosphorus are made subservient to the kind of material used in this country for making acid steel. In Great Britain there would be no difficulty in supplying acid steel with 0.04 phosphorous; and if you had submitted this specification to the steel mills in Germany ten years ago they would have asked to have the limits for phosphorus just reversed. It seems to me that you have sacrificed a specification in order to keep in view the kind of material commonly used in this country, and I see no reason why you should make a phosphorus limit double in one case what you do in the other. If you make it fifty per cent. more, you certainly are very conservative, and I agree with Mr. Webster to make it 0.06.

Mr. R. Modjeski (Consulting Engineer):—I also agree with the gentleman upon that question of reducing that to 0.06.

Mr. Snow:—The Committee is favorable to making the change, and with the permission of the Association, we will consider the figure changed from 0.08 to 0.06.

(The paragraph as amended was adopted.)

Mr. Snow:—Regarding paragraph 85, we decided at our meeting yesterday to reverse our previous action so that it will read: "If the ultimate strength varies more than 4,000 lbs. from that desired, a retest shall be made on the same gage, which to be acceptable shall be within 5,000 lbs. of the desired ultimate." I hope Mr. Webster's committee will see their way clear to meet us on that point.

Mr. Webster:—I will do what I can to have them do that. If there is going to be a large amount of material, structural steel, I should think it would be no great hardship to insist on the specification as you have it; in fact, 8,000 leeway flat would not be a hardship on the mills. They only think it is.

Mr. Snow:—Can you bring your committee to that?

Mr. Webster:—If they do not come to it, I assure you we will have a minority report to that effect.

(The paragraph was adopted as read.)

Mr. Modjeski:—Referring to paragraph 84, is that reduction from 0.08 to 0.06 on phosphorus applicable also to steel castings? I think it ought to apply also to steel castings.

The President:—Do you make that in the form of a motion?

Mr. Modjeski:—A special specification would be required to cover that.

The President:—You make that as a suggestion to the Committee that in next year's report they consider a special specification for cast steel of high ultimate?

Mr. Modjeski:—Yes, sir.

Mr. C. C. Schneider (Consulting Engineer):—That has been considered by the Committee, and they are willing hereafter to include in the specification special materials.

Mr. Condron:—This specification has been in use several years, and there was a good deal of discussion at the time this mean of 60,000 lbs. was adopted for structural steel. A minority of the Association was in favor of higher tensile steel at that time, and the discussion was very full upon that point. At the time the specification was first framed and adopted, it was thought that 60,000 lbs. was as high a mean as could reasonably be called for for every-day commercial purposes. I think it was the unanimous opinion that these specifications could then be safely adopted on that basis, with a view to ultimately raising the required strength. I wondered, in looking over these specifications, if the Committee had made any investigations as to the progress of manufacture of steel, and if the same had developed to such a point that we might at this time consider an advance of 2,000 lbs. in the strength of our material. It would seem to me that such an increase would be in the line of progress. There has been nothing in the past two or three years to cause me to change my opinion in that matter. I hesitate to make a motion, unless to get the expression of the Association; but I would inquire if the Committee has considered the feasibility of raising the tensile strength of structural steel to 2,000 lbs.

Mr. Webster:—I think it would be very unfortunate to change the structural material. With the limit you now have it is advantageous to everyone to have large tonnage on material ordered by standard specifications. We are going to take up shortly in the Society for Testing Materials the hull material for ships, and that will be about 61,000 to 71,000 lbs. tensile strength. This we hope to get in shape before long, and it will be practically the Lloyds specification with chemical requirements added.

Mr. Robinson:—If this scheme Mr. Webster speaks of goes into effect, we are coming virtually back to our original proposition of two grades of steel.

Mr. Webster:—I did not mean to open up that old question, but I did want to say that a large amount of that material is being rolled now, and there will be more.

Mr. Condron:—Then, in view of this proposed action, or the shadow of it before us, of the other society, in which we are so deeply interested, would it not be of material advantage to them to meet us half way? I therefore make the motion, to get the sense of this meeting, that in the first paragraph with reference to structural steel, the ultimate tensile strength desired shall be 62,000 lbs. per sq. in.

Mr. Schaub:—If you are going to make a change, I do not think you are radical enough. You all know that the steel from which the axle of a car is made runs from 65,000 to 75,000 lbs. per sq. in. in ultimate strength, and the axle manufacturers insist on using this kind of material. This material has probably worse usage than any other steel. It is subjected to impact without any intervening springs, and is subject to a continual reversal at high frequency. It seems to me if you change from 60,000 to 62,000 you will make a mistake.

Mr. Webster:—The axle has no holes punched through it and is put into use without reaming those holes. I would like to call attention to a motion I made last year, which was carried, reversing the action of the Committee on another matter. I do not think it is fair to any committee for the Association to reverse its findings.

Mr. Snow:—The motion, I suppose, is open to discussion. I sincerely hope the Association will not vote to change that figure from 60,000 to 62,000. If there is anything valuable about the work of this Committee during the four or five years that it has been at work, it is in establishing a uniform grade of material. We get commendations from a good many quarters, and it seems to work out first rate in our own practice, and I thought we were getting along nicely. I am sure, if we start in to make changes, there will be trouble in many directions. This specification, so far as a single grade of material goes, has given eminent satisfaction to manufacturers and to all the users that I have heard from. Every year we get a little dose of comments and suggestions from men who use a higher grade of material, as they call it, than this; but I am sure that the great bulk of work in this country is satisfied with this grade of material.

Mr. Webster:—I would like to offer an amendment to that motion, that it be given to the Committee to report on a year hence. I do not want to reverse the Committee's report now, whatever my personal views may be.

(The amendment was carried.)

The President:—The original motion as amended is now before you.

(The motion was lost.)

Mr. Condron:—I think there has been a misunderstanding. I see that more members of the Committee are in favor of the motion than there are opposed to it. I move, therefore, that the limit for the 60,000 lbs. named in the specification for the desired ultimate tensile strength of structural steel be made 62,000 lbs. instead of 60,000 lbs. I have been in the mills, and know that the manufacturers would not think seriously of the difference. They will talk a lot about it, but in actual practice they will hardly discover it, and will not object to it.

Mr. Webster:—I do not think we can change the properties of the steel. I think the properties of the steel are the same to-day as when we decided on 60,000 lbs. This material is largely used without reaming. If you get to 62,000, you will go up to 65,000, when you will get to the point where you had better not use the steel without reaming, especially if you use thick material.

Mr. C. F. Loweth (Chicago, Milwaukee & St. Paul):—I think it true that the bulk of the material entering into railroad bridges that are loaded heavy is three-quarters of an inch in thickness and thicker, and we are up to the proposition of reaming our material under these specifications whether we use 60,000 or 62,000 lbs. steel. I have been asking for 62,000 lbs. ultimate tensile strength for years past, and have had no difficulty in getting it. None of the bridge companies have objected to furnishing it.

Mr. C. S. Churchill (Norfolk & Western):—I objected to these limits of steel two or three years ago. We are using 57,000 and 65,000 as our specification limits.

Mr. Snow:—There would be no objection to the 62,000 Mr. Condron asks for as a desired ultimate *per se*, but it would carry the upper limit so high that it would be impracticable. If we could be assured the upper limit would not go above 65,000, there would be no objection to his figure. I understand there is no motion made.

The President:—The new motion has not been seconded, and the chair would rule the motion out of order, unless Mr. Condron alters the wording. There was an original motion before the house; an amendment was made and carried; then the question was upon the original motion as amended and was lost.

Mr. Condron:—I have no desire to be antagonizing or disrespectful to this Committee. I counted the votes of the members of the Committee, and noted that it was divided. In order to put this matter in an agreeable form, I will make the motion that it go to the Committee as a recommendation. The Committee has changed the report since it was published repeatedly, and there is no reason, if they want to change it again, why they should not change it right now.

The President:—The chair has decided that the motion is out of order.

Mr. Condron:—In order to bring this matter up and get some expression of sentiment, I move that it is the sense of the meeting that the desired ultimate strength of structural steel be made 62,000 instead of 60,000 lbs.

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis):—As I understand it, without having heard the matter very fully discussed, I do not think the floor of this convention is the place to decide an intricate technical question. As Mr. Theodore Cooper says in his discussion of the report of this Committee, he does not think a mere majority vote should decide an intricate technical matter, and I think the proper treatment of this question is to refer it back to the Committee, with the request that they consider it carefully and report at the next meeting upon the advisability of raising the limit of strength of structural steel.

(The motion was carried.)

Mr. Webster:—Now, for the information of the Committee, and of the other members present, I think we might ask for an expression of views on the subject of the members present.

The President:—The chair will entertain discussion upon that question. It is not necessary to make a motion.

Mr. Webster:—I did not know whether you wanted to vote on it or not. The members are requested to give their own views. We would like the sense of the meeting, or rather, the Committee would like the sense of the meeting on that subject. We will put it that way.

Mr. A. E. Reichmann (American Bridge Company):—I think next year, when the Committee makes its report, will be the proper time for the Association to express its opinion as to what it wants.

Mr. Loweth:—I am in favor of Mr. Webster's suggestion, that members of the Association express their opinion of this matter to-night. If we have to report a year hence on this question, it will be very desirable that we know the opinion of the members in advance, and I hope that this phase of the subject will not be dropped now.

Mr. McDonald:—If the Committee does its duty faithfully, I cannot see what sense there would be in having the convention express an opinion on this subject now. It strikes me, in the absence of the men who are making the steel—if they are here, I do not know it—and an expression from them as to their ability to furnish it, and in the absence of a full discussion of their ability to furnish it, an expression of this meeting would be of little value. The motion just passed was to the effect that this Committee investigate the matter, and our vote might, prior to this investigation, be premature; and, further, if the vote was taken, the Committee might consider the matter had been settled by the convention, and shape its course accordingly. What we want is to have the Committee look into this thing, and tell us what to do.

Mr. Richard Khuen (American Bridge Company):—If you reduce this matter to a question of percentage, you will find that it amounts to less than three and one-half per cent. We are taking a great deal of time to discuss a change amounting to three and one-half per cent. Anyone who has had anything to do with bridge designing knows that this amounts to very little, and we can therefore safely leave it with the Committee.

Mr. Robert Moore (Consulting Engineer):—Mr. McDonald has set a precedent I should like to see followed in another matter in connection with bridge construction, and that is that the Committee should continue to consider the matter of impact. For one, I feel unable to accept the formula adopted by them as the end of the matter. A formula which gives 33 per cent. impact on a 600 ft. span should hardly be considered a finality, and I should like very much to have this matter considered very thoroughly, not alone theoretically, but, above all, experimentally. It appears to me that it is a subject which above all requires experience and careful experiment to reach conclusions that are worth anything. For myself I cannot believe that in spans of any length the dynamic increment of the stress is anything like what this formula calls for. At the same time, I recognize the fact that in the absence of carefully conducted experiments the opinion of no one is worth much, and for that reason I should like to have the Committee charged with this duty of continued investigation and report upon this subject until they can give us conclusions that are based upon well-ascertained facts. Therefore, I move that it be the request of this meeting that the Committee continue to consider and report next year upon this matter of impact.

Mr. Snow:—For the information of the members I will say that we would be very glad to work out this thing on the lines suggested by Mr. Moore, provided sufficient funds can be obtained for the purpose. It costs considerable money to do it. I will say that some two thousand separate experiments were made by a member of this Committee on this very subject. The results of those experiments were quite discordant, and it was very difficult to bring them to a satisfactory law. About all that could be definitely said was that they showed that this formula is safe; that it goes a little above anything that was measured. The records as well as the instruments with which these experiments were made were destroyed in the Baltimore fire. They were made on the Baltimore & Ohio Railroad by our member, Mr. Greiner. The value of these experiments has never been appreciated by this Association. It is a tremendous undertaking to make them, and they were made without expense to the Association and without financial help from anyone; they were made at the expense of the Baltimore & Ohio Railroad.

I am not ready to say what we propose to do in the future, but I will repeat what I said when I started, that we will be very glad to make some more experiments if we can get the funds to do it with.

Mr. Moore:—I cannot conceive of any better object for the expenditure of money on the part of the users of steel than these experiments. If the results given by this formula are as much too high as I am inclined to believe they are, we are using material very wastefully, and I think that the users of steel would make a most desirable investment if they would contribute whatever is necessary to insure that these experiments be exhaustively made. Nor can I conceive of any better object for the expenditure of the surplus of this Association, which, I understand, is some ten thousand dollars, than to employ it, or a part of it, in this work. It is a work of the utmost value, which somebody must do, if we are to design the bridges as intelligently as we ought to do.

Mr. Robinson:—I hope the Association will go one step farther in this matter. It is my belief that the instruments used heretofore in making these tests have taken the distortions over too small a length. As a result these records have had to be multiplied 140 or 150 times to make them so that they could be read. I hope that when the matter is taken up, some instrument will be devised by which the elongation or the distortion of the member tested can be made longer, say, a full panel length in a truss bridge. In addition to this, I think we should determine what is the effect of a ballast floor in reducing this impact. The test should be conducted both on bridges with ballast and similar structures without ballast. There are plenty of bridges on quite a good many railroads in the country that can be tested, and it is my belief that if the various railroads are approached properly, they will be glad to furnish the locomotives and sufficient assistance to make these various tests if the Association will furnish the central head to guide the whole matter, and who will have the instruments to make the tests and who will look after them. I hope that the matter will be carried out. As Mr. Moore has said, I do not believe in the use of this impact formula. I am one of the unfortunates who signed the minority report, which has not been accorded any discussion as yet, and I for one hope to see the time come when we will have an impact formula that we can all accept. I cannot accept the present one; I think it is wrong.

Mr. McDonald:—It has occurred to me that the membership may not be aware of the fact that the President of the United States has requested this Association to appoint three members to represent the Association on an advisory board for the purpose of testing structural materials, and it seems to me, if this question is one that requires finances as well as intelligence to settle, and if it is one that is very important and should be settled, that there could be nothing better done by the Association to-night than to instruct its representatives on the advisory board to the effect that they use their endeavors to secure a proper investigation of this matter through the appropriation made by the Government.

Prof. F. E. Turneaure (University of Wisconsin):—As a result from some little experimentation I did six or eight years ago I appreciate the difficulties in making such experiments in the right way. My experience in making tests on some thirty or forty bridges of different span lengths, from 25 ft. to 150 or 200 ft., has led me to conclusions very similar to those of Mr. Moore, that the impact formula providing for such a large percentage on bridges of 400, 500 and 600 ft. span is much further on the side of safety than it is for very short spans. It seems to me that the dynamic effect of the moving load can be divided into two kinds—the direct effect which comes on very short spans—such as short span girders and floor systems, and which is probably not badly represented by this formula—and the indirect and accidental effect which comes on long truss spans, and which is very difficult to represent by a formula. I believe on long spans experiments can be carried on satisfactorily and without great difficulty by measurements of deflection, but for the floor systems and short girders, and for a good many of the truss members, undoubtedly a direct measurement of strains would need to be made. For the latter purpose some instrument measuring the strains over a good length would be needed. I think the matter an extremely important one, and I should like to see experiments carried out on a large scale. One thing which should be done is to make experiments on short spans which can be made similar in design so far as the girder itself is concerned, but with varying floor systems. I think that would be the most economical and practical method of determining the effect of ballasting and various designs of floor systems.

Mr. Schneider:—Those who have had no experience in making impact tests can have no conception of the amount of time and patient labor involved therein. Several years ago at a meeting of this Association I mentioned that I would be glad to co-operate with any of the members who had opportunities and desired to make such experiments; also, that I would let them have the use of the instruments which were at my disposal; but no response was received. The experiments made in this country are practically confined to the work of one man. Mr. Greiner, of the Baltimore & Ohio Railroad, has spent years on impact tests and made several thousand carefully conducted experiments, the results of which form a valuable contribution to our knowledge on this subject. His experiments were made by experienced men and are probably as reliable as any experiments of this kind can be made. I regret very much that his work is so little appreciated.

Mr. C. H. Cartlidge (Chicago, Burlington & Quincy):—I believe if this Association takes up the question of impact experiments, it will not only be well done, but the Association will be prepared to give the work the weight it deserves. I believe, contrary to Mr. McDonald, that the Association itself should make the experiments, and not the Government. The Association has money to do the work, and I believe there are brains enough in the Association to do the work properly. In fact, I think in this room there is a man who has had sufficient experience to undertake such experiments and carry them out properly. I speak of Prof. Turneaure, who has just addressed you. I think he is able to give us now an estimate of the amount of money such experiments would require, and after he has done so, I will move that we, as a Committee, or the Association as a body, request the Board of Direction to set apart that amount of money to be expended in these impact experiments during the coming year or the next two years.

Mr. Andrews Allen (Wisconsin Bridge Company):—I want to add a word of very hearty second to the suggestion that this Association take up the proposed impact experiments. I do not believe there is a member here who thinks that the impact formula which has been presented to us is right, theoretically or practically. It has simply been adopted as a safe empirical formula. I think that this Association, which stands for the highest development of railroad engineering, should take the lead in this matter. We have a fund available for this purpose. I think now is the time to bring this matter to some definite conclusion, to make some experiments under the proper auspices in the proper way and get results. I certainly will vote with great pleasure in favor of the motion to have these experiments made.

The President:—Part of this discussion is somewhat out of order, but very interesting. There is a motion before the convention, made by Mr. Moore, and seconded, to the effect that the Committee during the ensuing year consider the matter of obtaining further information with respect to the impact formula. It might be well, before we get off that particular subject, to call for the question on that motion.

Mr. Moore:—It is the main subject I am interested in, rather than the particular form of the motion, and the main point is that I should like very much if this Committee were empowered in some way, and furnished with sufficient money, to make impact experiments, and that this Association make it one of the main objects of its existence to keep at this matter until such experiments as are made shall be conclusive of something, and shall with certainty define the limits of our knowledge. As it is now, the matter is in such a nebulous and unsatisfactory condition that we, as engineers, should not remain satisfied with it. For myself, I am willing to modify my motion to the effect that this Association will back up the Committee in making these experiments—that it is the sense of the meeting that the Board of Direction be authorized to appropriate for these experiments such money as the Committee may need up to the limits of the ability of the Association.

The President:—Does that change in the motion meet the wishes of the second? The motion has taken an important form, and if carried, might have the effect of forcing the Board of Direction to spend the entire surplus. The Board has been working hard for several years to accumulate the surplus.

Mr. Cartlidge:—Would it be out of order to suggest that an estimate of the probable amount of money needed might be given on the floor here to-night before that action is taken? I do not think it is the intention of those who are in favor of this motion to spend the whole surplus on one year's experiments or two years' experiments. If it is not out of order, I suggest that Prof. Turneaure be asked to estimate how much the work would cost for one or two years' experiments.

Prof. Turneaure:—It is not an easy matter to make an estimate of the cost of what ought to be done. In talking this matter over with one or two members of the Committee some little time ago, a very crude estimate was made of the least amount that would be profitable to put into such work, and that was figured for the first season at some-think like $3,000, and for the second season at about $5,000. I do not think it would be worth while to begin the work with a less amount of money in sight than this. That is a very rough estimate, and it might be very desirable for this Committee to consider the matter and report at some subsequent session of this meeting.

Mr. Moore:—I would not want to be precipitate in this matter, and, of course, in anything of that sort we would give the Board of Direction very great discretion, but, subject to the good judgment and discretion of the Board of Direction, I would suggest that the Association authorize them to go ahead to such an extent as seems proper under the conditions which arise.

The President:—Within the last eighteen months there has been some earnest effort made to interest some of the larger railroads in this country in contributing to a fund for that very purpose, but so far without definite success, although the parties having it in hand have not given up all hope that they could obtain donations from various large systems, creating a fund and a special commission that would take this very subject in hand.

Mr. Moore:—Is this not a case in which the Lord will help those who help themselves? If we show ability to inaugurate and carry on such experiments, others who are interested in the experiments may be willing to contribute.

Mr. Schneider:—I am opposed to spending any of this Association's money for this purpose. I think the parties who should furnish the necessary funds should be those for whose benefit the experiments are made, viz., the railroad companies. If we spend our own time on committee work without hope of fee or reward, we are certainly contributing our share.

Mr. Robinson:—I think the railroads have done considerable in standing the expenses incident to the work of this Association. I believe that many of the roads are vitally interested in this proposition. I can see no reason why we cannot find a solution to this problem, and I am fully convinced that if the railways are approached properly in this matter, they will see that sufficient funds are provided to carry out those experiments. I am fully convinced that, when we know the exact effect of impact on our bridges, they can be so designed that a bridge with a ballast floor can be built which shall cost less money per running foot of span than the bridges we are building to-day—impact or no impact. I believe that the railroad companies will furnish all that is necessary over and above what the Association management feels that it can spare. I hope that the motion will go forward.

Mr. A. F. Reichmann (American Bridge Company):—I do not think it would be right for this Association to spend any large amount of money in determining an impact formula. There may be other sections of the Association that might call on us to spend money—for reinforced concrete, for example—for special experiments.

Mr. W. H. Finley (Chicago & Northwestern):—I very much question whether it would be wise to spend any amount of money in the attempt to determine the effect of impact on railroad bridges. There are so many factors entering into the question that I am satisfied it would be impossible to deduce any rational formula from such experiments. The condition of the track at each end of the bridge, the counterbalancing of the locomotive and the condition of the piers would all tend to change the result in structures otherwise identical. As an academic proposition it no doubt possesses some interest, but I do not believe that any series of experiments would cause us to regret the allowances we have made to cover this contingency in the past, or seriously change our present practice.

Mr. Schaub:—I would like to amend the motion, in view of what Mr. Robinson said. I do not think it is right for this Association to spend its surplus, for the reasons stated by Mr. Reichmann—there are other committees in this Association that may want to have the surplus spent for them in making experiments. It seems to me that Mr. Robinson has the right view of the matter—that if the railroad companies are approached in the proper way, they will be willing to meet the Association and provide the funds necessary to carry on the experiments; and unless some experiments are made, we will never make any progress in regard to this question of impact. If I may be permitted to make an amendment to the motion, I will move that it is the sense of this meeting that this question be referred back to the Committee to ascertain whether it is possible to obtain funds by the method suggested by Mr. Robinson; that is, in approaching the railroads interested in the question, and carrying on a series of experiments by the Committee itself, and report their results by means of progress reports, from time to time, to this Association.

Mr. Moore:—My motion was, in substance, perhaps not in form, that this matter be referred back to the Committee, with the request that they initiate experiments which shall determine the facts of this question, and that the Board of Direction be authorized in their discretion to furnish funds for this purpose. I think the movement, after we inaugurate it, will get very general support. It may be that we shall begin only on a very modest scale. We can certainly spare the three thousand dollars which Prof. Turneaure mentions, and after that is spent, the railroad companies, when they see the experiments inaugurated and in responsible hands, and under the auspices of this Association, will be much more likely to take the matter up than they would if we had not begun, so that it appears to me that the motion as I originally made it is in correct form.

Mr. Schaub:—If Mr. Moore will put it in shape so as to leave it at the discretion of the Board of Direction as to where the funds are to come from, I will withdraw my amendment.

Mr. Moore:—I should leave the Board of Direction with ample discretion in that matter, only I should wish some instructions from the Association that they do something to inaugurate these experiments.

Mr. Churchill:—I would suggest as an amendment to Mr. Moore's motion that this Committee be authorized to make an estimate of how much these experiments would cost, charged up against the railroads according to mileage, and that they be authorized to write each railroad represented in the Association and ascertain if each railroad will not stand its proportion of the cost on a mileage basis—it would probably not cost more than five or ten cents a mile from each railroad to carry out this whole work. I feel quite sure the company I represent will stand for it, and I think any other railroad will, as it will be a small sum for each railroad, after all.

Mr. Loweth:—The result of the amendment would be to put off this work for another year.

Mr. Churchill:—I do not think it would. I am simply giving the means to secure more than three thousand dollars.

Mr. Loweth:—It would not be possible to make an estimate, place it before the railroad companies and accomplish much before the next convention. It seems to me it could be well combined with the previous motion, and, if it is feasible to do that, I would suggest that Mr. Churchill and his second withdraw the amendment and Mr. Moore include it in his motion.

Mr. Moore:—I am somewhat at a loss to see how that can be done. My own thought is not to exclude the railroads; in fact, I think they ought to join in it, and I feel sure they will join in it. My thought is that they will be more apt to join in the undertaking after the Association starts it—even in a tentative and limited way. Prof. Turneaure mentioned the sum of three thousand dollars as an amount which would be sufficient to begin the experiments, and I feel sure that the railroads would take it up. I cannot conceive of any state of mind in which they would decline to take it up if it was presented to them by such a body as this. But I think this Association should begin the work, and therefore it is more for the purpose of having the experiments begun that I feel disposed to insist on a vote on my motion as originally put, not excluding the further motion afterward that the Committee call for such assistance from the railroads as they may think best.

Mr. Snow:—We seem to be talking a good deal about really what is not going to amount to anything, I am afraid. I will take you into my confidence a little and tell you that what you are talking about is exactly what the Committee are intending to proceed to take up, but you are forcing our hands a little by this way of getting at it. We have not considered the matter in Committee as yet, but we have hope before leaving Chicago to consider the matter, and we were intending to see if the Board of Direction would appropriate any money for the purpose. If they will not appropriate the money we will try to find it somewhere else. It seems to me, if you will leave the whole matter for us to work out, we can accomplish what you are trying to get at. We should not expect the Board of Direction to appropriate this money unless it was wise in their judgment to do it. It looks to me, in the light of what has been said, that it might be opening the door to trouble in the future. I assure you, without any compelling motion or anything of that sort, the Committee will do the best it can to carry out the very thing Mr. Moore suggested when he started.

Mr. Moore:—I am glad to hear that expression from the Committee and will take great pleasure in withdrawing my motion and leaving the whole matter in the hands of the Committee and the Board of Direction—with the explanation Mr. Snow gives, I cheerfully do that.

Mr. A. S. Baldwin (Illinois Central):—I think Mr. Churchill made a practical suggestion in regard to this matter. It is desirable that experiments of this kind shall be carried on. It is practically impossible that the Association should furnish the funds. If we leave it to-night with the understanding that it be left to the Board of Direction as to whether or not this money will be furnished from the funds of the Association, we can take it as a foregone conclusion, from the sentiment expressed so far, that it is not going to be done. By way of getting an estimate of the cost of this, suppose we take an outside figure, say, five thousand dollars, and put it up to the railroads to furnish that amount of money pro rata, with the understanding that if the Association is able to show in another year that these experiments are valuable and further experimentation is needed, they will call on the railroads for a further appropriation. The sum will be relatively small, and I believe the railroad companies will furnish it. I think, however, that the Board of Direction should take that up with the railroad companies, and believe they will get results which will establish a precedent which will be valuable for us to have established. The railroad companies are the direct beneficiaries of these experiments, and this Association, in the years to come, can do most valuable work in the way of getting appropriations from railroad companies for just such experimental work, and I believe you will be able to do it.

Mr. McDonald:—I desire to make a motion in lieu of all other motions, that the Committee be requested to inaugurate as soon as possible and push to an early completion an exhaustive series of experiments on the subject of impact, and to submit, as the result of such experiments, a formula for impact; and further, that the Board of Direction be requested to provide the necessary means for such experiments in such manner as it may deem advisable.

Mr. Schneider:—As a member of the Committee upon whom the duty will devolve to make the experiments, I will ask Mr. McDonald about how much time he is going to give us?

Mr. McDonald:—As much time as necessary—the motion does not prescribe any time limit.

Mr. Schneider:—Judging from my own experience, it will take many years and thousands of experiments before any practical results can be obtained. The conditions under which these various experiments have to be made are so variable that after many years of labor we may obtain some rough approximations, which perhaps will be no closer than those which we already have, excepting that they will cover a greater variety of cases and conditions.

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Mr. McDonald:—I do not think it is to the interest of this Association to consider this question for five or six hours each year, and even if it takes ten years, the sooner we begin the better.

(The motion of Mr. McDonald was carried.)

The President:—The question of impact having been settled temporarily, we will proceed with the balance of the Committee report. The changes in the remainder of the report are such that they can be disposed of very quickly.

Mr. Snow:—"(115) Rivet Holes.—When general reaming is not required, the diameter of the punch shall not be more than one-sixteenth-inch greater than the diameter of the rivet, nor the diameter of the die more than one-eighth-inch greater than the diameter of the punch. Material more than three-quarters-inch thick shall be sub-punched and reamed or drilled from the solid."

(The paragraph was adopted.)

Mr. Snow:—"(116) Punching.—All punching shall be accurately done. Drifting to enlarge unfair holes will not be allowed. If the holes must be enlarged to admit the rivet, they shall be reamed. Poor matching of holes will be cause for rejection."

(The paragraph was adopted as read.)

Mr. Snow:—"(117) Sub-punching and Reaming.—Where general reaming is required the punch used shall have a diameter not less than three-sixteenth-inch smaller than the nominal diameter of the rivet. Holes shall then be reamed to a diameter not more than one-sixteenth-inch larger than the nominal diameter of the rivet."

(The paragraph was adopted.)

Mr. Snow:—"(118) Reaming after Assembling.—Reaming shall be done with twist drills, after the pieces forming one built member are assembled and firmly bolted together. If necessary to take the pieces apart for shipping and handling, the respective pieces reamed together shall be so marked that they may be reassembled in the same position in the final setting up. No interchange of reamed parts will be allowed."

(The paragraph was adopted.)

Mr. Snow:—"(119) Burrs.—The outside burrs on reamed holes shall be removed."

(The paragraph was adopted.)

Mr. Snow:—"(120) Edge Planing.—Sheared edges or ends shall, when required, be planed at least one-eighth-inch."

(The paragraph was adopted.)

Mr. Snow:—"(126) Connection Angles."—We have changed this paragraph to read: "Connection angles for floor beams and stringers shall be flush with each other and correct as to position and length of girder. In case milling is needed or required after riveting, the removal of more than one-sixteenth-inch from their thickness will be cause for rejection."

(The paragraph was adopted.)

Mr. Snow:—"(132) Field Connections.—Holes for floor beams and stringer connections shall be sub-punched and reamed with twist drills to a steel templet one inch thick. Unless otherwise allowed, all other field connections shall be assembled in the shop and the unfair holes reamed, and when so reamed the pieces shall be match-marked before being taken apart."

(The paragraph was adopted.)

Mr. Snow:—"(133) Eye-bars."—We have changed this paragraph to read: "Eye-bars shall be straight and true to size, and shall be free from twists, folds in the neck or head, or any other defect. Heads shall be made by upsetting, rolling or forging. Welding will not be allowed. The form of heads will be determined by the dies in use at the works where the eye-bars are made, if satisfactory to the engineer, but the manufacturer shall guarantee the bars to break in the body when tested to rupture. The thickness of head and neck shall not vary more than one-sixteenth-inch from that specified. (See 160.)"

(The paragraph was adopted as amended.)

Mr. Webster:—Referring to Mr. Theodore Cooper's recent paper, showing the permanent elongation in pin holes at loads much below the elastic limit, it is desirable to have some information from the Committee, as there is a variance in the present specification. Some state that an excess in the head of 30 per cent. is satisfactory, and others that 40 per cent. is required. I would like the Committee at a later date to report to the Association as to their views on the excess in the head. They have not covered that point except in a general way.

Mr. Snow:—The Committee will be glad to take that subject up in detail in its next report.

"(134) Boring Eye-bars.—Before boring, each eye-bar shall be properly annealed and carefully straightened. Pin holes shall be in the center line of bars and in the center of heads. Bars of the same length shall be bored so accurately that, when placed together, pins one-thirty-second-inch smaller in diameter than the pin holes can be passed through the holes at both ends of the bars at the same time without forcing."

(The paragraph was adopted.)

Mr. Snow:—"(135) Pin Holes.—Pin holes shall be bored true to gages, smooth and straight, at right angles to the axis of the member and parallel to each other, unless otherwise called for. The boring shall be done after the member is riveted up."

(The paragraph was adopted.)

Mr. Snow:—"(143) Pilot Nuts.—Pilot and driving nuts shall be furnished for each size of pin, in such numbers as may be ordered."

(The paragraph was adopted.)

Mr. Snow:—"(144) Field Rivets.—Field rivets shall be furnished to the amount of 15 per cent., plus ten rivets in excess of the nominal number required for each size."

(The paragraph was adopted.)

Mr. Snow:—"(154) Starting Work in the Shop.—The purchaser shall be notified well in advance of the start of the work in the shop in order that he may have an inspector on hand to inspect material and workmanship."

(The paragraph was adopted.)

Mr. Snow:—"(157) Shop Plans.—The purchaser shall be furnished complete shop plans."

(The paragraph was adopted.)

Mr. Snow:—"(158) Shipping Invoices.—Complete copies of shipping invoices shall be furnished to the purchaser with each shipment."

(The paragraph was adopted.)

Mr. Snow:—"Section XI. Full-sized Tests. (159) Tests to Prove Workmanship.—Full-sized tests on eye-bars and similar members, to prove the workmanship, shall be made at the manufacturer's expense, and shall be paid for by the purchaser at contract price, if the tests are satisfactory. If the tests are not satisfactory, the members represented by them will be rejected."

(The paragraph was adopted.)

Mr. Snow:—In regard to paragraph 160, which takes the place of the one amended last year by vote of the Association, we have considered it as well as we are able; we have had considerable discussion over the amendment and we present the version as printed in Bulletin 71 as the best we can do. It is as follows:

"(160) Eye-bar Tests.—In eye-bar tests, the fracture shall be silky, the elongation in 10 ft., including the fracture, shall be not less than 15 per cent., and the ultimate strength and true elastic limit shall be recorded. (See 133.)"

(The paragraph was adopted.)

Mr. Khuen:—I would like to go back to paragraph 132. In the second part of the paragraph it says, "Unless otherwise allowed, all other field connections shall be assembled in the shop and the unfair holes reamed, etc." This is not specific enough. When a contractor is asked to bid on this specification, he cannot fix his shop cost unless he can cover himself for the assembling of this work in the shop, and that adds considerably to the cost. It seems to me this should be stated as follows: "If the assembling of the field connection in the shop is specifically called for in the invitation to bid, all other main field connections shall be assembled in the shop and the unfair holes reamed, and when so reamed the pieces shall be match-marked before being taken apart."

Mr. Snow:—This indefiniteness almost necessarily occurs in various places in the specification, where it is necessary to allow for a difference in practice. The fact has been called to the Committee's attention quite recently that this indefiniteness rendered the specification non-workable under certain conditions. I can see very clearly that it is so. For instance, if a General Manager of a railroad puts out this specification to a bridge company to build a bridge by, there are a number of points left open. It has been under contemplation to pick out all these elective features, as you might call them, and try to group them in some way so that they would have to be referred to specifically by the buyer of the bridge. The matter has not been under consideration by the Committee long enough so that we are able to formulate anything for your consideration that is satisfactory to us. I feel that we must beg your permission to leave the specification as it is until we can segregate these features and put them in some sort of shape to present to you. It is a harder subject than appears on the surface. The Committee would like suggestions from the floor in regard to this matter—whether it would be preferable to make two independent specifications or have a single specification, fixed, definite and precise, and then have something in the nature of an addendum, perhaps, covering these clauses that are optional, with a statement in the front part of the specification calling attention to them, stating that the buyer must make his decision on those points before putting the specification into the hands of competitive bidders. The specification, if used by the engineer who designs his own bridges, is all right; he does not need any definition, but its use by competitive bidders rather calls for modifications.

Mr. Schneider:—In view of the fact that many of the discussions on these specifications have come in too late to be properly considered by this Committee, and in view of the fact that many members on the floor have made motions regarding subjects to be referred back to the Committee for consideration, we fear our work is not quite completed, and for that reason I would make a motion that the report be referred back to the Committee, with the request that the Committee report to the Association at the next annual meeting.

The President:—The chair desires to say that if this motion carries, it will exclude these specifications from publication in the Manual of Recommended Practice.

Mr. Condron:—The specifications for material and workmanship have, I believe, been incorporated in the Manual of Recommended Practice, as they were laid before us a year ago. I do not know whether Mr. Schneider intends by his motion to have them withdrawn entirely from the Manual or whether he only meant that no amendment to that specification be adopted at this time.

Mr. Schneider:—Mr. Condron made a motion requesting this Committee to consider certain questions in reference to quality of material.

Mr. Condron:—I only want to have it made clear, if the Committee had in mind that that should be withdrawn.

Mr. Schneider:—The Committee does not feel as if its work was completed.

Mr. McDonald:—I hope the motion of the gentleman will not prevail, on account of the fact that the questions which have provoked the most discussion have been referred back—that is the question of impact and the question of increasing the ultimate strength of structural steel. There seems to have been no other questions, except those which have been left to the proprietor to decide before he submits the specification to the contractors, and I think if the Committee will rewrite the sentences in which the words in italics appear, or put a footnote at the bottom as to which of these sentences are optional and must be decided beforehand, then the specification will be in shape with the exception of the two paragraphs which have already been referred back to the Committee.

Mr. Webster:—As I understand it, the first part of the specifications have been accepted to-night, and if Mr. Schneider will withdraw his motion, I will move that the second part be accepted also. We appreciate that the specifications are in better shape than they were a year ago. The Committee has done good work, and the members of the Association should be able to avail themselves of that work, it being understood there may be modifications a year hence; but it would be a great mistake not to publish the specifications as they now are. Footnotes can be put in the report, saying that certain matters are now being considered. I hope Mr. Schneider will withdraw his motion.

Mr. Moore:—I appreciate very highly the value of the work of this Committee. I think while we acknowledge it is not in all respects complete, in very many respects it is as complete as such work can be. It is work which from the very nature cannot be finished up forever; but I think that in the form in which it is, with such footnotes as are necessary, it would be of great value to every member of the Association, and that therefore the report should be published.

Mr. Loweth:—I am partly in accord with Mr. Schneider's motion and partly in accord with what has been suggested. I believe inasmuch as the second part of the specifications have already been printed in the Manual of Recommended Practice, that the second part of the specifications as revised by the Committee may well go into the Manual of Recommended Practice again; but I would be in favor of referring back to the Committee to report a year hence the first part of the specifications. If it is in order, I move to amend the previous motion to that effect.

The President:—Mr. Webster is correct. The first part of the specifications were adopted by the Association as read. It will, therefore, be necessary to reconsider the action of the convention before we can take a vote on Mr. Schneider's motion or any other motion.

Mr. Webster:—If the Committee desires to reconsider that as a whole, I have no objection.

The President:—The second part has not received official endorsement; the first part has.

Mr. Schneider:—I withdraw my motion as far as the first part is concerned.

Mr. Webster:—Mr. Schneider having withdrawn his motion, I move that the second portion of the Committee report be accepted as read.

Mr. Snow:—It strikes me the only difficulty here is in printing this specification in pamphlet form, as we now have it with these manifest defects in it. I wonder if we could have permission to cure these defects, and then print the specification without formal vote of the Association, which, of course, could not be had until a year from now?

Mr. Webster:—Why not? When it is printed, let the Committee say they have considered the points referred to it, and their action is as follows. We can put that to a vote now. We want to make progress, and if the Committee does good work, we want to get the use of it.

Mr. Schneider:—As a member of the Committee, I am not very anxious to have the Association adopt our report at this time. The specifications are printed in the Bulletin and can be used in their present shape by those who wish to do so, with perhaps some individual modifications.

Mr. Reichmann:—In reference to bringing up these points in the convention as to what shall be used in certain contracts, that is merely a matter of transposing the specifications, and I do not see why the Association should object to permitting the Committee separating the different clauses.

Mr. Snow:—If we are at liberty to do that, I do not see any objection to accepting Mr. Webster's motion.

(The motion of Mr. Webster was carried.)

Mr. Reichmann:—I move that the Committee be authorized to transpose the specifications in such manner as to avoid any ambiguity as to workmanship by separating the different grades of workmanship.

Mr. Loweth:—I think the convention ought to instruct the Committee as to whether this clause calling for the highest character of workmanship shall be left in the specification or put in the addendum. Shall we write our specification for the cheapest quality of work and put the better quality of work in the addendum, or vice versa?

Mr. Snow:—I hope that question will be left to the Committee. It is a knotty question and hard to decide offhand.

The President:—I think a question of that kind can best be left to the Committee and to the Publication Committee, without changing the sense of the specification passed. They may want to clarify the construction of some of the sentences or put in some notations explanatory of the text.

Prof. W. D. Pence (Purdue University):—Is it not a fact that during the past year, in the preparation of the Manual of Recommended Practice, the Board of Direction has felt authorized to have such editorial revision and recastings made as would make the Manual presentable as a unit, and would not this come under that head?

The President:—It would, and that is the idea in mind. There are some slight changes to be made on page 5 of the Committee's report, which will take but a few moments.

Mr. Snow:—The Committee has changed the title to the introductory from the 1905 version to read as follows: "Recommended Practice in Contracting for Steel Railroad Bridges."

The second paragraph has been changed to read: "That it is preferable to invite bids on a pound price basis; and, if desired, alternate bids may be asked for the work, f o. b. cars, and for the work erected. That a lump sum bid is inadmissible, unless general detail plans and specifications are furnished."

The fifth paragraph has been changed to read: "That it is preferable in all cases that the railroad company furnish and lay the floor timber."

(The changes were adopted as read.)

The President:—We have completed the consideration of the report, and will relieve the committee with the thanks of the association.

REPORT OF COMMITTEE NO. XI.—ON RECORDS, REPORTS AND ACCOUNTS.

To the Members of the American Railway Engineering and Maintenance of Way Association:

Your Committee received notice of its appointment on May 19, 1905.

Three general meetings of the Committee have been held. The attendance was very poor. During the past year the railroads have been very busy and the members of the Committee have generally excused themselves from work on the ground of being too busy.

The first meeting was held at the office of the Association in Chicago, August 9, 1905. In a three-hour conference in regard to the work it was decided to address a circular letter to the important railroads of the country, requesting information in regard to the different subjects under discussion by the Committee. A number of replies were received to this circular, but the majority of roads, including the largest systems, failed to forward the information desired.

The second meeting of the Committee was held October 14, 1905, in Philadelphia, Pa., at the office of the Chief Engineer of the Philadelphia & Reading Railway.

The entire work of the Committee was considered and on account of the members of the Committee being so widely separated geographically, it was decided to refer the different subjects to sub-committees, as follows:

Ledger Accounts: J. B. Austin, Jr., Paul Jones.

System for Office Records of Bridges: V. D. Simar, B. T. Elmore.

Conventional Signs for Right-of-Way Maps: R. L. Huntley, W. Archer.

Progress Profiles: E. K. Woodward.

Track Charts: J. G. Bloom.

The third meeting of the Committee was held at the office of the Association in Chicago on December 21.

The several meetings were attended by Edwin F. Wendt, chairman; J. E. Turk, E. K. Woodward and J. B. Austin, Jr.

BRIEF REVIEW OF REPORT OF 1905.

The general purpose of the last report was to review, revise and supplement all matter adopted previous to that time and considered suitable for publication in the Manual of Recommended Practice.

The conclusions adopted by the Association give the clearest idea of the nature and extent of the report. These conclusions are contained in the Manual of Recommended Practice, pp. 83-121, inclusive, and are also printed in Vol. 6, page 656, as follows:

CONCLUSIONS.

(1) The following standard forms are considered essential and recommended as the special forms for a regular working Maintenance of Way Bridge Department:

Report of Foreman of Bridges..............	M.W. 1000,	Vol. 5,	page 247
Monthly Bridge Material Report............	M.W. 1001,	" 5	" 249
Foreman's Diary, Bridge Department........	M.W. 1002,	" 5	" 251-5
Bridge Department Tool Report.............	M.W. 1003,	" 5	" 258
Structure Report	M.W. 1004,	" 5	" 262
Current Bridge Inspection Report...........	M.W. 1005,	" 5	" 266
Summary Current Bridge Inspection Report..	M.W. 1006,	" 5	" 268
General Bridge Inspection Report...........	M.W. 1007,	" 5	" 272-3

(2) In Bridge Inspection there should be a clear distinction made between Current Inspection and General Inspection. The purpose of the Current Inspection is to keep the structure in safe condition, to promptly discover any defects and to report the same promptly, so that repairs can be made before the safety of the structure is affected. It is important that a simple record should be made while at the bridge and that the superior officer be kept advised of all such inspections promptly, whether made by a Bridge Mechanic, Gang Foreman, Division Bridge Inspector, Master Carpenter or others.

The purpose of the General Inspection, frequently called the annual inspection, although in many cases conducted semi-annually or even quarterly, is not only to check the maintenance work of the division organization, but to make a more careful investigation of important bridges and structures on the entire road, and, further, to ascertain and settle what extensive repair work or renewal work should be done in the following working season.

(3) The general forms of the railroad should be used in all departments, including Bridge Department, as far as applicable, for example, one form for reporting time should be used in all departments, the form being designed accordingly.

(4) Bridge records, when properly kept up to date in an accurate manner, will prove of the highest value to railroads and are essential for any system of complete and proper bridge records. However, forms

in connection with bridge records are not specially necessary for a Bridge Department, but are necessary generally for the compilation of records for several departments, and hence these forms are not recommended as standard special Bridge Department forms.

(5) Numerous minor special forms are used on all railroads for reporting information necessary to keep bridge records up to date, but such forms should be regulated by each individual railroad according to its peculiar requirements, and hence no standard forms for this purpose are recommended.

(6) Duplicate copies of Record Books and maps, particularly right-of-way maps, should be kept in quite widely separated localities, so that the trouble and expense of reproducing the same will be greatly reduced in case of fire or accident.

(7) Records.—Records consist of information or data in graphical, tabular or statement form, relating to the physical characteristics, condition, cost and such other information as may seem desirable for record.

(8) Reports.—Reports consist of the medium through which information is transmitted from a subordinate official to a higher official and from which records and accounts are prepared or compiled in the filing office.

(9) Accounts.—Accounts cover all statements required to enable payments to be made for labor performed and material furnished and all statements necessary in order to establish the detail, total and comparative cost of work and various classes of expenses.

(10) The "General Labor Report" or "Time Book" form, M.W. 1008, is recommended as a standard form for use by all employés or working gangs in a Maintenance of Way and Structure Department.

(11) The "Monthly Track Material Report," form M.W. 1009, containing the necessary information for keeping a proper check on material received and used, is recommended as a standard form.

(12) Right-of-Way Maps should be prepared and kept in general in accordance with form M.W. 1010, which is recommended as a standard form for Right-of-Way Maps.

In connection with the illustration of Right-of-Way Maps, the following descriptive matter should appear:

"Maps showing right-of-way in cities and boroughs should be drawn to a scale of 100 ft. to one inch. Maps showing right-of-way outside of municipalities may be drawn to a scale of 400 ft. to one inch. They should be prepared, generally, as shown in the illustration. They should be made in separate sheets for convenient handling, and the width of sheets as a rule should not exceed 18 in. The length of sheets will be determined generally by the size of the printing frame.

"Right-of-way sheets may be preserved in one of three ways:

"(1) The sheets may be bound together into an atlas.

"(2) They may be bound loosely in board covers so that the sheets may be easily removed and corrected and replaced.

"(3) They may be preserved as separate sheets and filed in regular order."

(13) The custodian of deeds should keep a Register of Title Deeds in accordance with form M.W. 1011, which is recommended as a standard form for Register of Title Deeds.

Under the head of "Register of Title Deeds" should appear the following descriptive matter:

"Deeds are filed with the Chief Engineer, the Real Estate Agent or the Secretary of a railroad company, according to individual practice.

"The Custodian of Deeds should keep a register of Title Deeds in accordance with the form illustrated.

"Deeds should be numbered consecutively, No. 1, 2, 3, etc., in the order of their receipt by the railroad company; then forwarded to the proper officer to record on right-of-way maps; then returned by the Chief Engineer to the Custodian of Deeds with notation thereon that the deed has been properly entered, after which all deeds should be filed in numerical order in a fireproof vault."

(14) The Custodian of Leases should keep a Contract and Lease Record Book in accordance with form M.W. 1012, which is recommended as a standard form for a Contract and Lease Record Book.

Under the head of "Contract and Lease Record Book" should appear the following descriptive matter:

"The Custodian of Leases should keep a Contract and Lease Record Book, containing in the body of the book a full record of the lease in accordance with the form illustrated.

"In the back part of the book twelve pages for the twelve months should be ruled into columns for years.

"Leases should be numbered and filed in numerical order, by road, branch or division in a fireproof vault.

"Immediately after the receipt of a lease it is entered in the body of the book, the lease number should be entered under the year on the proper month page when it expires.

"The names of the lessees should be indexed alphabetically in the front of the book, and each lease should be indexed by the station name.

"A few pages in the back of the book should be used for the purpose of keeping a record of the leases removed from the files."

REVISION OF MANUAL OF RECOMMENDED PRACTICE.

On April 3, 1905, President Kelley issued a circular requesting the members of the Association to criticise the definitions which had been adopted at the last convention.

On page 83 of the Manual appears a definition of the term "Reports:" "Reports consist of the medium through which information is transmitted from a subordinate official to a higher official and from which records and accounts are prepared or compiled in the filing office."

Mr. Hunter McDonald, Past-President, suggests that the first three words be cut out and Mr. H. J. Slifer suggests that the wording "subordinate official to a higher official" be changed to read "one to another official." The definition with the changes will read:

"Reports.—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."

On page 83 of the Manual is also printed the definition of the word "Records:" "Records consist of information or data in graphical, tabular or statement form relating to the physical characteristics, condition, cost and such other information as may seem desirable for record."

Mr. Hunter McDonald suggests that the first three words be omitted. The definition will then read:

"Records.—Information or data in graphical, tabular or statement form relating to the physical characteristics, condition, cost and such other information as may seem desirable for record."

On the same page appears the definition of the term "Accounts:" "Accounts cover all statements required to enable payments to be made for labor performed and material furnished, and all statements necessary in order to establish the detail, total and comparative cost of work and various classes of expenses."

Mr. Hunter McDonald suggests the following revision:

"Accounts.—Statements required to enable payments 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."

The Committee has approved the above changes and is exceedingly anxious to obtain from the members further information in regard to the other subject matter contained in the Manual of Recommended Practice.

GENERAL PURPOSE OF REPORT OF 1906.

The general purpose of the present report is to consider the subjects of Records, Reports and Accounts under five sub-headings as follows:

(1) Ledger Accounts for Individual Pieces of Work.

(2) System for Maintenance of Way Office Records of Bridges and Culverts.

(3) Recommended Standard Conventional Signs for Right-of-Way and Topographical Maps.

(4) Progress Profiles.

(5) Track Charts.

HISTORICAL.

The Committee has no historical matter to submit in connection with the above subjects. It is very difficult to trace the origin and development of forms, methods or practices in regard to the subjects under discussion. For previous historical matter see Vol. 5, pp. 243 and 244, and Vol. 6, pp. 633, 666 and 667.

LEDGER ACCOUNTS FOR INDIVIDUAL PIECES OF WORK.

Definition: "Statements kept in ledger form in order to establish the detail, total and comparative cost of any particular work or class of expenses."

In 1903, the position of the Committee in regard to Ledger Accounts was as follows:

"There being no agreement among maintenance engineers, regarding the value of Ledger Accounts, the Committee feels justified in taking the position that the record of cost of annual maintenance for each individual structure is desirable and will prove valuable information if accurately and continuously kept for a long term of years, but does not think such information is absolutely essential and, therefore, no special blank or form for the purpose is recommended for adoption. (See Vol. 5, page 229.)

"It is recognized that the Division Engineer, or Assistant Engineer or Engineer of Maintenance of Way will wish more detailed information than is given to the Accounting Department, for the reason that he has to keep track of the cost of the work and equip himself to furnish estimates of the cost of future work. . . . . The Chief Engineer's office will desire additional information not required by the Accounting Department in the way of records, and reports of the different Supervisors of Track, Buildings, Bridges, Signals and Water Supply should always be designed to furnish the information desired by these higher officers without multiplying the number of the reports. . . . . Unit costs of work are essential in any system, according to which statements and appropriations must be made before work can be undertaken, as the unit cost of the executed work under known conditions is practically the only basis on which a correct estimate of proposed work can be made."

(See Vol. 5, pp. 263 and 264.)

There is a general agreement among both constructing and maintenance engineers that the record of unit costs is essential information for the guidance of officers who estimate and authorize new work. The objection to any system of Individual Ledger Accounts is based not on principle but rather on the failure of the railroads to insure accuracy in the accounts. The general principle underlying the system is certainly correct and since the information derived from these accounts is considered essential, it is worth while to insist on accuracy and to outline an organization of the engineer's office, which will bring about the desired result. The objection based on expense is not well taken, because, if the principle is correct, the practice should conform thereto.

The replies received to the circular of the Committee indicate a variable practice and the Committee has undertaken to outline a simple system under which such accounts may be kept at reasonable cost. An agreement as to principle having been reached, the problem is to outline a system which can be used by all railroads at an expense commensurate with the results. The Committee has heretofore taken a definite stand in regard to a system for the preparation of Reports and Accounts for the information of superior officers.

According to this system the original data is sent through the various channels to the office of the Assistant Engineer, Engineer Maintenance of Way or Division Engineer, and the clerical force of that office compiles the records and reports and accounts for superior officers. This is the most economical and efficient system known to the Committee. For a more detailed account of this system see Vol. 3, pp. 388, 396 and 405; also Vol. 5, page 351, remarks of Mr. W. C. Cushing; also Vol. 6, pp. 636 and 651, of the Proceedings.

In connection with any system of Individual Ledger Accounts two special forms are required, the first being known as Repair Authority Blank, or Requisition for Improvement, or Approval of Authority of Expenditure, or Order for Construction and Repair Work; and the second being known as the Ledger.

The information collected by the Committee indicated that all railroads follow a system which requires the Engineer to estimate the cost of proposed additions or improvements and to submit this estimate to the executive officer for his approval of authority for the expenditure, in connection with Additions, Betterments or Improvements.

The Committee recommends Authority form known as M.W. 1013, which is illustrated herewith. Such a form is practically a requisition for authority to expend money for improvements. It shows in detail the estimate of the cost of the proposed work, as prepared by the Chief Engineer or his representative, and is signed by the executive officer in charge of improvements and is addressed to the officer who will have charge of the work.

Size 8 x 13 inches. Form M. W. 10 13

A. B. & C. R. R. CO.

ENGINEERING DEPARTMENT.

*APPROVAL OF AUTHORITY OF EXPENDITURE.

No._______ Chicago, Ill., ______________________19___

Mr.______________________________

____

DEAR SIR:—

Authority for the following expenditure is hereby approved:

Amount of expenditure $__________________

Chargeable to____________________________ $___________

____

Location : ____

Description : ____

Estimated cost in detail :

____

(Title of approving officer.)

ORIGINAL STRUCTURE, ETC. (REPLACED).

Estimated Cost of :______________________________________

Will be used { for____________________________
at ____________________________
present valuation____________________________ }

Will be dismantled, material valued at____________________________

REMARKS.

*See amendment, page 281.

The second form required in connection with Ledger Accounts is the Ledger, which should be of convenient size, of simple design and yet sufficiently comprehensive to give in moderate detail the items of the cost of the work. The book would be composed of loose leaves and the number of leaves would be in accordance with the special requirements of a particular railroad. Form M.W. 1014, illustrated herewith, is recommended.

SYSTEM FOR MAINTENANCE OF WAY OFFICE RECORDS OF BRIDGES AND CULVERTS.

In considering this subject it has been clearly kept in view that, for the present purpose, the report deals with a Maintenance Office and not a Construction Office. The two offices may be combined or separated as the case may be, but the system followed in the Maintenance Office will have features peculiar to itself.

The Committee gave some study to this same subject in former years. (See Vol. 3, pp. 361-366.)

An important feature of any system of office records of bridges is that pertaining to the care and filing of the plans. A most complete description of the card index system in this respect may be found in Vol. 3, pp. 366-375. Interesting data in regard to office bridge records may also be found in Vol. 5, pp. 235, 236, 237, 238, 243, 245, 275 to 284. The report of 1905 in Vol. 6 contained no subject matter in connection with this subject. Illustration of the forms used by the Nashville, Chattanooga & St. Louis Railway, in connection with office records of bridges, trestles and culverts, may be found in Vol. 5, pp. 365, 366 and 367.

Many of the forms received from the railroads, in reply to the circular of the Committee, relate to the record of monthly bridge inspections and are not illustrated in this report.

In Vol. 5, page 280, appears an illustration of a trestle record form, also on page 277 a form to be used in connection with the record of amount and character of bridges, trestles, culverts and other structures. This form seems more applicable to the compilation of information for use in the preparation of reports for the State and Interstate Railroad Commissions.

On page 275 appears a form used by the Southern Pacific Company in the Maintenance of Way Department for the purpose of ascertaining the condition of bridges, viaducts and trestles on a definite date.

On page 281 of the same volume appears a form for use in connection with the office record of bridges, the same having been prepared by

Size 14" x 17"

Form M. W. 1014

Authority No 99

A. B. & C. R. R. Co.

RECORD OF COST OF WORK.

Sheet No. 1

DESCRIPTION: Freight Car Repair Shop.

LOCATION: McKees Rocks, Pa.

2 3/4"	3/4"	3/16"	5 5/8"	3/4"	3/4"	3/16"	3/8"	3/8"	3/16"	3/8"	3/8"	3/4"

the Committee in 1903 and included in the report as an illustration, but not as a recommended form.

A number of forms have been received in reply to the circular of the Committee. They show the present practice of a number of the large railroads of this country. The practice is decidedly variable in detail but is singularly uniform in its aim to obtain the desired results. It should be kept clearly in mind that the subject under consideration is "System for Maintenance of Way Office Records of Bridges and Culverts."

The present report has no reference to a system for recording the results of bridge inspections. This subject was very carefully considered in former reports and the Association adopted the essential forms to be used, which are as follows:

Current Bridge Inspection Report......................Form M.W. 1005
Summary Current Bridge Inspection Report............Form M.W. 1006
General Bridge Inspection Report......................Form M.W. 1007
(See Manual of Recommended Practice, pp. 98-103.)

Any complete system of office records of bridges includes two features:

(1) A record of the design of bridges.

(2) A record of the present condition of bridges as shown by periodical inspections.

The present report deals with the first feature, viz., office records of the design of bridges.

The term "Bridges" should be interpreted broadly, to include all structures other than buildings, i. e., structures under the roadbed supporting the traffic. Any office system for recording bridges will apply equally as well to trestles and culverts.

The ideal system for maintenance of way office records of bridges and culverts would be as follows:

(1) The Chief Engineer, or other officer having in charge the design and care of bridges, trestles and culverts, should keep on file in his office complete plans of every structure showing all its details, its location and the physical characteristics of the territory within a reasonable distance of the structure.

(2) When changes in the design of any structure are made a record of the changes should be reported to the head office and the record plans should be at once brought up to date.

(3) Division officers, having in charge the maintenance of bridges, should keep on file in their offices blue prints of the general and detail plans of all bridges, and these prints should be furnished from the office of the Chief Engineer or other officer in charge of the design.

(4) Photographs of the record tracings of bridges may be prepared and furnished to division or other officers for use in the field. These photographic copies would be of standard sizes and bound in atlas form.

(5) The record of the condition of bridges should be kept in the office in accordance with the system outlined in the Manual of Recommended Practice, pp. 98-103.

A careful consideration of the entire subject leads to the conclusion that the system above outlined will insure the most complete, accurate and satisfactory results at the lowest reasonable cost. The proposed system is based on the principle that the Chief Engineer's office, should, at all times, have on file complete, up-to-date plans of bridges, giving all necessary information for any purpose; and the further principle that division officers require and should keep for their information, copies of the same plans. Incomplete information is frequently very misleading. The man in charge of the care of bridges, wants at times, information in regard to every detail of structure and the only way to obtain this information is from the record plans. The above system also contemplates the use of photographic copies in the field, which can be made at reasonable cost and which will give original and complete information in a convenient form for actual use while on the road.

The above system is ideal and complete because it includes an accurate record both of the design and present condition of bridges. No special forms or blanks are required in connection with this system other than those already published in the Manual and none are recommended.

RECOMMENDED STANDARD CONVENTIONAL SIGNS FOR RIGHT-OF-WAY AND TOPOGRAPHICAL MAPS.

Definition: "Conventional Signs.—Symbols, such as a mark, character, abbreviation or letter selected or sanctioned by general agreement and used to indicate upon a map or plan certain forms, conditions and objects, both natural and structural."

The idea in the mind of the Board of Direction in assigning this subject to the Committee was that it would be proper to endeavor to standardize the signs for various purposes on right-of-way and topographical maps, such as Center Line; Right-of-Way limits; Water Stations; Various Classes of Buildings; Nature of Ground, whether woody, swampy, etc.; Class of Material, such as steel, cast-iron, wood, masonry, concrete, etc., similar to what the Government and some railroads have already standardized. Several technical journals and some newspapers have adopted standard conventional signs and ask their correspondents and others in preparing plans for publication to use such signs.

The list of recommended signs for the Maintenance of Way Association should not be too elaborate, but should rather be limited to the most important signs that all railroads necessarily must use. The data collected by the Committee is valuable and shows a general practice in respect to Conventional Signs, but the field has not been fully explored by the Committee and additional data should be collected before any recommendation is finally made. On this account the Committee submits for the information of the Association such data as has been collected and suggests that the subject be referred back to the Committee for further study next year.

The data collected include illustrations of the signs used by the following railroads:

Nashville, Chattanooga & St. Louis Railway.
Central Railroad of New Jersey (2 illustrations).
New York Central & Hudson River Railroad.
Norfolk & Western Railway.
Canadian Pacific Railway.
Illinois Central Railroad.

Also Circular No. 2 of Illinois Central Railroad, which relates to the standard sizes of plans and conventional signs. Also the standard requirements for drawings of Pennsylvania Lines West of Pittsburg.

PROGRESS PROFILES.

Definition: "Progress Profile.—A graphical record of the progress of work prepared at stated periods."

An appendix to this report will be printed in the next Bulletin; it will contain the replies to the circular of the Committee. The information received shows that the majority of railroads have no standard Progress Profile.

The Committee recommends for adoption and publication in the Manual of Recommended Practice form M. W. 1015, illustrated herewith, to be known as Standard Progress Profile. The illustration has been taken from the Progress Profile of the Canadian Pacific Railway; it shows the progress of all classes of work, including grading, masonry, superstructure, track, and accessories. The recommended form is very complete and speaks for itself.

TRACK CHARTS.

Definition: "Track Charts.—A diagram showing the physical characteristics of track and roadbed."

It is probably correct to say that all railroads have some form of a Track Chart. Many are very simple and give only information relating to rail, ballast, alinement and grades.

A complete Track Chart should show all the physical features of the road which are of interest to operating officers, such as Superintendents, Trainmasters, Master Mechanics, Assistant Engineers, Supervisors, et al. The form illustrated by the Committee, known as M.W. 1016, was received from the Pennsylvania Lines West of Pittsburg and is considered to be the best example of a Track Chart known to the Committee. It gives all the information which an operating officer may possibly want and is in convenient form to be carried in the pocket, on the private car or in the office.

The purpose of a Track Chart is to enable an operating officer to know at once, wherever he may be, in the office or on the road, whether physical characteristics of the road may be affecting operation and maintenance. The form submitted by the Committee fulfills this purpose and it is recommended for adoption and publication in the Manual of Recommended Practice.

Committee on Records, Reports and Accounts.

STANDARD PROGRESS PROFILE.

STANDARD TRACK CHART.

page 83
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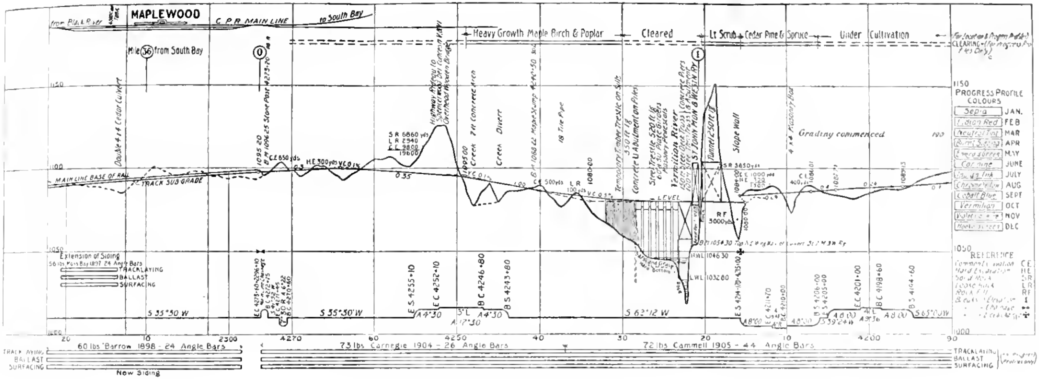
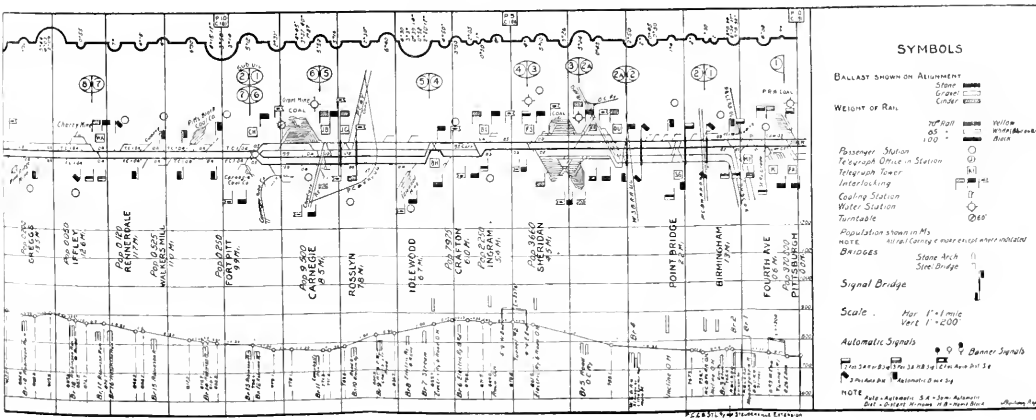


STANDARD PROGRESS PROFILE.



STANDARD TRACK CHART

CONCLUSIONS.

(1) The Committee recommends that the definitions on page 83 of the Manual of Recommended Practice be revised to read as follows:

"Records.—Information or data in graphical, tabular or statement form relating to the physical characteristics, condition, cost and such other information as may seem desirable for record."

"Reports.—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."

"Accounts.—Statements required to enable payments 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."

(2) The Committee recommends for adoption and publication in the Manual of Recommended Practice the following additional definitions:

"Ledger Accounts for Individual Pieces of Work.—Statements kept in ledger form in order to establish the detail, total or comparative cost of any particular work or class of expenses."

"Conventional Signs.—Symbols such as a mark, character, abbreviation or letter selected or sanctioned by general agreement and used to indicate upon a map or plan certain forms, conditions and objects, both natural and structural."

"Progress Profile.—A graphical record of the progress of work prepared at stated periods."

"Track Chart.—A diagram showing the physical characteristics of track and roadbed."

(3) Ledger Accounts with Individual Pieces of Work, showing the detail, total, comparative and unit costs of work are essential in any system, according to which statements and appropriations must be made before work involving Additions and Betterments can be undertaken; therefore Ledger accounts should be kept by the Maintenance of Way Department showing the cost of authorized work.

Two special forms are required in a simple system of Individual Ledger Accounts:

M. W. 1013, "Approval of Authority of Expenditure."

M. W. 1014, "Individual Ledger."

Illustrations of these forms accompany the report.

(4) No special forms are required in a proper system of Maintenance of Way Office Records of the design of bridges and culverts. Such records should be kept in accordance with the following system:

(a) The Chief Engineer, or other officer having in charge the design and care of bridges, trestles and culverts, should keep on file in his office complete plans of every structure showing all its details, its location and the physical characteristics of the territory within a reasonable distance of the structure.

(b) When changes in the design of any structure are made a record of the changes should be reported to the head office and the record plans should be at once brought up to date.

(c) Division officers having in charge the maintenance of bridges should keep on file in their offices blue prints of the general and detail plans of all bridges, trestles and culverts, and these prints should be furnished from the office of the Chief Engineer or other officer in charge of the designs.

(d) Photographs of the record tracings of bridges should be prepared and furnished to division or other officers for use in the field. These photographic copies would be of standard sizes and kept in atlas form.

(e) The record of the condition of bridges should be kept in accordance with the system outlined in the Manual of Recommended Practice, pp. 98-103.

(5) The Committee makes no recommendation in regard to Conventional Signs, except that the subject, after being discussed by the convention, be referred back to the Committee for further study and report.

(6) A profile showing complete information respecting the rate of progress of work pertaining to the different features of a railroad is necessary, and the standard "Progress Profile," form M. W. 1015, herewith illustrated, is recommended as good practice.

*(7) A Track Chart showing complete information respecting the grade, alinement and other physical features of a railroad is necessary, and the "Track Chart," form M. W. 1016, herewith illustrated, is recommended as good practice.

The Committee recommends for adoption by the Association and for publication in the Manual of Recommended Practice, conclusions Nos. 1, 2, 3, 4, 6 and 7.

Respectfully submitted,

EDWIN F. WENDT, Assistant Engineer, Pittsburg & Lake Erie Railroad, Pittsburg, Pa., *Chairman.*

W. S. KINNEAR, Assistant General Manager, Michigan Central Railroad, Detroit, Mich., *Vice-Chairman.*

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* See amendment, page 281.

W. Archer, Assistant Real Estate Agent, Baltimore & Ohio Railroad, Cincinnati, O.

J. B. Austin, Jr., Engineer Maintenance of Way, Long Island Railroad, Jamaica, N. Y.

J. G. Bloom, Engineer of Maintenance, Chicago, Rock Island & Pacific Railway, Topeka, Kan.

B. T. Elmore, Assistant Chief Engineer, Tidewater Railway, Norfolk, Va.

R. L. Huntley, Chief Engineer, Union Pacific Railroad, Omaha, Neb.

Paul Jones, Superintendent, Cincinnati & Muskingum Valley Railroad, Zanesville, O.

V. D. Simar, Acting Chief Engineer, Duluth, South Shore & Atlantic Railroad, Marquette, Mich.

J. E. Turk, Superintendent, Philadelphia & Reading Railway, Tamaqua, Pa.

E. K. Woodward, Principal Assistant Engineer, Wabash Railroad, St. Louis, Mo.

H. A. Woods, Assistant Chief Engineer, Grand Trunk Pacific Railway, Montreal, Canada.

Committee.

AMENDMENTS.

Amend title of blank form to read: "Approval of Authority for Expenditure."

Conclusion 7:—"A Track Chart showing complete information respecting the grade, alinement and other physical features of a railroad is necessary, and the 'Track Chart,' form M.W. 1016, herewith illustrated, except the conventional signs, which are subject to the later action of the convention, is recommended as good practice."

APPENDIX.

Supplementing its report published in Bulletin 72, your Committee on Records, Reports and Accounts submits herewith a summary of replies received in answer to requests for information on the subjects of Ledger Accounts for Individual Pieces of Work; System for Maintenance of Way Office Records of Bridges and Culverts; Recommended Standard Conventional Signs for Right-of-Way and Topographical Maps; Progress Profiles, and Track Charts.

LEDGER ACCOUNTS FOR INDIVIDUAL PIECES OF WORK.

Illinois Central Railroad, A. S. Baldwin, Chief Engineer.

"We have in use a system of authority blanks covering maintenance work on bridges and waterways. The system consists of a formal authority issued from this office covering work other than regular maintenance work. Each authority bears a specified number, and as they are issued, record is made of the amount of the authority in a book provided for that purpose, and the division officers report at the close of each month to the Auditor of Disbursements the amounts expended on each authority during the month. These are consolidated in the Auditor's office and the total amount expended transmitted to this office as soon thereafter as possible, by the Auditor. When this statement is received from the Auditor it is entered in the before-mentioned book, sheets from which are enclosed.

"The benefit received from individual ledger accounts is to enable a sufficient amount of supervision to be kept on expenditures to prevent division officers from overrunning their accounts. It would be impracticable to do without this, I believe, on construction authorities and it is of great value as a check on repair authorities, also."

Philadelphia & Reading Railway, W. Hunter, Chief Engineer.

"Division Superintendents keep a memorandum book of individual pieces of work, made up from the reports of the Supervisors and Section Foremen. These items are collected, showing the cost of the particular work done, as per requisition (form herewith). Under the Account heading, 'Improvement Expenditures,' they are reported to the Auditor of Disbursements.

"On the General Ledger only the one account is kept, 'Improvement Expenditures' (sample page of Ledger herewith).

"A sample page (marked B) of book record kept by Auditor of disbursements, which is classified according to 'Account Headings' per classification of Improvement Expenditures, Nos. 250-262, pp. 42-44, of book of instructions, etc., in effect July 1, 1903, which classification also appears on form 2005-1. Requisition for Improvements and authority for same (see sections 34 and 35, pp. 120-124, of book above referred to, and to form 2005-2) giving detail of expenditures per record of Division Superintendent, which is based on the report in detail of Supervisor and Section Foremen.

"The above account, 'Improvement Expenditures,' does not include the cost of constructing new or branch lines, extensions of existing lines, expenditures for additional rolling stock or marine equipment, nor improvements that may have a special earning power. There may be items of work involving questions of financial policy as to whether they should be charged to Capital Account in accordance with the usual classification of Construction Expenses, or whether the property of the road should be improved out of current earnings and charged to operating expenses, under account, 'Improvement Expenditures,' other than to merely keep up the general standard of efficiency; these are disposed of according to the direction of the management and are charged to specific accounts as may be arranged."

Nashville, Chattanooga & St. Louis Railway, Hunter McDonald, Chief Engineer.

"Except in the case of an improvement or betterment, no ledger accounts are kept of any individual piece of work. Such accounts for improvements and betterments are kept in the office of the Comptroller, the entries showing the dollars and cents and the sources of the charge, such as payroll, store house, road stock, etc.

"I am unable to submit a sample page, but it contains no special feature.

"We formerly kept individual accounts of all bridges and trestles on the road, but after 10 years' experience have concluded that it is not worth while to do so. Our present practice is to keep a complete record of all work done on each structure, on the forms for bridges, trestles and culverts, copies of which are enclosed. No effort is made to keep account of the dollars and cents. The price of material and the efficiency of labor vary with the demand therefor. The record of the cost of the work in the past is therefore of little value for work in the future, and I know of no other use to which individual accounts could be kept."

Louisville & Nashville Railroad, W. H. Courtenay, Chief Engineer.

"Itemized accounts are kept by the Accounting Department of the cost of the work. I submit a specimen page showing how charges are made. Charges for such work as that shown are posted to our General Ledger. This is followed by details of the cost of individual work in a book which is called Detail Ledger. The specimen submitted is a copy of a page from the Detail Ledger.

"The benefit derived from such accounts is to enable us to check the cost of work. It is often important to know long after a certain piece of work has been completed what the cost was, and the detail of the cost."

El Paso & Southwestern System, H. J. Simmons, General Manager.

"We do not keep ledger accounts at present for individual pieces of work."

Chicago & Northwestern Railway, F. H. Bainbridge, Asst. Chief Engineer.

"All accounts of the Chicago & Northwestern Railway are kept by the Division Superintendents under the direction of the Accounting Department."

Canadian Pacific Railway, F. P. Gutelius, Engineer of Maintenance of Way.

"It is not the practice on this railway to keep Ledger Accounts in the engineering offices. These accounts are kept by the Superintendent's Accountant and monthly statements, showing amounts expended on each piece of work are furnished by the Accountant to the Resident Engineer. This system seems to be satisfactory and we would not recommend ledger accounts in the engineering office."

Pennsylvania Lines West of Pittsburg, Southwest System, W. C. Cushing, Chief Engineer Maintenance of Way.

"Structure reports showing detail of material used and cost of labor are prepared by the foreman in charge of each particular piece of work on which he was engaged during the month. The reports are approved by the Master Carpenter or Master Mason and forwarded to the office of Engineer Maintenance of Way on completion of work, or at the end of the month if the work is not completed during the current month.

"The cost of material is placed on reports in office of the Engineer and charges are then entered in the Ledger in brief detail under appropriate captions, together with other charges which do not appear on structure reports, but originate from shop bills, accounts payable and other sources handled direct in the office of the Engineer Maintenance of Way. After being entered in the Ledger, structure reports are filed by months for future reference. Sample page of Ledger submitted herewith.

"On the Pittsburg Division, individual Ledger Accounts have been found a very valuable adjunct to our records, especially on account of the numerous changes in the personnel of the office force. They furnish a permanent and ready reference that gives necessary details of cost of any important work done and forms a reliable precedent for estimating cost of future work of a similar nature.

"I consider that the benefits derived from individual accounts greatly exceed the expense of recording them."

Louisiana Western Railroad, E. B. Cushing, General Superintendent.

"It is our practice to keep a detailed record of cost of all individual pieces of work chargeable to Construction and Improvement Accounts, also to jobs chargeable to Operating Expenses, in excess of $100.00. This record is kept in an ordinary stock Journal and all charges to different jobs are posted in same monthly. On pieces of work where this record is kept, work order (form 2449, sample attached) is prepared by the department under whose supervision the work is to be done. After said work order has been approved by the General Superintendent, it is forwarded to the Auditor, who keeps a detail of all charges against each job. The benefits received from individual Ledger Accounts are commensurate with the expense in a number of respects, as follows:

"It induces a more careful accounting for material and labor expended by those supervising the work as they may be required to explain abnormal difficulties between the estimated and actual cost.

"It affords the Accounting Department a closer check on the reports of material and labor expended.

"It places a permanent record carrying a detail exhibit of cost of each job within easy access of the management."

Boston & Maine Railroad, J. P. Snow, Bridge Engineer.

"Ledger Accounts for individual pieces of work are not kept except in cases where such work is charged to Construction or Improvement Account. In these cases the items are drawn off on sheets monthly, during the progress of the work, and reported to the General Auditor. Construction work is done under special appropriations and the above charges are checked against the appropriations.

"The cost of sidetracks built for outside parties are ledgerized in a general book where an account is kept separately for each such track.

"The benefit of keeping individual ledger accounts, except as above, is not commensurate with the expense involved under the Boston & Maine system of accounts."

Central Railroad of New Jersey, Jos. O. Osgood, Chief Engineer.

"The present practice is to keep the details of the various classes of work in our Construction Ledger and on completion of the work a final bill is rendered showing the cost of each subdivision of work, viz.: Grading, Tracklaying and Surfacing, Handling, Material, etc.

"Benefit received from individual ledger accounts is that the cost of any particular branch of the work may be determined during the progress, as well as total cost to any date, and the benefit is without doubt commensurate with the expense."

Pennsylvania Railroad, Joseph T. Richards, Chief Engineer of Maintenance of Way.

"With respect to Ledger Accounts, I would say that all detailed records of individual pieces of work are kept by the Comptroller in the

Accounting Department, making it unnecessary for anyone else to keep a duplicate record, particularly for the reason that a copy of the monthly C. & E. List, showing items of work authorized, the amount of the appropriation and the amount spent to date is furnished each General Superintendent. You understand, of course, that we keep a copy of all bills, together with a copy of our statements of charges for labor, etc., which are in addition to charges originating in the shape of bills."

Norfolk & Western Railway, Charles S. Churchill, Chief Engineer.

"We do not keep what may be strictly called Ledger Accounts. We advance the records, however, as far as what might be termed a Journal and these records are left in such shape that we can at any time secure the cost of any piece of work. Form C. T. 70, enclosed, shows the manner in which an authority for the expenditure of money is issued by this road, whether it be a charge to Construction or Betterment, or a charge to Operating Expenses. This sheet covers an authority issued in 1904 for an Electric Turning Gear at one of our bridges, and at the bottom of the sheet the actual cost of the work has been filled out with the month of completion. While we think it is very important to have record of cost of individual pieces of work we doubt the expediency of going much further into Ledger records than we do. We think that it is very important to determine promptly the cost of any piece of new work and our accounts are kept so that we are able to do this."

SOUTHERN PACIFIC COMPANY.

ORDER FOR CONSTRUCTION AND REPAIR WORK.

HOUSTON, TEXAS, ________________ 190__. No. _______

SIR:

Authority for the following work on the plant of this company has been given.

Date authorized ________________ Number _______

Work to be done under the direction of ______________________________

Division ________________ Estimated cost ___________

Location ____

Description ____

____
Engineer of Maintenance of Way.

Approved:

____
Manager.

Illinois Central Railroad Company. No. R 3850

OFFICE OF CHIEF ENGINEER.

Chicago, Ill., ______________ *190*__

REPAIR AUTHORITY BLANK.

____
SUPERINTENDENT

Authority is hereby given to do the following work on ______________ *Division at an estimated cost of $* __________. *Charge to maintenance account* ______________

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____
CHIEF ENGINEER

Illinois Central Railroad Company, No. R 3850

OFFICE OF CHIEF ENGINEER.

Chicago, Ill., ______________ *190*__

REPAIR COMPLETION REPORT BLANK.

____
CHIEF ENGINEER

The following work authorized at an estimated cost of $ __________ *has been completed at an actual cost of $* __________ *Final charge made in month of* __________ *19*__ ______________

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SUPERINTENDENT

Illinois Central Railroad Company. No. R 3850

OFFICE OF CHIEF ENGINEER.

Chicago, Ill., ______________ *190*__

REPAIR AUTHORITY BLANK.

____

____

Authority is hereby given to do the following work on ______________ *Division at an estimated cost of $* __________. *Charge to maintenance account* ______________

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Illinois Central Railroad Company. No. R 3850

OFFICE OF CHIEF ENGINEER.

Chicago, Ill., ______________ *190*__

REPAIR AUTHORITY BLANK.

____
AUDITOR OF DISBURSEMENT

Authority is hereby given to do the following work on ______________ *Division at an estimated cost of $* __________. *Charge to maintenance account* ______________

____

____

____

____
Assistant CHIEF ENGINEER

Philadelphia & Reading Railway Company.

_______________ Division _______________ Branch

REQUISITION FOR IMPROVEMENTS.

Description.

Location.

Estimated Cost in Detail.

Total, $

Expense of work to be borne by _______________ $_______
_______________ $_______

Remarks:

Correct.	Examined.	Approved.
Date________ 19___	Date________ 19___	Date________ 19___
No.________	No.________	No.________
________ Supt.	________ Gen. Supt.	________ First Vice-President.

NOTE—This form, in triplicate, must be submitted promptly on receipt of authority for any item of new work, renewals, or improvements, as per section 35 of Accounting Instructions.

For Real Estate, give location, description, etc.

For Tracks and Sidings, give length in feet of track, grading, ties, rails, track fastenings, etc., in detail.

For Bridges, give location, description, and cost of engineering, substructure, superstructure, etc.

For Buildings, give location, description, and cost of construction, drainage, curbing, paving, etc., but not including portable furniture.

Philadelphia & Reading Railway Company—Continued.

IMPROVEMENT EXPENDITURES.

	CLASSIFICATION OF ACCOUNTS.		Total.	
A	Real Estate			
	Tracks and Sidings			
B	Extension of Main Tracks			
C	Second, Third and Fourth Tracks			
D	Meeting and Lay-off Sidings			
E	Colliery and Washery Tracks			
F	Yard and Depot Tracks			
G	Coal Yard Tracks			
H	Manufactory Tracks			
I	Shop, Turntable and Scale Tracks			
	Bridges, Trestles and Culverts			
J	Wooden			
K	Steel and Iron			
L	Stone			
M	Interlocking Plants and Signals			
N	Passenger Stations and Shelters			
O	Freight Stations and Yards (exclusive of tracks)			
P	Water and Fuel Stations			
Q	Shops and Engine Houses			
R	Docks and Wharves			
S	Turntables, (exclusive of tracks)			
T	Coal Yards (including trestles of same)			
U	Shop Tools			
V	Sundries			
...	...			
	Total			

ORIGINAL STRUCTURE, ETC. (REPLACED).

Estimated cost of ____________

Will be used { for ____________ / at ____________ / present valuation ____________

Will be dismantled, material valued at ____________

REMARKS.

Form C F

NORFOLK AND WESTERN RAILWAY COMPANY

OFFICE OF GENERAL MANAGER.

APPROVAL OF AUTHORITY OF EXPENDITURE

An order on this form will be given for all work authorized.

All expenditures must be charged to the proper account and reference given to the President's or General Manager's number

AUTHORITY FOR EXPENDITURE Norfolk

President's No. 800

Gen'l Mgr.'s No.

Roanoke, Va., 2 May 1904

Mr C. S. Churchill,
Chief Engineer.

Dear Sir

Authority for expenditure of $ 5,000.00

chargeable to C.E.& B.Sus.Acct.No.12 as follows, is hereby approved

To install Electric Turning Gear for operating Bridge #7:

Electrical Transformers, Motors, Switch Board, Controller, &c.	$3,500.00
Four Miles Poles for Current	400.00
Gearing and Shafting	700.00
Platforms and Housing	200.00
Incidentals	200.00
	$5,000.00

Mr. Churchill will arrange for this.

Copy to:
A C N
J W C
W G M
J B L
E T B
W C W

Yours truly,

N D Maher
General Manager.

Amount Expended During Month of	C. and Equip. or Imp. and Bettr.	Operating Expenses	Total Amount Expended	REMARKS
July 1904	15.00		15.00	
August 1904	154.75		154.75	
September 1904	1275.00		1275.00	
December 1904	579.88		579.88	
January 1905	338.00		338.00	
February 1905	871.22		871.22	
March 1905	22.20		22.20	
April 1905	27.50		27.50	
May 1905	1708.20		1708.20	
GRAND TOTAL.	$4991.75		$4991.75	

Committee on Records, Reports and Accounts.

BRIDGE RECORD BLANKS.

BRIDGE RECORD, ILLINOIS CENTRAL RAILROAD.

DIVISION NO. ____ BRIDGE NO. ________ ________ MILES FROM ____________

ABBREVIATIONS: O—WHITE OAK; Y—YELLOW PINE; W—WHITE PINE; CR—CEDAR; CY—CYPRESS; B—BRICK; S—STONE.

STRUCTURE			OPENINGS			SUPPORTS					SWAY BRACES, COLLARS AND GIRTS				CAPS AND SILLS				STRINGERS				TIES				GUARD RAILS				IRON	INSPECTION AND ESTIMATES					DATE REPAIRS WERE COMPLETED	REMARKS
							Pile or Frame Bents																										Estimated Cost		Actual Cost			NOTE. Enter up, in RED, under Headings at Left, the Estimated Items for Repairs, and in BLACK the Amounts actually Used.
KIND	YEAR WHEN BUILT OR RENEWED	TOTAL LENGTH	NUMBER	LENGTH	MAX. HEIGHT (From Base of Rail)	MASONRY or BANK SILLS	Number of Posts in Each Bent	MATERIAL	SIZE	LENGTH	MATERIAL	NUMBER	SIZE	LENGTH	MATERIAL	NUMBER	SIZE	LENGTH	MATERIAL	NUMBER IN EACH PANEL	SIZE	LENGTH	MATERIAL	SIZE	LENGTH	DIST. SP. O. TO O.	MATERIAL	SIZE	DEPTH OF NOTCH	CLEAR DIST. FROM RAILS	Bolts, Washers, Drift Bolts, Spikes	Date Inspected; By Whom (initials)	$ LABOR	$ MATERIALS	$ LABOR	$ MATERIALS		

Illinois Central Railroad Company.

Form 1188

BRIDGE RECORD.

DIVISION NO.____ BRIDGE NO. ________ ________ MILES FROM ____________

ABBREVIATIONS: O WHITE OAK, Y YELLOW PINE, W WHITE PINE, CR—CEDAR, CY—CYPRESS, B BRICK, S STONE

STRUCTURE			CULVERTS						ARCHES								TUNNELS				OVERHEAD BRIDGES								INSPECTION AND ESTIMATES					DATE REPAIRS WERE COMPLETED	REMARKS
																							RAILROAD			HIGHWAY				Estimated Cost		Actual Cost			NOTE. Enter up, in RED, under Headings at left, the Estimated Items for repairs, and in BLACK the Amounts actually used
KIND	YEAR WHEN BUILT OR RENEWED	Total Length (Along Track)	MASONRY, WOOD OR PIPE	Cross Section of Openings (Dimensions)	LENGTH (Across Tracks)	NUMBER OF TRACKS	END WALLS	Elevation of Base of Rail Above the Bottom	STONE, BRICK OR CONCRETE	NUMBER OF OPENINGS	SPAN	LENGTH (Across Tracks)	Rise of Crown Above Spring Line	Dist. from Base of Rail to Crown	Elevation of Base of Rail Above the Bottom	NUMBER OF TRACKS	Stone, Brick or Timber Lining	IN EARTH OR ROCK	Clear Height Above Rail	Least Side Clearance from Center of Track	Number of Tracks Crossed	By Whom Built and by Whom Maintained	NAME OF RAILROAD	Clear Height Above Rail	Least Side Clearance from Center of Track	Clear Height Above Rail	Least Side Clearance from Center of Track	MATERIAL	Date Inspected; By Whom (initials)	$ LABOR	$ MATERIALS	$ LABOR	$ MATERIALS		

NORFOLK & WESTERN RAILWAY COMPANY. ____________ DIVISION.

STATEMENT OF REPAIRS, RENEWALS AND IMPROVEMENT OF BRIDGES AND CULVERTS FOR YEAR 189

Sheets.

Work Sheet No

Bridge No.	Kind	Length	Height	WORK TO BE DONE	ESTIMATES FOR IRON PIPES OR CULVERTS AND FILLING						Would Cost to Renew (If only part of a bridge is to be filled, this column shows cost to renew that part)	ESTIMATES FOR REPAIRS AND RENEWALS		REMARKS	Month Work is Completed	ACTUAL COST			REMARKS	Bridge No.
					Lin. Ft. of Bridging to be Filled In	Approximate Cubic Yards	Price per Yard Cts	Cost of filling taking out old timbers, extra Rip Rap, Etc.	Cost of Proposed Iron Pipe or Culvert	TOTAL COST		Cost of Proposed Repairs	Cost of Proposed Renewals			Labor	Material	Total		

SYSTEM FOR MAINTENANCE OF WAY OFFICE RECORDS OF BRIDGES AND CULVERTS.

Union Pacific Railroad, J. B. Berry, Chief Engineer.

"On the white sheets the book gives a record of each successive bridge that is built under a particular number. It has always seemed desirable for us to know just what has been at a certain point for some time past, as we are frequently called upon for information as to what was in existence there a number of years back.

"Another sheet is the report of work done by local parties, giving a sketch and information in regard to the work, and the third sheet is a statement of the cost. This statement is used later on to make a summary for use of the higher officers without so much detail."

Illinois Central Railroad.

"Attached are sheets showing system of reports covering the condition of bridges and culverts, which I believe will be self-explanatory."

Philadelphia & Reading Railway.

"The record of maintenance of bridges and culverts is kept in the same manner as the other items of Maintenance of Way and Structures, all of which is shown in detail on pages 8 to 15, in book sent you herewith, which also explains the method of accounting, forms of reports, their uses, etc."

Nashville, Chattanooga & St. Louis Railway.

"The bridge, trestle and culverts forms, sent with my answer under subject 'Ledger Accounts,' are the only records we keep. The information for entry on these blanks is furnished on form 577, herewith enclosed. Form No. 577 is also filed for record. Form No. 1477 is used for determining the cost of any special piece of work, and special instructions are generally issued for reporting on this form."

Louisville & Nashville Railroad.

"Records are kept on sheets provided for this purpose. A sample is attached (Form 963), for South and North Alabama Division. We keep no systematic record of culverts."

Canadian Pacific Railway.

"The enclosed sample sheets are taken from our Bridge Record. The original copy of these books is prepared by the Resident Engineer, the diagram sheet which is photographed and sufficient prints made from the negative to provide books for the various officers interested."

Pennsylvania Lines West of Pittsburg.

"We have on file in our office detail plans of all bridges of which there is any record. In addition to this some of the divisions are preparing a general plan of all the bridges, giving the general dimensions, type of bridge, character of foundation, date built and all information valuable in a bridge record. These sets will be bound in a Shipman binder and indexed for convenient reference. Sample copy of record enclosed. In addition we have a blank for report of Bridge Inspection, which is general over the entire system."

Boston & Maine Railroad.

"The maintenance of bridges and culverts is in the hands of the division officers. The Chief Engineer keeps the records of all bridges, culverts and crossings of all kinds, and is required to make periodical inspections of all openings. He handles all new construction and advises as to repairs of magnitude. The general record is described on page 360, Proceedings 1904, Vol. 5, as well as the schedules which are typewritten and distributed to such officers as need them. I enclose a sample page of these schedules marked 'Exhibit 1.' Our system of inspection, which is annual, is outlined on page 358, Vol. 5."

Central Railroad of New Jersey.

"Sketch plans of all bridges are made on which are shown the principal dimensions, together with information regarding data of building, loading etc., with reference to the detail plans on file. Whenever changes are made in the structure, they are noted on the sketch. These sketches have, to the present time, only been prepared for the steel and iron bridges, but similar methods will be used for making up records for masonry bridges and culverts."

Pennsylvania Railroad.

"The only record that we keep in this office of bridges and culverts is a list of the same giving data as to length of span and distance from base of rail to ground or water. Of course, the Division Master Carpenters keep a record of the repairs which they have made to individual bridges from time to time, but this record does not come to this office."

Norfolk & Western Railway.

"We keep a current record of work done on bridges on the enclosed form (M.W. 46). We have similar sheets to cover every bridge on the road, and when these are bound, constitute a record for the entire system as a convenient book of reference. Our work sheets, both for bridges and buildings, show at the beginning of each year the work to be done during the year. Sample sheets of these are also enclosed. Form M.W. 47 is a form on which we keep our record of culverts, pipes, etc. Report is made by each division on the road about November of each year, and shows the work to be done on same. The sheets are bound and kept in this office as a record of reference for the coming year and the work to be done is issued specifically to all the divisions. Form M.W. 53 is a form on which we receive reports of fencing built during the year, and we use the same form when bound to give a permanent record of existing fencing."

UNION PACIFIC RAILROAD COMPANY.

DETAILED STATEMENT OF BRIDGE OR CULVERT NO. 24.

.... District, ... Division

Number (old), ... Number (new), ... feet .... of Mile Post ....
Grade of track, per cent .... Tangent or degree of curve ....
Old structure .... Length .... Opening for ....
New structure .... Work Order No. ....

PILES: Kind .. Number per { bent .... pier .... abutment .... } ... Average penetration per { bent ..... pier .... abutment ... }
.... Date pile driving completed ....

MASONRY: Footings { Abutments .... Pier .... Arch .... End Walls .... } Walls { Abutments .... Pier .... Arch .... End walls .... }
Drawing No. .... Date masonry completed ....

TRESTLE: Length .... Bents .... Drawing No. ....
Sills, kind .... Size .... Posts, kind .... Size ....
Girts, kind .... Size .... Sway braces, kind ..... Size ....
Caps, kind .... Size ....
Stringers .... Number .... Size ....
Ties, kind .... Size .... Guard-rail, kind .... Size ....
.... Date trestle bridge completed ....

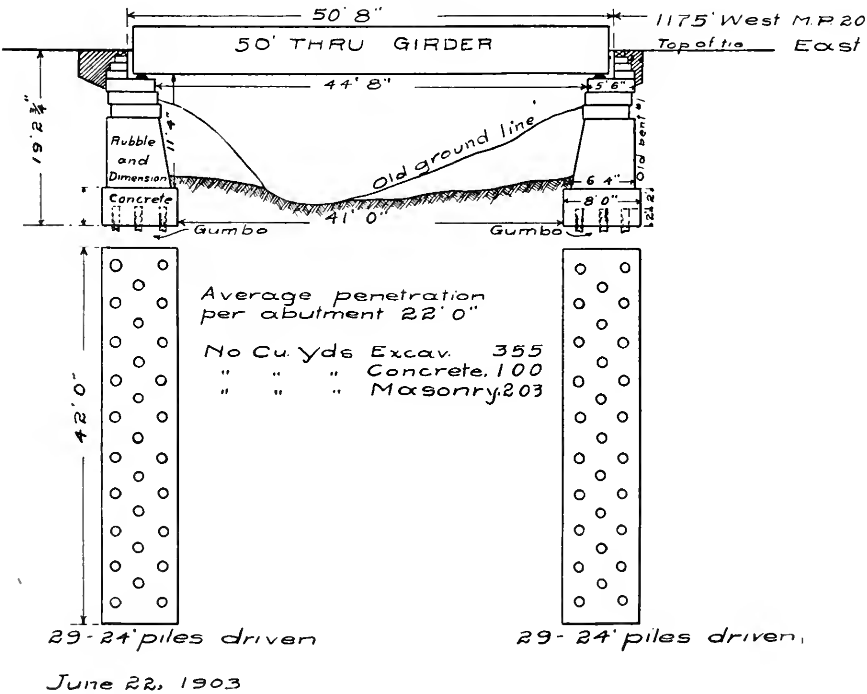
CULVERT: Kind .... Size .... Length .... Drawing No. .....
.... Date culvert completed ....

TRUSS OR GIRDER Kind .... Length .... Drawing No. .....
.... Date truss or girder placed ....

High water mark, measured from top of tie ....

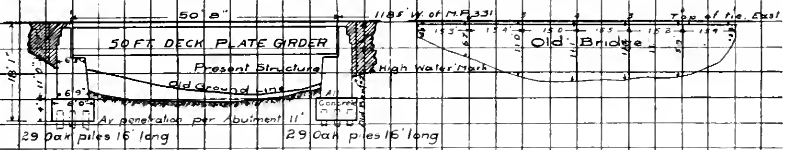
FILLING: Lineal feet of old bridge filled ...... Date filled ....

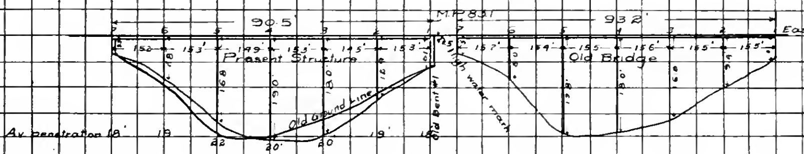
SKETCH.

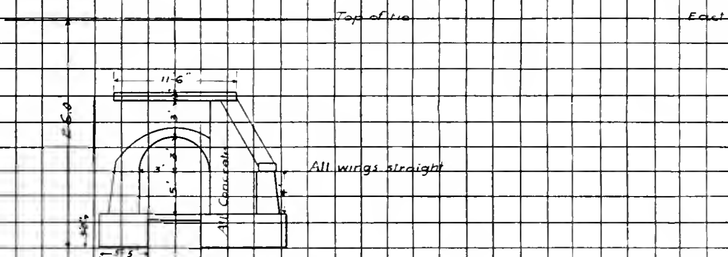


UNION PACIFIC RAILROAD COMPANY

Number and Location	When Built	Description	Length	Kind of Piles	Sills Size	Posts Size	Sway Braces Size	Caps Size	Stringers in Span No	Stringers in Span Size	Ties Kind	Ties Size	Guard Rails Size	Trusses Kind	Trusses No. of Spans	Trusses Length of Each	
211	~~June 1892~~	~~Pile Bridge~~	~~91.8'~~	~~Oak~~			~~3"x16"~~	~~12"x12" 14'~~	~~6~~	~~8x16~~	~~Oak~~	~~6"x8" 12'~~	~~7"x8"~~				
MP 331.1	Jan. 1901	Deck Plate Girder	50.7	Concrete abutments							Fir	8"x8" 10'	5"x8"	Deck Plate Girder	1	50'	
212	~~Aug 1893~~	~~Pile Bridge~~	~~93.2~~	~~Oak~~			~~3"x12"~~	~~12"x12" 14'~~	~~6~~	~~8x16~~	~~Oak~~	~~6"x8" 12'~~	~~7"x8"~~				
MP 83.1	Oct 1902	Pile Bridge	90.5	Cedar			3"x10"	12"x14" 12'	6	8"x16"	Fir	8"x8" 10'	5"x8"				
73	July 1900	6' Concrete Arch	103.0'	Drawing No. 6157													
MP 112.1																	


50' 8"
50 FT. DECK PLATE GIRDER
Present Structure
Old Ground Line
Old Bridge
High Water Mark
Top of tie. East
18' 1"
11' 0"
Av. penetration per Abutment 11'
29 Oak piles 16' long
29 Oak piles 16' long


90.5'
93.2'
East
Present Structure
Old Bridge
Old Ground Line
High water mark
Old Bent #1
Av. penetration 18'


Top of tie
East
11'-6"
All wings straight
All Concrete

Form 3003 A 7-21-04 2M

UNION PACIFIC RAILROAD COMPANY.

STATEMENT OF ACTUAL COST OF PERMANENT BRIDGE AND CULVERT WORK.

/Copy/ *Bridge No.* 697

Old Structure 3 Span Pile Bridge

New Structure 50 Ft Thro Plate Girder *Date Completed* March 1904.

Eastern *District.* Colorado *Division.*

CLASS OF WORK	QUANTITY	COST PER UNIT Labor	COST PER UNIT Material	COST PER UNIT Total	TOTAL COST Labor	TOTAL COST Material	TOTAL COST Total
Coffer Dams, Bailing and Draining							
Back Filling,					28.87		28.87
Excavation,	150 Cu. Yds.	0.192			143.24		143.24
Foundation Piles	800 Lin. Ft	0.3743	0.2226	0.5969	299.45	178.06	477.51
MASONRY:							
Dimensions,	14.7 Cu. Yds.	6.50	4.00	10.50	95.55	58.80	154.35
Rubble,	82.0 Cu. Yds.	3.96	3.43	7.39	324.47	281.77	606.24
Concrete,	80.0 Cu. Yds	2.60	3.50	6.00	208.00	280.00	488.00
Falsework,	Lin Ft.				41.25		41.25
Metal,	69083 Pounds			2.47		1707.45	1707.45
Erection,	69083 Pounds	0.335	0.074	0.409	231.87	50.83	282.70
G R & Bolts	$30.29						
*Train Service,	$60.62						
Removal of Old Structure,	Lin. Ft						
Total Actual Cost,					1372.70	2556.91	3929.61
Estimated Cost,					1440.00	2815.00	4255.00
~~Increase or~~ Decrease,					67.30	258.09	325.39

MEMORANDA

~~Company~~ Foreign freight charges included above, $ 94.35

STONE. From Rubble from Frey's quarry / Crushed from Rawlins Crusher / Dimension from Frey's quarry Quarry

Price -- Dimension 21.13 cents per foot

Rubble .72 per ton Concrete $1.00 per Cu. Yd.

CEMENT Kind Vulcanite No. of barrels used 67

Price $2.55 per barrel F. O. B.

CEMENT Kind Atlas No. of barrels used 67

Price $2.62 per barrel F. O. B.

SAND Price per obtained at bridge site

LABOR Wages of Foremen $110.00 per month, of Masons $3.50 per day, of Helpers $1.75 per day.

REMARKS Cause of decreased cost:
Less cost for falsework than estimated
Less cost for girder than estimated
Less cost for erection than estimated.
Cost of train service distributed under headings to which it belongs.

DATE. April 7, 1905. (Signed) T. J. Wyche Resident Engineer.

*Includes wages of conductors, brakemen, engineers, firemen and round house men, also cost of fuel, water, oil and waste and rental of outfit cars.

(24-3-05 6846)
3 Form 926 Eastern Division

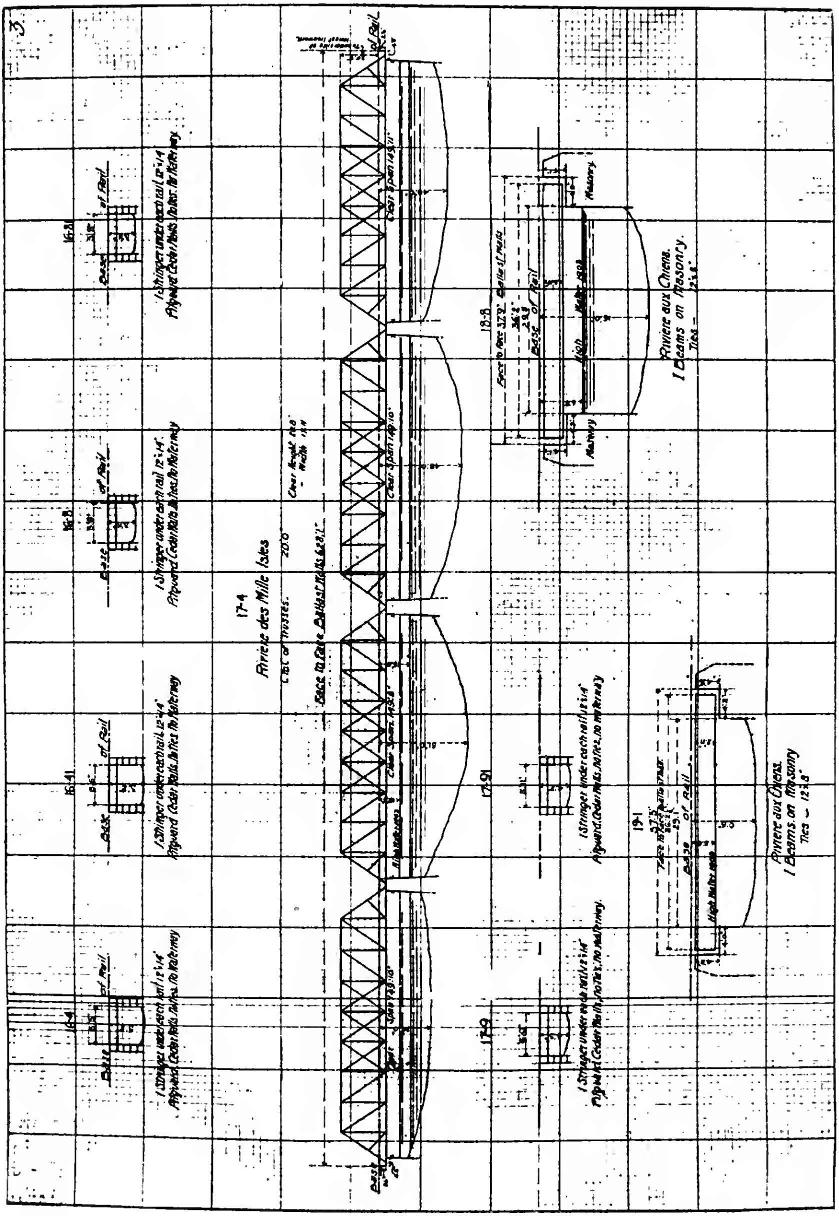
BRIDGES
CANADIAN PACIFIC RAILROAD COMPANY.

Ottawa

Form 926
Section or Branch

Bridge Number Old	Bridge Number New	Location	Length	Kind	Date Built		Cost Material	Cost Labor	Cost Total
	16.4	2286	7'6"	W C		Stringers on wood Pitguard No water			
	16.41	2287	7'5"	W C		Stringers on wood Pitguard No water			
	16.5		76'0"	S B		Dry stone box 3 x 3			
	16.7		53'0"	S B		Dry stone box 3 x 3			
	16.8	4275	7'8"	W C		Stringers on wood Pitguard			
	16.81	4333	7'10	W C		Stringers on wood Pitguard			
	16.9	4903	77'0"	S B		Dry stone box 3 x 3			
17 A	17.4	2347	638'1	I T	1884	Four spans Thro' trusses Edgemore Iron Co. St. Rose River. Riviere des Mille Isles			
	17.9	4793	7'7"	W C		Stringers on wood Pitguard No water Cote de Blainville			
	17.91	4852	8'0"	W C		Stringers on wood Pitguard No water.			
	18.0	278	46'5"	S B		Dry stone box 3 x 3			
	18.6	3260	23'0"	S B		Dry stone box 2 x 2			
18 A	18.8	4450	36'1"	DPG		Deck Plate Girder Toronto Bridge Co. Riviere aux Chiens			
19 A	19.1	511	37'5"	DPG		Deck Plate Girder Toronto Bridge Co. Riviere aux Chiens			
	19.3	1530	30'6"	S B		Dry stone box 3 x 3			
	19.9		116'0	W B		Wood Culvert St.Therese Yard 1-1/2 x 1-1/2			
	20.0		70'0"	W B		Wood box on skew 1 x 1			
	20.2		57'0"	S B		Dry stone box 3'6" wide 3' deep			
	20.9	4818	34'0"	S B		Dry stone box 3' x 3'			
	21.2	999	34'0"	S B		Dry stone box 3' x 3'			
	21.3	1820	37'0"	S B		Dry stone box 2 x 2'6"			
	21.5	2688	28'0"	S B		Dry stone box 2-1/2 x 2-1/2			
	21.6	3374	36'0"	S B		Dry stone box 2-1/2 x 3			

CANADIAN PACIFIC RAILROAD COMPANY. BRIDGE RECORD BOOK.



C. R. R. OF N. J.
CENTRAL DIVISION MAIN LINE
BRIDGE N° 28
AT Jefferson Ave Elizabeth

BUILT BY Pencoyd Iron Works

MATERIAL Soft Steel

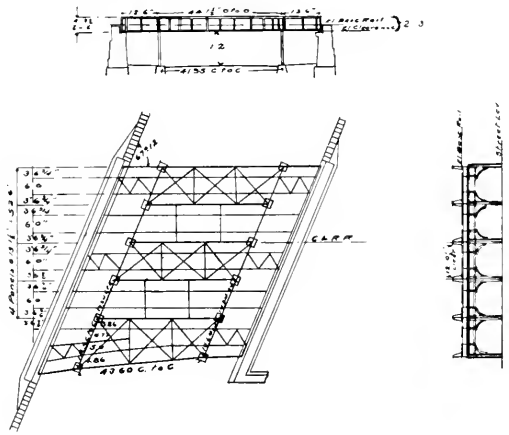
BUILT 1895

SPECIFICATIONS

ASSUMED DEAD LOAD

LIVE LOAD 2-126 ton Eng. foll. by 4000# per lin. ft. on each track

Bench Mark #IX
Steel Bolt-Top
S W Cor Back wall
W Abut. Bridge #26
Sta. 578+46 -38 8½
El 35 819



Scale 1" = 30

Detail Plans No 1013 A-3

9-29-03 H F

RECOMMENDED STANDARD CONVENTIONAL SIGNS FOR RIGHT-OF-WAY AND TOPOGRAPHICAL MAPS.

Illinois Central Railroad.

"Attached is sheet showing the Conventional Signs in use and a copy of Circular No. 2, giving instructions in regard to making drawings."

Philadelphia & Reading Railway.

"I am sending you a blue print of our standard Conventional Signs for use on Right-of-Way and Topographical Maps. This sheet is explanatory and it seems unnecessary to call special attention to any point or to describe any of it in detail."

Nashville, Chattanooga & St. Louis Railway.

"I enclose blue print No. 511-26 showing the only Conventional Signs in use on our lines. The only explanation which may be necessary is that they are made with a view of getting the best results when blue printed. When a location survey is put under construction one line is drawn on the side of the dots and when completed another line is drawn on the opposite side. The provision for showing fences on the property line may be of some interest. The letters "E. C." and "E. S." in the second column, indicate end of curve and end of spiral, in contradistinction to point of curve and point of spiral."

Pennsylvania Lines West of Pittsburg.

"This subject is answered in the accompanying small book of "Standard Requirements for Drawings."

Boston & Maine Railroad.

"I am sending you two sample location plans marked 'Exhibits 2 and 3,' which show all that we need on such plans, although they contain but few Conventionals."

STANDARD REQUIREMENTS FOR DRAWINGS—PENNSYLVANIA LINES WEST OF PITTSBURG.

SIZE OF DRAWINGS.

BRIDGE MASONRY.—Bridge Masonry drawings to be 16x21 in. out to out—15x19 in. inside the border, allowing 1½ in. on left hand margin for binding.

BRIDGE SUPERSTRUCTURE.—Bridge Superstructure drawings to be 24x 36 in. out to out—23x34 in. inside the border, allowing 1½ in. on left hand margin for binding.

"STANDARDS."—Pennsylvania Lines drawings of standard material, appliances, etc., to be 22x28 in. out to out—21x26 in. inside the border, allowing 1½ in. on left hand margin for binding.

ARCHITECTURAL DRAWINGS.—Architectural drawings to be 24x36 in. out to out, so far as possible, allowing 1½ in. on left hand margin for binding.

CONTRACTS R. E. D. AND L. D. FORMS.—Drawings to accompany contracts, agreements, Real Estate and Law Department forms, to be 8x14 in. out to out, allowing 1 in. at top for binding. Any additional width or length required shall be multiples of 7 in. and 13 in., respectively.

CORRESPONDENCE.—Drawings to accompany correspondence to be 8x10½ in., allowing 1 in. margin on left hand side and top for binding. Any additional width or length required shall be multiples of 7 in. and 9 in., respectively.

SIGNAL PLANS.—Signal plans to be 8x10½ in. or multiple thereof, out to out, including ½ in. margin all around.

PROFILES.—Profiles to be 11 in. wide. (This is obtained by cutting profile rolls on the middle line of ruling.)

ROLLED DRAWINGS.—Rolled drawings to be 20 in. wide whenever possible.

GENERAL.—In addition to the above sizes the following may be used for general maps and drawings: 10x16 in. out to out, and 15x19 in. out to out, allowing 1½ in. on left hand margin for binding.

TITLE.

PLACE.—The title to be placed in the lower right hand corner of each drawing. In addition, rolled plans and profiles shall have the subject and file number placed on the outside of both ends.

COMPOSITION OF TITLE.—Title to show the following:

"Name or initials of Railway Company."
"Division."
"Place."
"Description."
"Scale." "Date."
"Office where made."
"Initials of Draughtsman."
"Number."

In addition to the above the word "Exhibit A," etc., shall be placed over the title of all drawings which accompany contracts, deed descriptions, agreements, legal documents, etc.

SCALE.

MASONRY AND BUILDING PLANS.—Masonry and Building plans shall generally be to scale of ⅛-in. or ¼-in. equal to 1 foot. Details to be shown by larger scales.

MAPS.—Maps shall generally be to scale of 1 in. equal to 50 feet, 100 feet, 200 feet or 400 feet, as required to fit standard sizes of drawings, or to clearly illustrate the subject.

BRIDGE SUPERSTRUCTURE.—Bridge superstructure plans shall generally be to scale of 1/8-in., 3/16-in., 1/4-in., or 1/2-in., equal to 1 foot, according to character of drawing.

"STANDARDS."—Drawings for standards to be to scale of 1/8-in., 1/4-in., 1/2-in., 1 in., 1 1/2 in., or 3 in., equal to 1 foot, according to character of drawing.

STANDARD PROFILES.—Standard profiles to be to scale of 1 in., equal to 400 feet for horizontal, and 1 in. equal to 20 feet for vertical scale.

SIGNAL PLANS.—Signal plans should be to scale of 1 in. equal to 50 feet or 100 feet.

SYMBOLS.

SYMBOLS.—Present tracks owned by Company to be indicated by black lines on tracings and white lines on blue prints. Main track lines should be heavier than those for other tracks. Single lines to be used for tracks when the scale is 100 ft. to the inch or smaller; double lines to be used for tracks when larger scale is used.

Tracks to be taken up or rearranged to be shown by finely dotted lines.

Boundary lines of property owned to be shown by dot-and-dash lines.

Ground outline of buildings to be drawn with heavy line and the enclosed space to be hatched and shaded when necessary.

Fences, when not coincident with property lines, to be indicated by dash lines.

State, City, County, Township and other corporation lines to be shown by dash and three dots.

In the case of profiles, the ground line on the north or west side to be shown by light full line, shaded brown on the underside; ground line on south or east side to be shown by light dotted line similarly shaded.

All symbols used, other than standard, to be explained on the plan.

COLORS.

COLORS.—When necessary to color present tracks and property lines of this Company, use yellow. When property questions are involved, ownership must be designated in colors, and yellow used to indicate this Company's property lines.

Proposed tracks to be shown on tracings and prints in red—full lines for work to be undertaken, and dashed lines for ultimate development. Property proposed to be acquired will have red tint on proposed line of purchase.

Private tracks to be shown in brown on tracings and prints.

Tracks and property of foreign roads to be shown in green and other colors as may be necessary.

Color scheme used on plans accompanying contracts, agreements, etc., should be explained on the plan.

GENERAL INFORMATION NECESSARY TO BE SHOWN ON MAPS, PLANS AND DRAWINGS.

All maps and plans are to be drawn with letters and figures in upright position toward the north and west, the meridian being indicated on the drawing by an arrow.

MAPS.—The following should be shown on maps:

(a) Names of rivers, streams, owners or occupants of properties, lot numbers, names of town or city additions or subdivisions, sections, townships, ranges, military or other official surveys, etc.

(b) Official survey stationing, giving station number at each fifth station, with marks for each 100 ft. between; also show location of mile posts.

(c) Dimensions and distances.

(d) All information which is necessary to enable the plan to be used for the purpose intended.

(e) Both magnetic and true meridian, when known.

PLANS FOR TRACK CHANGES.—Plans for track changes should have a table showing in feet, (a) Present Tracks, (b) New Track, (c) Transferred Track, (d) Total, and (e) Increase or Decrease.

All track plans should show at least one M. P. plus.

All track plans (except ordinary business or industrial sidings) should have a profile, preferably at the bottom, on which grades and the quantities in cuts and fills are marked, and disposition of material indicated; character and amount of bridge and culvert extensions also to be shown.

When scale plans for new passing sidings, running tracks, or additional main tracks are made, the plan should be accompanied by standard track diagram and profile showing the proposed full scheme of which the plan submitted is to be a part.

Plans for engine house and ash pit layouts must have profiles showing grades of tracks, and elevations of ash pit, turntable and engine house floor.

SIGNAL AND INTERLOCKING PLANS.—Signal plans should show clearly:

(a) All switches to be included in Interlocking Plant.

(b) Section and weight of rail within the limits of work.

(c) Distance between track center lines, with notes whether tracks can be spread to allow location of high signals between them.

(d) Direction and class of traffic on each track.

(e) Location of signal tower with respect to work, and nearest station or mile post.

(f) Location of leadout.

(g) Location of telegraph or telephone pole line where electric circuits are involved.

Bridge Masonry.—Bridge masonry *drawings should show clearly:*

(a) A small scale general location plan with alignment of tracks, location of stream or road several hundred feet above and below the bridge, and distance along the center line of track from face of abutment under coping to the nearest official profile station number.

(b) A small scale profile of grades over and near bridge, with elevation of highest known water marked thereon.

(c) Lines of standard roadbed and ballast section.

(d) Character of foundation material and construction of foundation work.

(e) Elevation above ocean datum of foundation, high water, bridge seats, and base of rail (low rail on curves).

(f) Estimates of quantity of excavation, quantity of masonry, piles, timber; pressure intensity on foundation, material, etc.

Profiles.—Profiles should be drawn with right-hand end toward Pittsburg and should show clearly:

(a) Ocean datum line.

(b) Datum lines for cities, U. S. Government, etc., referenced to ocean datum.

(c) Grade line (base of rail—low rail on curves).

(d) Line of top of slope in cuts and toe of slope on fill, on each side of roadway.

(e) Elevation of high and low water of adjacent streams and rivers.

(f) Description and elevation of bench marks.

(g) A sketch of track alignment near bottom of sheet, with arcs of circles to show direction of curves.

(h) Stationing and elevations at important places.

General.—The number of the notebook containing the field notes should be shown on map or plan.

If a map or plan is to be anything more than a picture, it must have the dimensions and distances marked on it.

Plans requiring the approval of officers should have proper place provided for that purpose, preferably near the title.

GENERAL INSTRUCTIONS.

Permanent Filing Place for Tracings.—All plans of construction or renewal work, such as bridges, bridge masonry, culverts, buildings, etc., which require approval, shall be submitted in tracing to the proper officer, and, when approved, negatives from them will be returned to the originating office.

Each main and side track change completed shall be shown on plan made on tracing cloth and sent to the office of the Chief Engineer M. of W., where a negative will be made and retained for his record, the tracing being returned to the originating office.

All tracings of proposed changes or additions, or those to illustrate correspondence, shall be retained in the office where they originate, a sufficient number of prints being made and forwarded with the letters.

FILING.—All new drawings shall be placed in a special drawer for drawings not indexed until they are placed in the permanent file.

Drawings taken from files for use should be returned to the proper place every night by the person using them.

Drawings taken from draughting room will be returned to a special drawer and then put in proper file by person designated for that purpose.

NUMBER OF PRINTS.—The following number of prints must be furnished with:

Correspondence,	2;
Application for authority,	5;
Forms 819, 826, 827, 844, 845, 850,	3;
Forms 801, 835,	4;
Agreements,	2 extra.

Illinois Central Railroad Company.

OFFICE OF THE CHIEF ENGINEER.

CIRCULAR NO. 2.

CHICAGO, June 1st, 1902.
Re-issued July 1st, 1903.

In order to secure uniformity in the preparation of standard plans, the following instructions must be carefully observed in future:

The following scales must be used:

100 feet to the inch for all ordinary plats.

50 feet to the inch for plats requiring more details than can be shown on scale 100 feet to the inch.

200 to 400 feet to the inch for plats which would be rendered too bulky in size by using a larger scale.

Smaller scales only when absolutely necessary.

The object to be attained is to get plats which can be scaled with a foot rule with the minimum amount of calculation, and which for convenience of folding will be either the size of a sheet of letter paper or multiples thereof, so that when folded they will conform to that size. In attaching them to letters they should be fastened in the upper left hand corner in such a way as to unfold without being unfastened.

On Every Plat the Points of the Compass must be Shown. If not known exactly they must be put on approximately, and when put on approximately it must be so stated.

The names of the Terminals of the Line at both ends must be shown. As a rule the left side or top should be used for north or west, and the lower or right side for south or east.

The Title, Scale, Date and Office where plat is made must be marked on every plat.

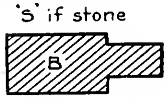
On all Plans involving Tracks, the names and numbers by which the tracks are known must be given.

Where Changes are proposed, show present arrangement in solid black lines on tracing and solid white lines on blue print, and proposed arrangement in dotted red lines on tracing and solid red lines on blue print.

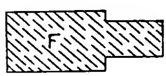
When using Color Shading to distinguish between different owners, use red to denote Company's property.

In making Plats of Station Grounds, show all Buildings, not only those belonging to the Company, but also on the properties directly adjoining, and designating:

Brick or stone buildings by heavy boundary and solid line hatching, thus: - - -



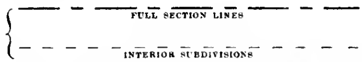
Frame buildings by light boundary and dotted line hatching, thus: - - -



The Following Conventional Signs will be Adopted as Standard:

For Company's property lines, - - -

For Government section lines, - - -



Immediately upon Completion of any Changes in tracks or buildings, or whenever grades are changed, new water tanks or coaling arrangements constructed, or any other changes made affecting the line, correct plans or profiles must be sent to this office in order that the official records may be corrected accordingly.

J. H. Wallace
Chief Engineer.

Eng. M. W.—289. 9 20 1900.

THE PENNSYLVANIA RAILROAD COMPANY.

N. C. Ry., P., W. & B. R. R., and W. I. & S. R. R.

Office of Engineer Maintenance of Way.

GENERAL NOTICE.

For the purpose of establishing a uniformity and as an aid in filing plans, &c., the following standard dimensions and specifications are adopted for use in this Department for all plans, whether Signal, Architectural, Real Estate, Bridges, Surveys, Maintenance of Way, or others:—

DIMENSIONS.

Dimensions of Plans.

SIGNAL PLANS between border lines, 17 inches wide, length not less than 29 inches (one line border).

ARCHITECTURAL PLANS........24 inches x 36 inches.

REAL ESTATE PLANS........8 inches wide ; length not less than 14 inches.

BRIDGE PLANS........24 inches x 36 inches.

M. W. STANDARDS between border lines........16 inches x 23 inches (one line border).

SCALE.

Track Plans and Property Maps

The scale for TRACK PLANS and PROPERTY MAPS should be as follows:—

WORKING DRAWINGS showing details for construction of *yard tracks, switches, &c.*, 40 feet = 1 inch.

GENERAL PLANS for *large yards* (not working drawings), showing no particular details, where two lines, each represent a rail of a track, 100 feet = 1 inch. A still further reduction for an outline plan, giving a general system with only one line to represent a track—200 feet or 400 feet = 1 inch, according to the scope of the subject.

Surveys.

For PRELIMINARY SURVEYS showing *topography* and *contour lines*—400 feet = 1 inch. Any *detail* of the same, separate from the general survey, should be enlarged to either 200 feet or 100 feet = 1 inch. The *contour lines* of such surveys should be 5 feet to 10 feet, according to the topography of the country, or less for detail work on very level country.

Profiles.

PROFILES of *long surveys* to be made on Plate B—30 feet vertical scale; for detail surveys, to be on Plate A—20 feet vertical. The horizontal scale of profiles of all surveys to be the same as of the map to which it belongs. In level districts, such as along the seashore, profiles may be varied to be 10 feet vertical and the same horizontal scale as the map.

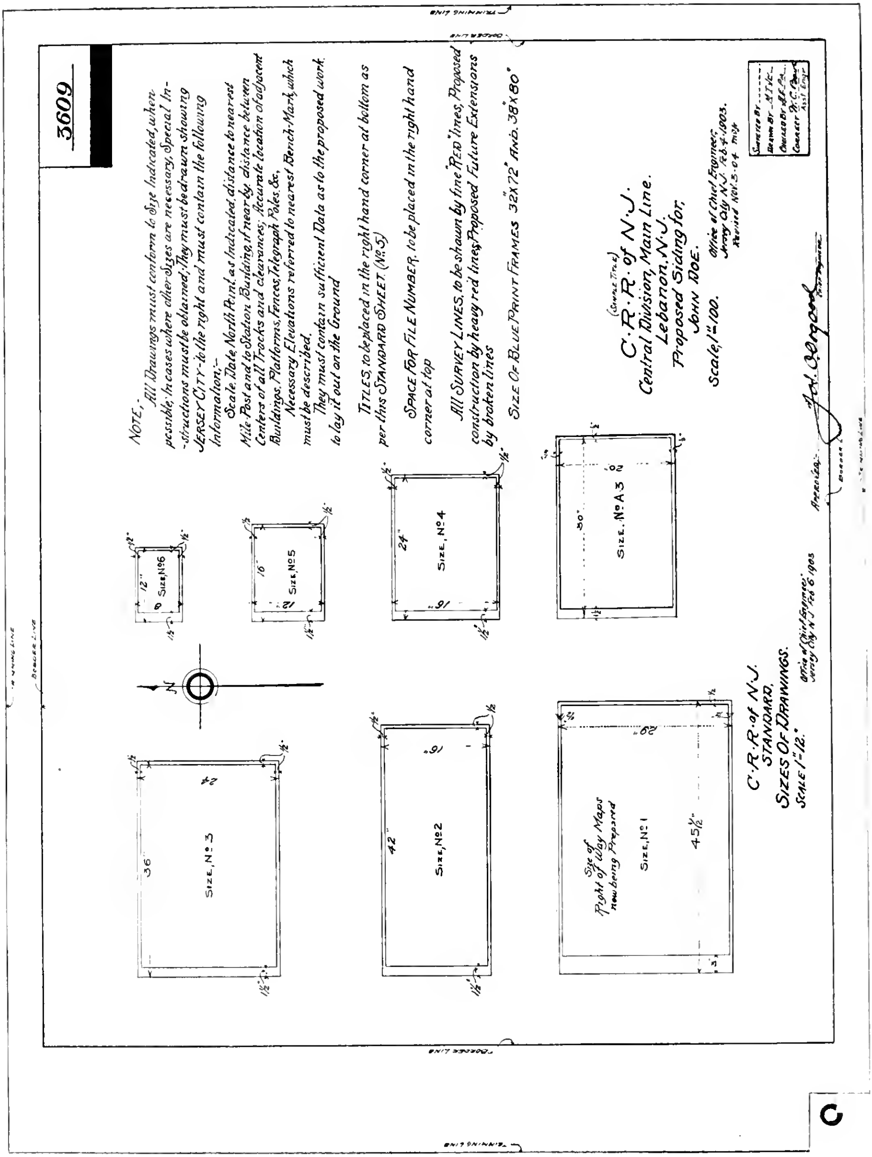
TITLE.

All Plans and Profiles.

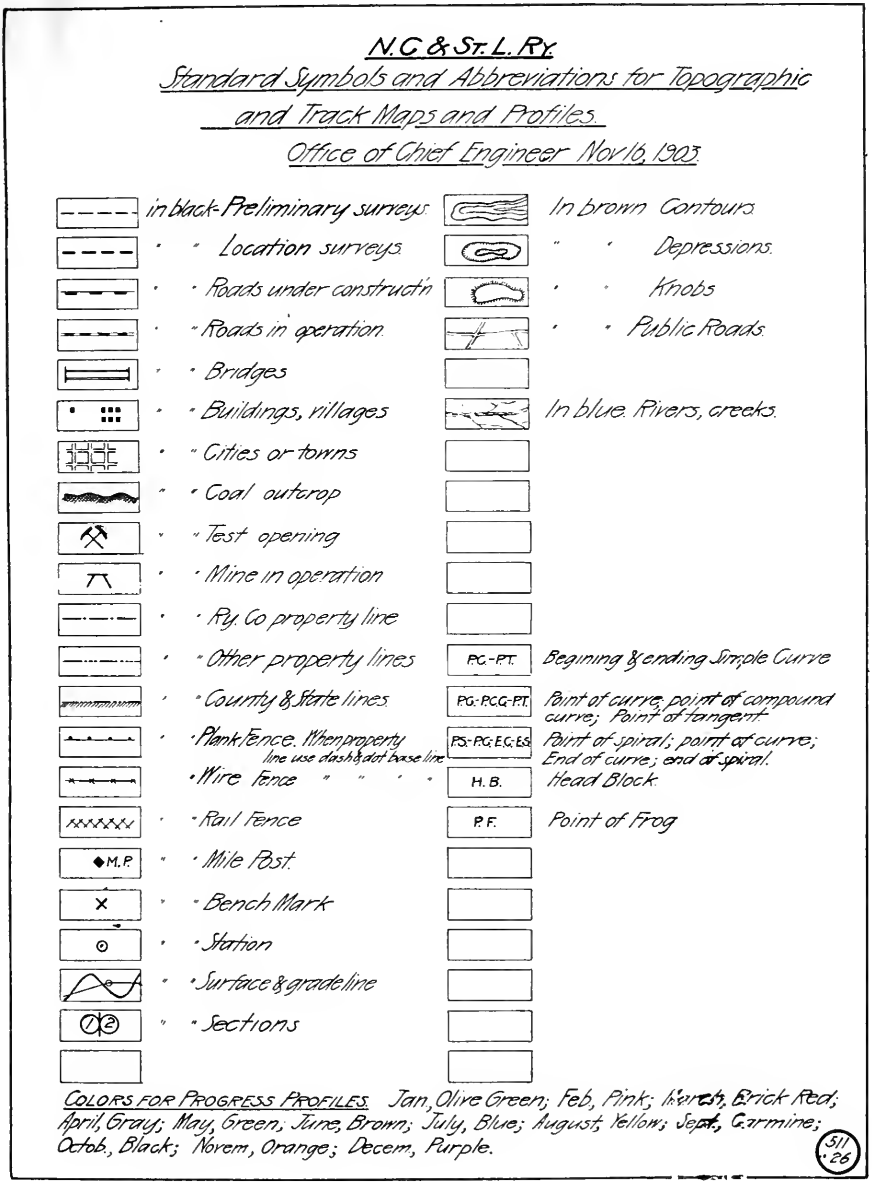
The TITLE of all drawings shall clearly state the subject matter ; the locality by Superintendent's Divisions and by Railroad or Branch ; the scale, meridian, date and file number. Plans to accompany statements of purchase and lease shall show in addition the State, County and Township in which the property is located. All roll plans and profiles to have the subject and scale named on outside of the two end edges.

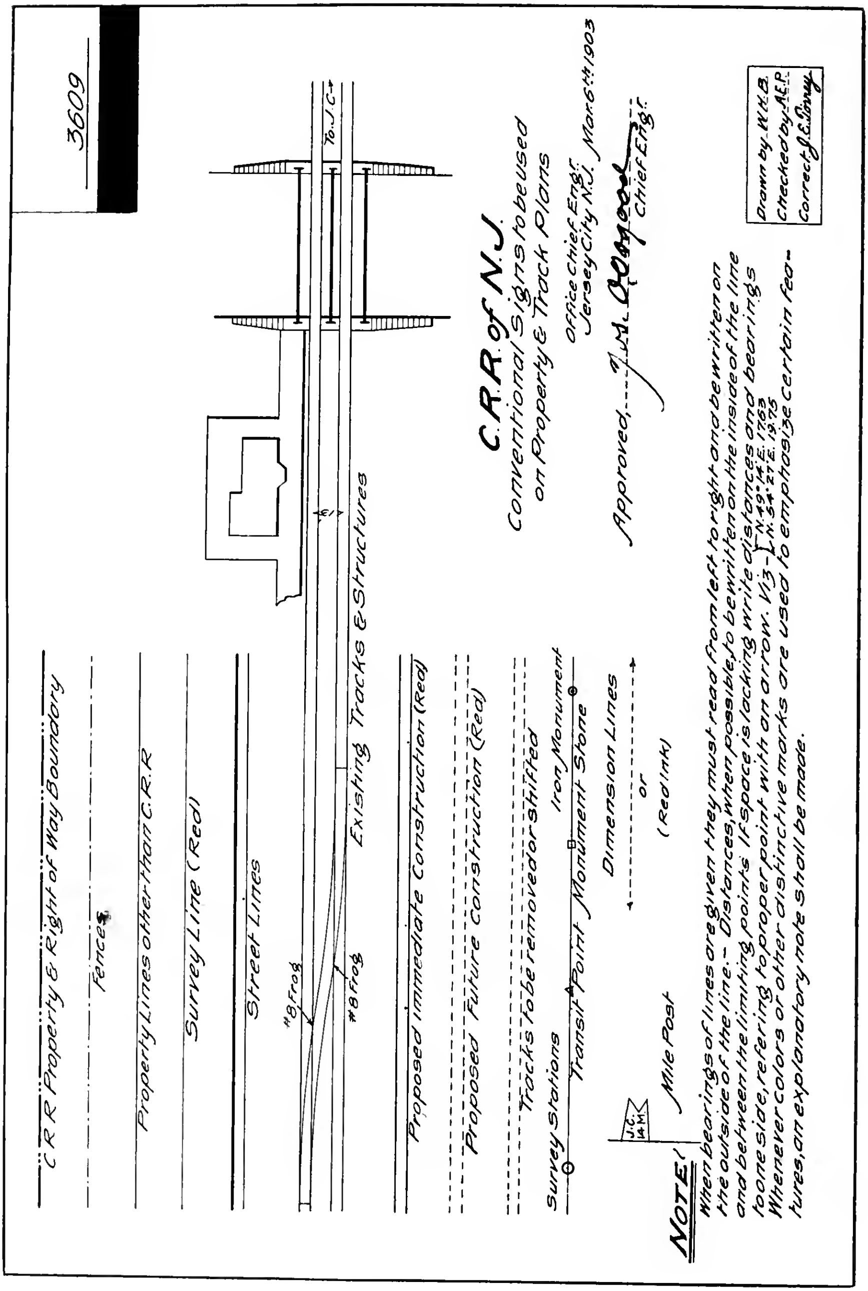
JOSEPH T. RICHARDS,
Engineer Maintenance of Way.

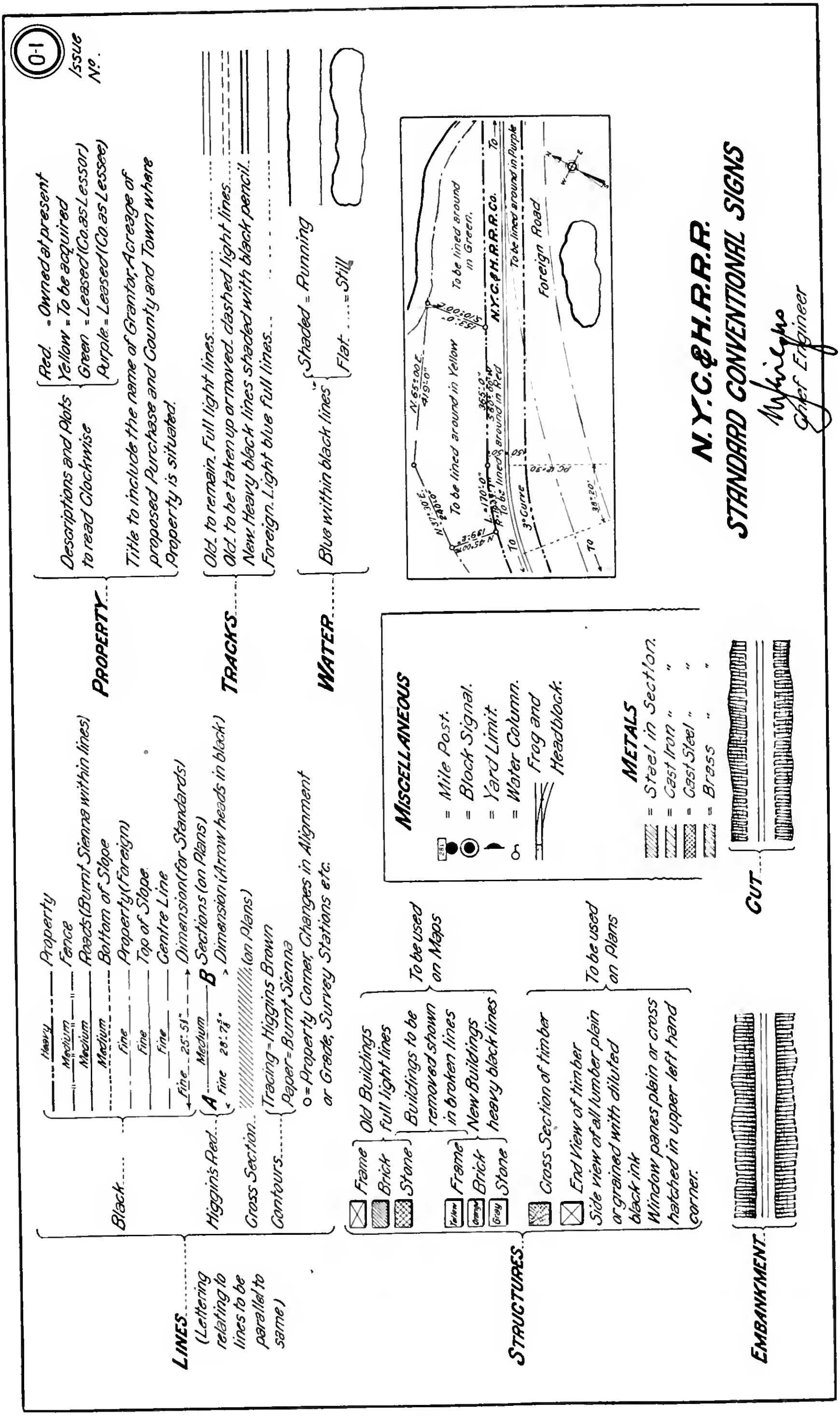
PHILADELPHIA, September 19th, 1900.

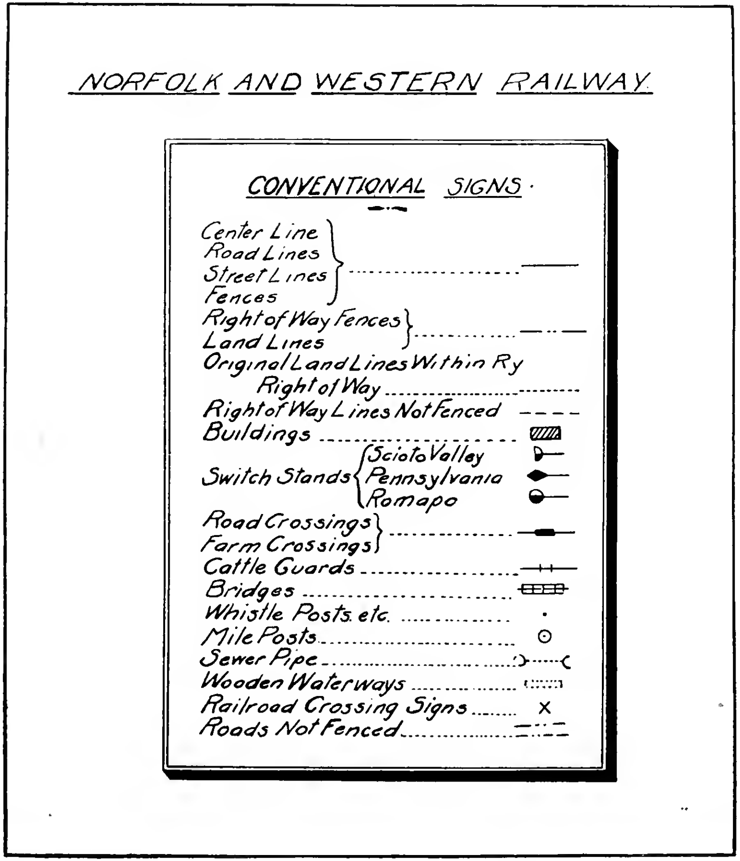


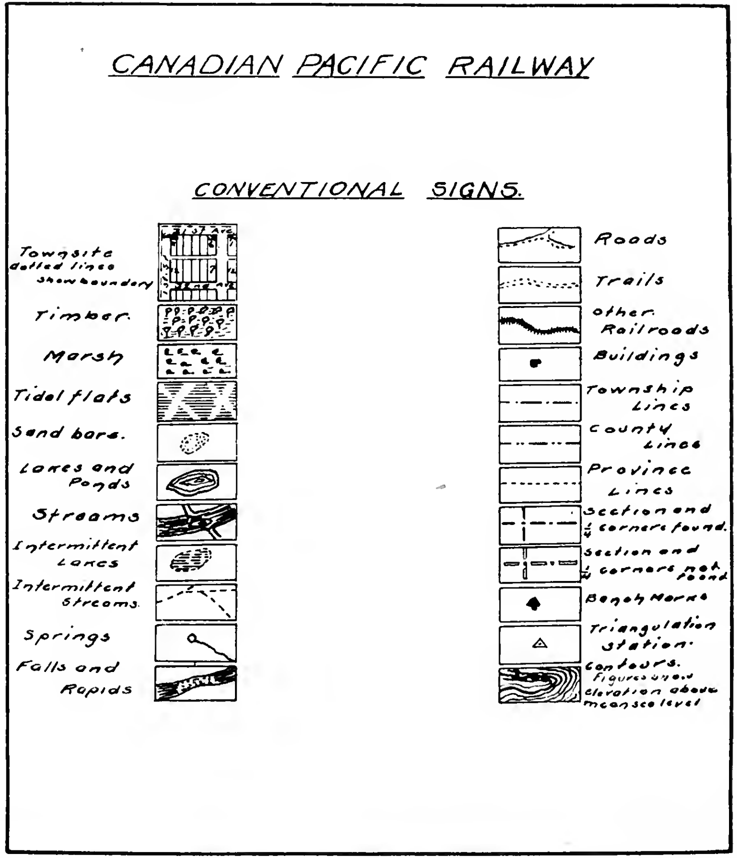
3609
NOTE; All Drawings must conform to Size Indicated, when possible; In cases where other Sizes are necessary, Special Instructions must be obtained; They must be drawn showing Jersey City - to the right and must contain the following Information:-
Scale, Date, North Point, as Indicated, distance to nearest Mile-Post and to Station, Building, if nearby, distance between Centers of all Tracks and clearances; Accurate location of adjacent Buildings, Platforms, Fences, Telegraph Poles &c.
Necessary Elevations referred to nearest Bench-Mark, which must be described.
They must contain sufficient Data as to the proposed work to lay it out on the Ground
Titles, to be placed in the right hand corner at bottom as per this Standard Sheet (No. 5)
Space for File Number, to be placed in the right hand corner at top
All Survey Lines, to be shown by fine "Red" lines, Proposed construction by heavy red lines, Proposed Future Extensions by broken lines
Size of Blue Print Frames 32"x72" and 38"x80"
(Sample Title)
C. R. R. of N. J.
Central Division, Main Line.
Lebanon, N. J.
Proposed Siding for,
John Doe.
Scale, 1"=100.
Office of Chief Engineer, Jersey City N. J. Feb. 4, 1903.
Revised Nov. 5-04
Approved:
Size, No 6
Size, No 5
Size, No 4
Size, No A 3
Size, No 3
Size, No 2
Size of Right of Way Maps now being Prepared
Size, No 1
C. R. R. of N. J.
Standard
Sizes of Drawings.
Scale 1"=12."
Office of Chief Engineer, Jersey City N. J. Feb 6 1903

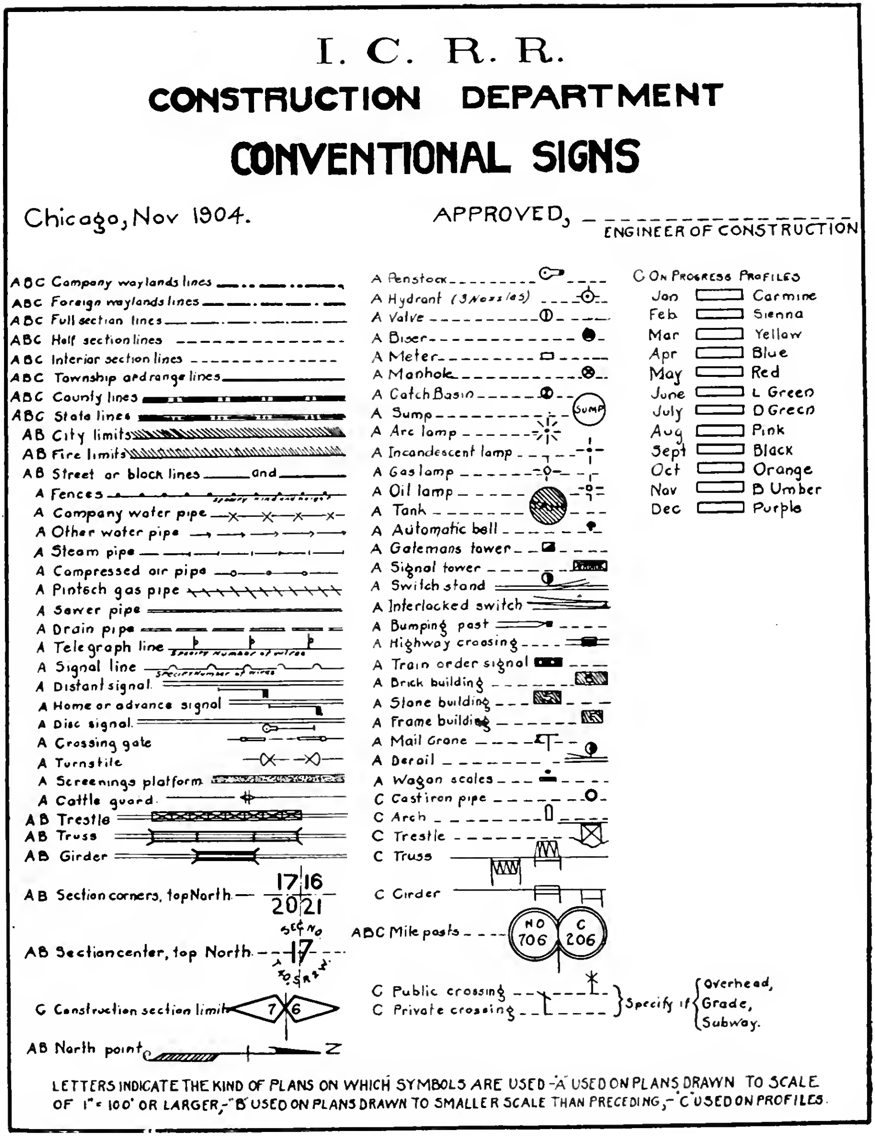

N.C & St. L. Ry.
Standard Symbols and Abbreviations for Topographic and Track Maps and Profiles.
Office of Chief Engineer Nov 16, 1903.
in black- Preliminary surveys
" " Location surveys
" " Roads under constructn
" " Roads in operation
" " Bridges
" " Buildings, villages
" " Cities or towns
" " Coal outcrop
" " Test opening
" " Mine in operation
" " Ry. Co property line
" " Other property lines
" " County & State lines
" Plank Fence. When property line use dash & dot base line
" Wire Fence " " " "
" Rail Fence
" Mile Post
" Bench Mark
" Station
" Surface & grade line
" Sections
In brown Contours
" " Depressions
" " Knobs
" " Public Roads
In blue Rivers, creeks
P.C.-P.T. Begining & ending Simple Curve
P.C.-P.C.C.-P.T. Point of curve; point of compound curve; Point of tangent
P.S.-P.C.-E.C.-E.S. Point of spiral; point of curve; End of curve; end of spiral.
H. B. Head Block
P. F. Point of Frog
♦M.P.
Colors for Progress Profiles. Jan, Olive Green; Feb, Pink; March, Brick Red; April, Gray; May, Green; June, Brown; July, Blue; August, Yellow; Sept, Carmine; Octob., Black; Novem, Orange; Decem, Purple.
511 26


3609
C R R Property & Right of Way Boundary
Fences
Property Lines other than C.R.R
Survey Line (Red)
Street Lines
#8 Frog
#8 Frog
Existing Tracks & Structures
To J.C.
Proposed Immediate Construction (Red)
Proposed Future Construction (Red)
Tracks to be removed or shifted
Survey Stations
Transit Point
Iron Monument
Monument Stone
Dimension Lines
or
(Red Ink)
J.C. 14 M.
Mile Post
C.R.R. of N.J.
Conventional Signs to be used on Property & Track Plans
Office Chief Engr. Jersey City N.J. Mar 6th 1903
Approved,
Chief Engr.
NOTE:
When bearings of lines are given they must read from left to right and be written on the outside of the line.— Distances, when possible, to be written on the inside of the line and between the limiting points. If space is lacking write distances and bearings to one side, refering to proper point with an arrow. Viz—
N.49°14'E. 17.63
N.54°27'E. 19.75
Whenever colors or other distinctive marks are used to emphasize certain features, an explanatory note shall be made.
Drawn by W.H.B.
Checked by A.E.P.
Correct


0-1
Issue No.
LINES (Lettering relating to lines to be parallel to same)
Black
Heavy — Property
Medium — Fence
Medium — Roads (Burnt Sienna within lines)
Medium — Bottom of Slope
Fine — Property (Foreign)
Fine — Top of Slope
Fine — Centre Line
Fine 25' 5½" — Dimension (for Standards)
Higgin's Red
A Medium B Sections (on Plans)
Fine 28' 7⅝" Dimension (Arrow heads in black)
Cross Section (on Plans)
Contours
Tracing = Higgins Brown
Paper = Burnt Sienna
o = Property Corner, Changes in Alignment or Grade, Survey Stations etc.
PROPERTY
Descriptions and Plots to read Clockwise
Red = Owned at present
Yellow = To be acquired
Green = Leased (Co. as Lessor)
Purple = Leased (Co. as Lessee)
Title to include the name of Grantor, Acreage of proposed Purchase and County and Town where Property is situated.
TRACKS
Old. to remain. Full light lines.
Old. to be taken up or moved. dashed light lines.
New. Heavy black lines shaded with black pencil.
Foreign. Light blue full lines.
WATER
Blue within black lines
Shaded = Running
Flat = Still
STRUCTURES
Frame
Brick
Stone
Old Buildings full light lines
Buildings to be removed shown in broken lines
Yellow Frame
Orange Brick
Gray Stone
New Buildings heavy black lines
To be used on Maps
Cross Section of timber
End View of timber
Side view of all lumber plain or grained with diluted black ink
Window panes plain or cross hatched in upper left hand corner.
To be used on Plans
MISCELLANEOUS
= Mile Post.
= Block Signal.
= Yard Limit.
= Water Column.
Frog and Headblock.
METALS
= Steel in Section.
= Cast Iron "
= Cast Steel "
= Brass "
EMBANKMENT
CUT
To be lined around in Yellow
To be lined around in Green.
To be lined around in Red
To be lined around in Purple
N.Y.C.&H.R.R.Co.
Foreign Road
3° Curve
TO
N.Y.C.&H.R.R.R.
STANDARD CONVENTIONAL SIGNS
Chief Engineer


NORFOLK AND WESTERN RAILWAY
CONVENTIONAL SIGNS.
Center Line
Road Lines
Street Lines
Fences
Right of Way Fences
Land Lines
Original Land Lines Within Ry Right of Way
Right of Way Lines Not Fenced
Buildings
Switch Stands
Scioto Valley
Pennsylvania
Romapo
Road Crossings
Farm Crossings
Cattle Guards
Bridges
Whistle Posts etc.
Mile Posts
Sewer Pipe
Wooden Waterways
Railroad Crossing Signs
Roads Not Fenced


CANADIAN PACIFIC RAILWAY
CONVENTIONAL SIGNS.
Townsite dotted lines show boundary
Timber
Marsh
Tidal flats
Sand bars.
Lakes and Ponds
Streams
Intermittent Lakes
Intermittent Streams
Springs
Falls and Rapids
Roads
Trails
other Railroads
Buildings
Township Lines
County Lines
Province Lines
Section and ¼ corners found.
Section and ¼ corners not found
Bench Marks
Triangulation station.
Contours. Figures show elevation above mean sea level


I. C. R. R.
CONSTRUCTION DEPARTMENT
CONVENTIONAL SIGNS
Chicago, Nov 1904.
APPROVED,
ENGINEER OF CONSTRUCTION
ABC Company waylands lines
ABC Foreign waylands lines
ABC Full section lines
ABC Half section lines
ABC Interior section lines
ABC Township and range lines
ABC County lines
ABC State lines
AB City limits
AB Fire limits
AB Street or block lines and
A Fences
A Company water pipe
A Other water pipe
A Steam pipe
A Compressed air pipe
A Pintsch gas pipe
A Sewer pipe
A Drain pipe
A Telegraph line
A Signal line
A Distant signal
A Home or advance signal
A Disc signal
A Crossing gate
A Turnstile
A Screenings platform
A Cattle guard
AB Trestle
AB Truss
AB Girder
AB Section corners, top North
17 16
20 21
AB Section center, top North
17
C Construction section limit
7 6
AB North point
Z
A Penstock
A Hydrant (3 Nozzles)
A Valve
A Riser
A Meter
A Manhole
A Catch Basin
A Sump
SUMP
A Arc lamp
A Incandescent lamp
A Gas lamp
A Oil lamp
A Tank
A Automatic bell
A Gatemans tower
A Signal tower
A Switch stand
A Interlocked switch
A Bumping post
A Highway crossing
A Train order signal
A Brick building
A Stone building
A Frame building
A Mail Crane
A Derail
A Wagon scales
C Cast iron pipe
C Arch
C Trestle
C Truss
C Girder
ABC Mile posts
NO 706
C 206
C Public crossing
C Private crossing
Specify if Overhead, Grade, Subway.
C On Progress Profiles
Jan Carmine
Feb Sienna
Mar Yellow
Apr Blue
May Red
June L Green
July D Green
Aug Pink
Sept Black
Oct Orange
Nov B Umber
Dec Purple
LETTERS INDICATE THE KIND OF PLANS ON WHICH SYMBOLS ARE USED - "A" USED ON PLANS DRAWN TO SCALE OF 1" = 100' OR LARGER, - "B" USED ON PLANS DRAWN TO SMALLER SCALE THAN PRECEDING, - "C" USED ON PROFILES.

PROGRESS PROFILES.

Illinois Central Railroad.

"The attached is sample of Progress Profiles which I believe will be self explanatory."

Philadelphia & Reading Railway.

"We use two kinds of Progress Profiles on work of any magnitude.

"(1) A regular scale profile of the road upon which we show the progress with cross-sectioning each month, either with different colors, different angles, or both. The same method is used in indicating progress in masonry construction. As these are made on mounted paper, we have no duplicates unless they are specially made and as we use no standard for color, I have not forwarded any.

"(2) A progress chart to represent the progress of the work is prepared and kept up for work of any magnitude. A sample sheet is sent you herewith. It is a copy of that used by the Rapid Transit Commission in New York and has been published and described by them.

"The diagram to the left shows graphically—in a horizontal direction, the total value of the work in dollars and cents, sub-divided into its component items, while the vertical scale shows the percentage of work done, each rectangle being numbered to represent the number of the month. The diagram to the right shows diagonal lines representing the contract rate of progress, while the actual percentages done each month are plotted on the broken line."

Nashville, Chattanooga & St. Louis Railway.

"We keep no Progress Profiles, except on new construction."

Louisville & Nashville Railroad.

"The Progress Profile kept is merely a profile of the line on which is shown in color the work done during each month. There is nothing unusual or special in the type of progress profile kept by this company."

Canadian Pacific Railway.

"I hand you herewith sample of Progress Profile."

Pennsylvania Lines West of Pittsburg.

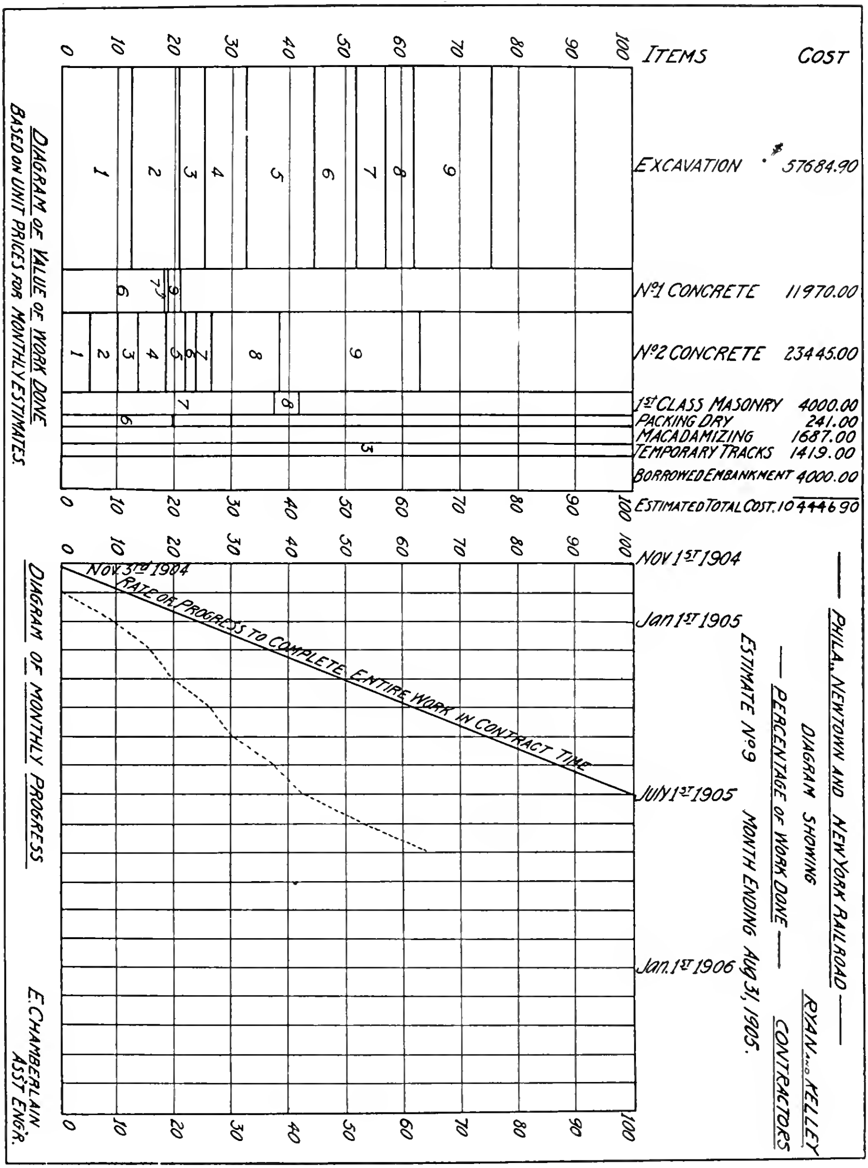
"We have no regular blanks for this purpose but when we consider the work warrants it we make special Progress Profiles to suit the case."

Central Railroad of New Jersey.

"We have no standard Progress Profiles."

Norfolk & Western Railway.

"On new work we make monthly reports, in the case of tunnels we make weekly reports. Progress Profile of double track tunnel near Bluestone, completed in 1902, is enclosed and shows you how record of this work is kept up. Progress on construction of double track work or branch lines is shown monthly on standard profile by means of colors adopted for each month as usual."


PHILA., NEWTOWN AND NEW YORK RAILROAD
DIAGRAM SHOWING
PERCENTAGE OF WORK DONE
RYAN AND KELLEY
CONTRACTORS
ESTIMATE No. 9 MONTH ENDING AUG 31, 1905.
ITEMS
COST
EXCAVATION 57684.90
No. 1 CONCRETE 11970.00
No. 2 CONCRETE 23445.00
1st CLASS MASONRY 4000.00
PACKING DRY 241.00
MACADAMIZING 1687.00
TEMPORARY TRACKS 1419.00
BORROWED EMBANKMENT 4000.00
ESTIMATED TOTAL COST. 104446.90
DIAGRAM OF VALUE OF WORK DONE
BASED ON UNIT PRICES FOR MONTHLY ESTIMATES.
NOV 1st 1904
Jan 1st 1905
July 1st 1905
Jan. 1st 1906
Nov. 3rd 1904
RATE OF PROGRESS TO COMPLETE ENTIRE WORK IN CONTRACT TIME
DIAGRAM OF MONTHLY PROGRESS
E. CHAMBERLAIN
ASS'T ENGR.

TRACK CHARTS.

Union Pacific Railroad.

"In regard to the records for track, the white printed sheet is the old method of keeping the record of ballast, ties and rail. This has been dispensed with.

"The blue print which I have marked with a cross shows a very convenient and condensed method of keeping a record of rail, ballast, rectification of grades, etc., especially for use when out on the line, as one can keep a large mileage in a small space.

"The other blue print is a method that we have devised for keeping the same information in the office. It also gives considerable additional information in regard to fences, etc."

Illinois Central Railroad

"Attached is copy of the Chicago Division condensed profile which is the standard track chart for the system."

Philadelphia & Reading Railway.

"A sample track chart is forwarded you herewith. It shows the location of all rail, its weight and pattern and year of laying."

Nashville, Chattanooga & St. Louis Railway.

"We keep no track charts."

Louisville & Nashville Railroad.

"We have nothing which corresponds exactly to this description, but make condensed profiles for the convenience of officers of the company, on which are shown the character of rail, its weight per yard and year when laid. A sample of page No. 28 showing miles 138-141, inclusive, for the Knoxville Division, is enclosed. The rail record is shown at the bottom. The alignment is shown at the top. The fine lines parallel to the alignment record indicate sidings. The position of these fine lines with reference to the alignment record indicates on which side of the track the sidings are constructed. The profile shows the grades in feet per mile. The page also indicates bridges, tunnels, water tank and section houses."

Canadian Pacific Railway.

"I attach copy of specimen track profile, standard ballast chart and standard rail chart. We believe that it is better to have separate charts for rail and ballast than to attempt to show all of this information on the track profile, as to show the history of these two items on the profile would require too wide a profile to be convenient."

Pennsylvania Lines West of Pittsburg.

"I enclose two copies of our standard track diagram taken from the same tracing. In size it is arranged so as to be folded letter size and bound in Shipman binders for the benefit of general officers, one copy for private cars and one for the office. It is also of such size that the sheets can be trimmed down and folded for division use, so as to put in the pocket."

Louisiana Western Railroad.

"Enclose you herewith white print of our standard pocket size track chart, the one enclosed representing the Houston Division. This track chart shows the composition of rail in track, water stations, tie plated track, ballasted track, fencing, elevation top of rail at stations, mile posts, section numbers, Roadmaster's districts and mileage through counties. This chart is very convenient, being of such size as you can put in your vest pocket, and for the use of officials on the road the backs are usually made of leather."

Boston & Maine Railroad.

"Exhibit 5 is a Track Chart covering about 100 miles of line, mostly double track. It shows kind of rail, its manufacture and year of laying; kind of joint connections; kind of ballast and date of ballasting, oiling, location of stations and section limits."

Central Railroad Company of New Jersey.

"We have no standard track charts."

Norfolk & Western Railway.

"We have used for many years as a rail record, a book of sufficient size to cover the entire system. I enclose you two sample leaves. We do not keep further records in the way of charts."

Mr. Hiram J. Slifer.

"I would say that Track Charts should be considered both from the engineering and operating side of the question, and in addition to showing the physical characteristics on these charts, arrangement should be made on the reverse side of same for recording industrial establishments and leases of station grounds. In other words, these track charts should be so arranged that a Superintendent could carry one with him and find on it a graphical indication of the condition of the entire property.

"It may be thought that this is impracticable, but I know of several such charts having been made and they were of great benefit to the parties who had them prepared."

DISCUSSION.

Mr. Edwin F. Wendt (Pittsburg & Lake Erie):—The conclusions in our report are found on pages 128 and 129. The report deals with some subjects which have been under discussion and studied by the Committee for one or more years. I refer particularly to the subject of maintenance of way bridge office records. The Committee earnestly hopes that the investigation in respect to this question will meet with the approval of the Association in order that it may be discharged from further consideration of that subject.

The first subject, "Ledger Accounts with Individual Pieces of Work," is really one which grew out of the instructions which the Board of Direction gave the Committee two years ago to consider the classification of expenses, especially with reference to additions and improvement expenditures. No report was ever made in regard to that subject, as it was found impossible to hold any conference with the Association of Accounting Officers, and the matter was practically dropped. But as the result of that work the Board of Direction assigned to the Committee this first subject of Ledger Accounts with Individual Pieces of Work, which has been under study for the past year and which is now included in the report. The other new business taken up by the Committee relates to conventional signs, progress profiles and track charts. No official report is made in regard to conventional signs, because it was found quite impossible during the year to compile the information necessary as a basis for drawing certain conclusions. The Committee hopes, however, that the question will be discussed before the Association in order that we may know whether we are working on the proper lines. Conclusions are presented in regard to progress profiles and track charts, and they speak for themselves. I presume in accordance with the practice of the Association, conclusions 1 and 2 will not be discussed, as they relate to additional definitions and the revision of former definitions.

The President:—The chair desires to extend to professors of colleges who may be present the freedom of the floor in debate. The Secretary will read the conclusions.

The Secretary:—"(3) Ledger Accounts with Individual Pieces of Work, showing the detail, total, comparative and unit costs of work, are essential in any system, according to which statements and appropriations must be made before work involving Additions and Betterments can be undertaken; therefore Ledger Accounts should be kept by the Maintenance of Way Department showing the cost of authorized work.

"Two special forms are required in a simple system of Individual Ledger Accounts:

"M. W. 1013, 'Approved Authority of Expenditure.'

"M. W. 1014, 'Individual Ledger.'

"Illustrations of these forms accompany the report."

The President:—It is hoped there will be some discussion on this Committee report. It is rather a dry subject, but one to which the Committee has given considerable attention. Their work has been excellent, and the Committee feels it should receive some expression from the Association at large. Free discussion is invited and requested.

Mr. Wendt:—I will open the discussion, in order that the purpose of the Committee may be better understood. As the President has stated, these are rather dry subjects. Engineers of Maintenance of Way seem to take great interest in the rail, the ties, the ballast, the roadway, and many other details; but when it comes down to making up records and reports and accounting for the expenditures, apparently but little interest is displayed by the engineers. The Board of Direction has seen fit to provide a committee to study these subjects, and we believe that a careful study of them will convince all of us that they are of very pressing importance.

When the Committee first started out a few years ago to study these subjects, it was thought there was not much to the work of the Committee; but from year to year we find that there is a vast field to be covered, and that the subjects are of great interest. The questions under consideration heretofore have been in relation to the forms used in the bridge department with respect to recording the results of inspection, and the forms used in various departments for taking care of the time. This year a step forward was taken, and the first subject, "Ledger Accounts," was assigned. The position of the Committee is very conservative. There seems to be no agreement among the members of this Association with regard to ledger accounts. In prosecuting the work of the Committee, we find that a large percentage of the membership believes that the engineers have nothing to do with the accounting business. However, if we read the subject carefully, we will find that it relates to such accounts as Chief Engineers and Engineers of Maintenance of Way desire to have kept in their own offices for their own information, and for the information of their managing officers, and not to the accounts which the accounting department keeps for reporting to the Interstate Commerce Commission in regard to other matters.

Your careful attention is asked to the wording of the conclusion just read, and we earnestly hope there will be some discussion on this conclusion, because it is very specific.

Mr. W. F. Tye (Canadian Pacific):—I would ask the Committee, as to this form on page 108, whether it relates to capital or maintenance expenditures, or both?

Mr. Wendt:—The form is used in various ways. On some of the largest systems of railroads the form is used with relation to work that involves both construction—that is, charges against capital—and maintenance—charges against expense. Necessarily the charge against expense is the smaller in proportion to the total. Whether it is used exclusively with reference to maintenance expenses I am not able to say. My opinion is that it is not.

Mr. Tye:—The reason I ask is that you give the amount of the expenditure—space for the amount—and then you give "chargeable to." What would be inserted in that space? For instance, if it was a capital charge, would you say, "chargeable to capital," or if maintenance, would you insert, "chargeable to maintenance?"

Mr. Wendt:—That would be chargeable to construction, which is capital, or to replacements, which is expense account, maintenance, or to individuals and companies, outside parties, or to miscellaneous. Some companies make a charge against additions, making a distinction between additions and construction. The form on page 108 is deficient in the respect mentioned by Mr. Tye, and in reality it should be amplified to show these different subheadings along the lefthand side.

Mr. Tye:—If you are going to use one form only, there should be a number of blanks there, because in many cases the expenditure is chargeable to capital, or construction, as you call it—and to maintenance, or to other accounts, and I think you should have blanks enough to show how much of the expenditure is chargeable to each one. On the Canadian Pacific we have two forms—one a capital or construction form and the other a maintenance form. While the amount chargeable to construction is shown on the construction form, where there is more than one item to which it is chargeable, it refers to another blank showing the amount of the maintenance charge. I think this form is incomplete in that respect.

Mr. A. L. Buck (Canadian Pacific):—What the chairman has said about the lack of interest in this Committee's work is in a measure true; but taking into consideration that its work covers ground that depends upon uniform organization to make the results of its work applicable to all, it is hardly to be expected that interest or enthusiasm can be aroused when the members of the Association realize that each railway has a system of accounting which varies in some particular from that of any other railway, and that the records, reports and accounts must be made in each case so as to meet the demands of their individual system.

The railway managers know pretty well what they want, and the Government commissions believe that they know what they should have, and their requirements are paramount to what the engineers might believe would best suit their own ideas. So that until a uniformity in organization is brought about through a managers' or kindred association, it will be a difficult matter to establish a uniform system of records, reports and accounts that will fulfill the demands of all.

As the chairman has said, this is a dry subject and it is one that can hardly be hoped to be brought to a uniform basis until uniform work can be obtained in the different organizations as well as the different departments of the organization.

Mr. W. M. Camp (Railway and Engineering Review):—It seems to me the comparative cost is an interesting feature of these accounts; and I wish to ask the chairman of the Committee how that is brought in on this form.

Mr. Wendt:—Under a system of accounting such as you outline, and a system that is especially adapted to a Chief Engineer's office—a system not used in the accounting department—there is first the authority for the expenditure, which is given on the form on page 108. That authority form shows how much money you are authorized to spend, and how that shall be charged. Next, it is necessary to keep ledger accounts with each individual organization. Some railroads issue as many as one hundred of these authorizations in one week, and as the different departments carry out the work the charges all go to the office and are posted against this individual account. After the work has been completed, a comparison and an analysis of the cost are made, in order that you may know what a structure costs per unit. That unit may be one thing or it may be another. If you are carrying on work with company forces—for instance, a large piece of concrete work—you will at the close of the work figure out what it costs per cubic yard. If you are building a roundhouse, you will figure out what that cost per stall per cubic foot or per square foot of floor space. The matter of analysis and comparison of costs may be carried to any extent desired. The information would all appear in the ledger, and in the future when work of a similar character is estimated, it would be possible to determine at once the cost of the proposed improvement.

Mr. L. C. Fritch (Illinois Central):—I consider that the Committee has given us a very good blank in form 1013, but I think in order to carry out the ultimate purpose of it, that there should be a completion report added. This completion report should cover the same work that is authorized by the authority blank, and that should be the report from which the ledger account is finally closed, and I suggest that the Committee draft such a form. I would also suggest that the wording of the form on page 108 be "Authority for Expenditure" instead of "Authority of Expenditure."

The President:—The Committee accepts the suggestion of Mr. Fritch, and also Mr. Tye's suggestion to add separate lines for the distribution of the charge to various accounts.

Mr. A. Montzheimer (Elgin, Joliet & Eastern):—In some cases I think it would be well to have a space on the blank on which the estimate number could be entered Very often authority for the work is not given until some months after the work is started. In a large number of cases we begin work as soon as the estimate is made and get the authority later. If the estimate number is placed on the blank, we can at once determine the work on which we are engaged, and in charging out work before authority is issued we make charges to the estimate number. Later, when the authority is issued, it is easy to change the charge from the estimate number to the authority number.

The President:—You know your authority before you start the work?

Mr. Montzheimer:—Yes; that is a copy of this blank M. W. 1013. As an addition I would recommend that there be a line set aside for the estimate number.

The President:—The Committee states that the intention was that this should be considered as an estimate until it was actually signed, and then it became the official authority, but up to that time it was an estimate submitted, bearing a number to which reference could be made. Mr. Montzheimer, do you make that in the form of a motion?

Mr. Montzheimer:—It seems to me that this is all right as far as it goes, but an estimate number on this blank would improve it. When the General Manager or other official gives authority for the appropriation, he would not take your number. A large number of estimates are never approved, and therefore these numbers would be blank, and not issued as appropriations. The General Manager's number would come in numerical order. For that reason I would move that a line be added to the blank at some convenient point on which the estimate number could be shown.

Mr. Tye:—I would think the way to meet that would be to have the Chief Engineer's number on it, which you could put above the number shown.

Mr. H. T. Porter (Bessemer & Lake Erie):—In sending in requisitions, we give our requisition number, and then when the Purchasing Agent makes an order he places the Purchasing Agent's number on the blank, so that when bills come to us they have not only the Purchasing Agent's order number but the requisition number. The estimate number which the gentleman asks for is similar to the requisition number I have explained, and I think it is a very good point. The parties authorizing the expenditures have their system of numbers which are fixed by the Comptroller or Auditor, and there may be a dozen departments or a dozen different companies that send in estimates asking for authority, so that the estimate number shows the number from the department where the request originates, and as long as the blank is to be general and may be used by others than the Chief Engineer, that estimate number is a very good thing, and I think one number could be placed opposite the other, or right under the other, so that you could have an estimate number, an appropriation number, and an authority number.

Mr. Wendt:—I think the point is probably covered by the illustrations. You will notice on page 134 that in the illustration there is a President's number, and a General Manager's number, and on page 132 provision is made for three different numbers. I presume that these numbers would be different, each department having its own system.

Mr. Buck:—It seems to me that this is a good form and could be made to meet the demands that the different speakers have illustrated by making the blank number line read, "Estimate or Appropriation Number," then whoever uses the blank can insert the number to which they wish to refer, as, "Vice-President's Number," "General Manager's Number," or "Chief Engineer's Number." This makes the blank flexible and applies to many other forms now in use, otherwise it will burden the form to provide separate lines for any number that it might be desired to use. The number inserted in any case would refer to or be the same number used on the original estimate or appropriation for the work to which this form refers.

Mr. Chas. S. Churchill (Norfolk & Western):—I think the form as proposed by the Committee is, generally speaking, a most excellent one. We find that it is necessary to use but one form in our practice, whether the charge be construction, betterment, individual and company, or maintenance expenses. It often occurs that a portion of the cost of a piece of work is charged to construction or betterments, and the other part to maintenance. The division is shown plainly on the face of the request. When the request is authorized the same figures are repeated; and the form of the authority which is issued is shown on page 134, which is really a copy of the original request in my office. The bottom of the page shows the closing up of the account. A great many hundred of these are turned out of my office, and there is no multiplication of blanks, one form answering for the whole work. By leaving plenty of space on the blank—a blank very little larger than this page—there is no trouble in finding room for the different accounts.

Mr. Tye:—On page 134, the sample to which Mr. Churchill refers, the estimate is shown, but is not signed by anyone. In this case, who is responsible for the estimate? If the estimate was not right in the end, who would be held responsible? Would not several of your officials have to prepare an estimate—have you any blanks for their approval?

Mr. Churchill:—Every road has somewhat different practice in detail. We have an estimate or request blank, which is almost identical with the blank shown, and it is signed first by me as Chief Engineer, thence to the General Manager for approval; and in case it is a construction charge, it is approved by the President, and becomes a record of the President, General Manager and accounting officers. Finally authority is issued, bearing the President's number, which is an exact copy of the request, and that is my authority to go ahead with the work. I cover the other point that was brought up here a few moments ago, namely, of keeping track of my estimate number by simply placing in one of the spaces provided my original request number, so that I can refer back to my books very readily, and then to my files to see who is responsible to me for certain portions of the estimate.

Mr. Tye:—In that case it would seem to me that the Committee should have another form—the estimate form referred to by Mr. Churchill. This is not complete without such an estimate form. In our practice we accomplish the same result by having it all on the one form. It is signed first of all by the man who makes the estimate—the Engineer, the Superintendent, or whoever he may be—and then we have the place for the approval of the General Superintendent, if he knows about it, and he does, of course, about all maintenance work; there is a place for the signature of the Chief Engineer and General Manager or Vice-President, as the case may be; and if it is a capital account, we have a blank for the approval of the President. If not, it is approved by the Vice-President. All this is on one form.

Mr. Buck:—What I intended to convey was to make this number an "Estimate or Appropriation Number," leaving a sufficient blank space to receive the official's number. As I understand this blank, it is simply a notification blank from a superior official that the authority has been granted for the prosecution of a certain piece of work that has been applied for on the regular appropriation form, and the number used on this notification form would be identical with that on the original or regular appropriation form. I do not understand this form to be intended to ever take the place of an estimate form, and if it is not, then I do not see why it is not sufficient to have a flexible arrangement of numbering by which it can be easily identified.

The President:—The action of the convention will be on the motion of Mr. Montzheimer, that the Committee should add at a convenient place on this form a line for two numbers.

(The motion was carried.)

The President:—The chairman of the Committee desires to have it stated that the Committee does not wish to have these forms absolutely approved, but that after full discussion and expression of opinion, and directions to them, such as this motion, that the matter of each particular form be referred back to them so that during the year they can proceed along the lines indicated by the Association, and not have the report as presented to-day adopted as final. The chairman also desires that attention be called to form M. W. 1014, which is a record of cost of work.

Mr. Tye:—Before proceeding to form M. W. 1014, I move that the Committee be requested to prepare an estimate blank to accompany this authority for expenditure, or that they change the blank so as to make one form do for both, whichever the Committee considers desirable.

(The motion was carried.)

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis):—I understand the discussion is on conclusion No. 3, page 128. The Committee seems to have requested an expression of opinion from the convention as to the propriety of keeping ledger accounts in the maintenance of way engineer's office. I want to ask the Committee whether they consider this entirely practicable. It appears to me that charges come to various pieces of work which the engineer never sees until they show up on the Controller's accounts. I hardly see how he would keep his accounts balanced, unless he went over them each month and adjusted them. Has the Committee considered that feature of the suggestion?

Mr. Tye:—I do not think that the Comptroller should be allowed to make charges against any piece of work unless approved by the engineer.

Mr. McDonald:—The charges of the legal department defending suits, and for legal advice, are often charged to such accounts. I do not know whether it is customary to refer them to the engineer on all roads.

Mr. Buck:—The different departments must come to a common understanding in regard to this work before we can reach a satisfactory form. There are charges made against the work by the various departments in such a way that oftentimes it is difficult to arrive at the exact cost of a piece of work. There are charges which are hard to reach, as there are so many departments interested. It is difficult for an engineer to keep a ledger account of the exact cost of the work, and next to impossible without a great deal of trouble.

Mr. Wendt:—It is entirely practicable to keep these accounts, with the exception of the charges from the legal department. The Committee did not give that phase of the subject very thorough consideration.

Mr. McDonald:—I mentioned that as one instance where they come from. They come from a good many different sources in my experience.

Mr. Wendt:—In my experience, no charge is made against any work that would be covered by this authorization form of which the engineer could not be easily apprised and have cognizance of except charges from the legal department. If that is a conflicting feature, I see no reason why the Comptroller or Auditor would not be under obligation to report once a month to the head of the engineering department just what expenses have passed through his office from every department chargeable to these individual pieces of work. It woud be reasonable to assume that such should be the case. The Committee sent out a circular asking for an expression of opinion as to whether it was worth while to keep these accounts—individual ledger accounts—and the replies were favorable; that is, a majority of the replies stated that it was worth while—worth the expense to keep these accounts.

Mr. Buck:—As a rule, the engineer is most interested in the items over which he has absolute control. An engineer, in making an estimate, will estimate the quantities of material and labor involved from the engineering standpoint and will be able to estimate very accurately as far as his department is concerned; but for the other items of expense coming through other sources it is often difficult for the engineer to get them, and it seems to me that the accounting department is the proper one to keep up that part of it, and that the engineering department is going beyond its bounds when it goes beyond what it has under its control.

Mr. L. C. Fritch (Illinois Central):—In the operating department it is customary to render bills against each other for the service performed by them. It seems to me that any legal expenses would be covered by general expense, which would not enter into the department accounts at all. It is thoroughly practicable on most roads to keep ledger accounts as the Committee has recommended.

Mr. Buck:—I would like to know where the Committee would recommend the keeping of the ledger accounts; would they have the engineering department go to the expense of duplicating the accountants' work when it has access to the accountants' records?

Mr. Wendt:—The Committee is opposed to any duplication, and all of the forms presented in the last few years have been designed with respect to that point—that there should be no duplication of labor and no additional expense. We think it improper that these accounts should be kept in any but one office. The assumption of the Committee is that the Chief Engineer will be in charge of the work, and that therefore all charges against the work will pass through his office, and he will be in possession of all information with respect to expense. If any other officer should keep the accounts, depending upon the individual organization of the company, then the system would apply to whatever office keeps the accounts, whether that should be the Chief Engineer, General Superintendent or General Manager or Superintendent or Engineer of Maintenance of Way. We do not care what the organization is in detail, but we do insist that the person in charge of the work shall keep these accounts and that the charges shall come to that office. We have steadily endeavored during the last two years to steer clear of this question of organization in detail, having some two or three years ago suggested an organization as the basis for our work, and it should be clearly understood that the Committee is dealing with accounts which should be kept in the engineer's office—not in the Comptroller's or Auditor's office—accounts which are strictly for the information of the engineering and operating officers.

Mr. C. H. Ewing (Philadelphia & Reading):—I think the Committee is generally proceeding on correct lines. It appears to my mind of distinct advantage for the engineer's office to keep an absolute record of the cost of any particular item of work. I am also fully aware, as Mr. McDonald has said, that it is impossible to finally complete that account from the records in the engineer's office; but so far as the work performed is concerned, there is no difficulty at all in carrying out that part of it. There are numerous charges made in the general office against particular items of work, and upon inquiry we very often find that the general office has charged amounts to a certain account; that is something foreign to the actual work and should not be taken into consideration in this matter.

Mr. Churchill:—It seems to me that the whole matter can be covered, if any railroad decides that the general scheme is a correct one and to the advantage of the company. Our practice, and I think the practice of many other roads, is that no bill shall be charged to any authorized individual piece of work unless that bill goes through the hands of the Chief Engineer. It does not make any difference whether it is a bill for track laying, which in nearly all cases is done by forces under the Superintendent, or the bill of a contractor under the control of the Chief Engineer, or a bill from the legal department. If the legal department wishes to charge against an authorized piece of work, that department should have some way of notifying the Chief Engineer that it has made the charge, and thereby furnish a record. Of course, there are many roads that do not follow the plan I describe; but the point I make is that it is an easy matter to route the bills so that the Chief Engineer shall get a record of them. It is seldom my office is obliged to go into the Comptroller's office to find a bill that has slipped through without any record thereof. We are working in close touch with the Comptroller—of course he is the grand assembler of all accounts—but his office works in close touch with mine; and everything goes on easily, and we secure our record. As far as expense goes, it means to my office the cost of one good clerk to carry this system through.

The President:—The Committee would like an official expression on conclusion No. 3, as to whether it meets the views of the convention or not. The Committee desires that some member make a motion either for or against the adoption of conclusion No. 3. The expression of the Association will then indicate to the Committee somewhat their method of work for the coming year.

Mr. Churchill:—I move that the conclusion be approved.

(The motion was carried.)

The President:—The Secretary will read conclusion No. 4.

The Secretary:—"(4) No special forms are required in a proper system of Maintenance of Way Office records of the designs of bridges and culverts. Such records should be kept in accordance with the following system:

"(a) The Chief Engineer, or other officer having in charge the design and care of bridges, trestles, and culverts, should keep on file in his office complete plans of every structure showing all its details, its location and the physical characteristics of the territory within a reasonable distance of the structure.

"(b) When changes in the design of any structure are made, a record of the changes should be reported to the head office and the record plans should be at once brought up-to-date.

"(c) Division officers having in charge the maintenance of bridges should keep on file in their offices blue prints of the general and detail plans of all bridges, trestles and culverts, and these prints should be furnished from the office of the Chief Engineer or other officer in charge of the design.

"(d) Photographs of the record tracings of bridges should be prepared and furnished to division or other officers for use in the field. These photographic copies would be of standard sizes and kept in atlas form.

"(e) The record of the condition of the bridges should be kept in accordance with the system outlined in the Manual of Recommended Practice, pp. 98-103."

Mr. Wendt:—By way of explanation, I would state that in former years the Committee reported in regard to the method for recording the results of the inspection of bridges. Therefore this report does not touch upon that point. It covers the maintenance of way office records or the design of bridges and culverts.

The President:—If there is no objection, conclusion No. 4 will stand approved as read. The Committee desires that conclusion No. 5 be read and referred back to them.

The Secretary:—"(5) The Committee makes no recommendation in regard to conventional signs, except that the subject, after being discussed by the convention, be referred back to the Committee for further study and report."

The President:—If there is no objection, conclusion No. 5 will be referred back to the Committee.

The Secretary:—"(6) A profile showing complete information respecting the rate of progress of work pertaining to the different features of a railroad is necessary, and the standard 'Progress Profile,' form M. W. 1015, is recommended as good practice."

The President:—The Committee desires that conclusion No. 6 be discussed and either adopted or altered with a view to publication in the Manual. The progress profile shown on the plate is a typical section prepared by Mr. Tye, of the Canadian Pacific, showing their practice.

Mr. Tye:—I desire to say that we use this for new lines. I do not know whether it would well fit the progress profile where you were simply making improvements on existing lines.

The President:—The chair would say that in grade revision work he uses almost an identical profile and has no difficulty.

Mr. Tye:—Yes, on grade revision; but I mean on very small work.

The President:—Changes of two and three feet, as well as heavy changes, show up very plainly on this profile.

Mr. Tye:—We use them for that, too.

Mr. Wendt:—The Committee received a number of profiles from different railroads. It was necessary to settle on some general form, and this one seemed to meet the requirements so excellently that it was adopted.

The Secretary:—"(7) A track chart showing complete information respecting the grade, alinement and other physical features of a railroad is necessary, and the 'Track Chart,' form M. W. 1016, is recommended as good practice."

The President:—The Committee would like to have the convention indicate its approval or disapproval of the track chart submitted.

Mr. Tye:—It is not very clear how the weight of rail is to be shown. I notice it is indicated by different colors.

Mr. Wendt:—The illustration is somewhat defective, therefore does not show up properly.

Mr. Buck:—I would suggest that the item of "Make of Rail" be inserted following the items of weights of rail, instead of being placed further down among other subject matters.

Mr. McDonald:—Is it the understanding that if this track chart is adopted, the Committee will finally make their conventional signs to conform to it?

Mr. Wendt:—While this track chart unfortunately does show some conventional signs, we are not certain that these will be the ones which the Committee will recommend a year hence. As there are many other details of our work which have not been finally passed upon by the Association, we will have to consider this with the understanding that when standards are adcpted the work of the Manual shall be brought up-to-date.

Mr. McDonald:—I move an amendment to conclusion No. 7 to the effect that a track chart in general form similar to that shown be adopted, because if we adopt this as it exists we are adopting many conventional signs that we have not passed upon at all.

The President:—The chairman of the Committee suggests that this same end could be attained by adopting the conclusion as read, with the modification, "except the conventional signs, which are subject to the later action of the convention," and the Committee will embody that phraseology in the conclusion.

If there are no objections, conclusions 6 and 7 will stand approved as amended. The Committee states that all the points they desire to bring before the convention are now covered. The Committee desires suggestions from the members concerning the work for the coming year. There being no suggestions, the Committee will be relieved with the thanks of the Association.

REPORT OF SPECIAL COMMITTEE ON CLASSIFICATION OF TRACK.

To the Members of the American Railway Engineering and Maintenance of Way Association:

Your Committee on Classification of Track begs to submit the following report for adoption:

Recommended, that when a district of a railway has reached the conditions of traffic hereinafter specified, it shall be placed in one of the following classes:

Class "A" shall include all districts of a railway having more than one main track, or those districts of a railway having a single main track with a traffic that equals or exceeds the following:

Freight car mileage passing over district per year per mile.......150,000
or, Passenger car mileage per annum per mile of district.......... 10,000
with maximum speed of passenger trains of 50 miles per hour.

Class "B" shall include all districts of a railway having a single main track with a traffic that equals or exceeds the following:

Freight car mileage passing over district per year per mile........50,000
or, Passenger car mileage per annum per mile of district.......... 5,000
with maximum speed of passenger trains of 40 miles per hour.

Class "C" shall include all districts of a railway not meeting the traffic requirements of Classes "A" or "B."

The statistics collected by the Committee, on which the above conclusions are based, are printed herewith as an appendix.

Respectfully submitted,

CHAS. S. CHURCHILL, Chief Engineer, Norfolk & Western Railway, Roanoke, Va., *Chairman.*

W. M. CAMP, Editor, *Railway and Engineering Review,* Chicago, Ill., *Vice-Chairman.*

C. H. ACKERT, Vice-President, Southern Railway, Washington, D. C.

D. D. CAROTHERS, Chief Engineer, Baltimore & Ohio Railroad, Baltimore, Md.

W. C. CUSHING, Chief Engineer Maintenance of Way, S. W. Sys., Pennsylvania Lines, Pittsburg, Pa.

W. A. GARDNER, Vice-President, Chicago & Northwestern Railway, Chicago, Ill.

W. J. HARAHAN, Vice-President, Illinois Central Railroad, Chicago, Ill.

WM. HUNTER, Chief Engineer, Philadelphia & Reading Railway, Philadelphia, Pa.

J. KRUTTSCHNITT, Director Maintenance and Operation, Harriman Lines, Chicago, Ill.

WM. MICHEL, Engineer Maintenance of Way, Hocking Valley Railway, Columbus, O.

C. A. WILSON, Chief Engineer, Cincinnati, Hamilton & Dayton Railway, Cincinnati, O.

H. R. WILLIAMS, President, Pacific Railway, Seattle, Wash.

Committee.

NAME OF ROAD	Maximum weight of Locomotives in Freight Service without tender.	Maximum weight of Locomotives in Freight Service including tender.	Maximum single axle load of Locomotives in Freight Service.	Maximum weight of Locomotives in Passenger Service without tender.	Maximum weight of Locomotives in Passenger Service including tender.	Maximum single axle load of Locomotives in Passenger Service.	Maximum single axle load of Loaded Freight Car.	Maximum schedule speed of Freight Trains.	Maximum schedule speed of Passenger Trains.	Maximum actual speed of Freight Trains.	Maximum actual speed of Passenger Train.	Freight train miles per annum per mile of division.	Passenger train miles per annum per mile of division.	Freight tonnage per mile per year.	[illegible]	Total car Mileage per mile of division.	[illegible] Mileage.	[illegible]	[illegible]	[illegible]	No. of Tracks
ALABAMA GREAT SOUTHERN																					
Chattanooga to Birmingham	200,000	320,000	45,000	172,000	292,000	43,520	36,000	....													Single.
Birmingham to Meridian	159,000	259,500	34,800	144,000	244,500	36,000	36,000	....													"
Chattanooga to Meridian	......	......	......	....	...	.....	...	19.95	30	40	65	3,551	2,609	[illegible]	[illegible]	83,108	14,842				"
ATLANTIC COAST LINE:																					
Richmond to Savannah	155,000	256,000	38,000	155,000	256,000	38,000	32,000	20	41.39	30	60			4,161,302		......		5.68	18.32	56	Single.
Norfolk to Columbia (via Wilm.)	155,000	256,000	38,000	130,000	216,000	38,000	32,000	18	33	30	60					....					"
Savannah to Jacksonville	171,000	274,000	38,000	156,000	259,000	36,000	32,000	18.20	38.28	30	60			3,619,741		.....		5.68	18.32	56	"
Jacksonville to Port Tampa	112,000	187,000	31,000	105,000	185,000	32,000	32,000	10.53	28.30	30	60										"
BALTIMORE & ANNAPOLIS SHORT LINE	98,000	161,000	49,000	78,000	130,000	35,500	38,500	15	33	15	33	812	5,080				13,241				"
BALTIMORE & OHIO *																					
Philadelphia to Baltimore	168,700	263,500	38,500	156,100	257,100	39,000	36,500					9,145	8,539	5,567,415	5,857,103	207,608	42,028				Double.
Baltimore to Brunswick	210,000	349,000	45,850	177,000	323,000	54,000	36,500					7,164	8,076	12,086,447	13,041,883	221,210	38,077				"
Harper's Ferry to Staunton	108,600	173,600	24,000	94,300	162,300	31,500	27,250					1,397	1,452	701,326	725,219	19,352	6,049				Single.
Brunswick to Grafton	193,500	336,500	43,250	177,000	320,000	54,000	36,500					15,116	4,649	6,452,996	7,312,195	196,968	31,770				Double.
Grafton to Parkersburg	193,500	336,500	43,250	177,000	320,000	54,000	36,500					3,207	1,875	16,187,192	17,271,986	58,725	9,499				Single.
Grafton to Wheeling	193,500	336,500	43,250	177,000	320,000	54,000	36,500					7,383	2,963	6,863,412	7,234,463	202,871	16,061				"
Wheeling to Chicago Junction	193,500	336,500	43,250	141,200	231,200	37,400	36,500					5,060	2,461	6,983,513	8,135,843	116,177	11,660				"
Wheeling to Lorain	193,500	336,500	43,250	109,200	169,200	37,400	36,500					4,437	2,169	7,922,627	8,392,059	108,689	7,308				Sin. & Dble.
Wheeling to Kenova	124,600	184,600	25,000	109,200	169,100	37,400	30,000					1,916	2,261	1,591,002	1,885,160	35,608	8,044				Single.
Cumberland to Connellsville	193,500	336,500	43,250	149,600	250,600	41,940	36,500					4,468	2,293	9,621,816	10,315,254	109,799	12,248				Double.
Pittsburg to New Castle Junction	193,500	336,500	43,250	149,600	250,600	41,940	36,500					8,016	6,056	13,575,422	14,787,461	221,042	27,691				"
New Castle Junction to Chicago Junction	193,500	336,500	43,250	149,600	250,600	41,940	36,500					6,022	1,620	8,996,344	9,378,285	177,441	9,004				Sin. & Dble.
Chicago Junction to Chicago	193,500	336,500	43,250	177,000	320,000	54,000	36,500					6,714	3,883	5,959,654	6,384,948	280,542	22,790				" "
BALTIMORE & OHIO SOUTHWESTERN:																					
Cincinnati to Columbus and Belpre	162,580	288,380	38,780	177,000	320,000	54,750	39,050	20.6	37.6	40	70	1,510	3,429	3,499,386	3,989,508	140,912	17,690				Sin. & Dble.
Cincinnati to Louisville and Washington, Ind.	162,580	288,380	38,780	177,000	320,000	54,740	39,050	18.7	41.1	40	60	3,091	3,746	4,311,831	4,685,085		10,403				" "
Washington to St. Louis and Springfield Division	162,580	288,380	38,780	177,000	320,000	54,750	39,050	18.1	39.5	30	65	1,681	2,307	2,138,514	2,320,716	43,974	11,763				Single.
BELLINGHAM BAY & BRITISH COLUMBIA:																					
Bellingham to Glacier	133,000	203,000	29,750	82,000	140,000	28,000	33,000	20	30	25	50	1,107	965	270,454		11,560	3,262		97.15	2.84	Single.
BOSTON ELEVATED RAILWAY:	......	...		60,000	80,000	21,000			35		40	...	313,000				1,054,000		...		Double.
CAMMAL & BLACK FOREST:																					
Cammal to Pump Station	100,000	125,000	...	50,000	70,000			15	25	...		36,000	12,000		....		......				Single.
Pump Station to Carnett	100,000	125,000	.....	50,000	70,000	....		15	25	...		36,000	2,000			..			...	...	"
Pump Station to County Line	100,000	125,000		50,000	70,000		.....	12	20	...		2,000	12,000		....	....				.....	"
CANADIAN PACIFIC:																					
Brownville Jct. to Megantic	190,000	312,000	51,575	173,830	300,430	49,100	40,000	22	40	30	50	2,300	734		1,474,556	44,199	6,405	16	79	5	Single.
Montreal to Smith's Falls	172,000	298,000	45,000	173,830	300,430	49,100	40,000	22	40	30	50	4,784	3,684	....	5,066,548	162,044	14,590	20	77	3	Single. 20 Double
Chalk River to North Bay	192,125	314,125	51,775	192,125	314,125	51,775	40,000	22	40	30	50	2,147	1,860	.....	2,386,043	61,454	15,395	10	89	1	Single.
CAROLINA & NORTHWESTERN:																					
Chester to Lenoir	108,600	162,000	30,000	62,000	84,000	21,000	31,000	10	25	24	40	924	682	119,871	621,437	560,512	269,425	2.03	64.46	33.51	Single.
CENTRAL NEW ENGLAND:																					
Hartford to Poughkeepsie Jct.	137,000	238,700	34,060	105,200	196,000	33,500	32,500	20	40	30	50	1,593	1,719	939,754	945,000	25,485	5,605	2.17	39.63	58.2	Single.
CENTRAL OF GEORGIA:																					
Savannah to Macon	192,000	314,000	44,500	190,000	322,000	44,500	37,600	20	30	40	60	2,935	3,507	862,784	968,194	93,150	17,032	...	...		"
Macon to Atlanta	192,000	314,000	44,500	190,000	322,000	44,590	37,600	20	30	40	60	6,760	6,905	1,326,679	1,559,761	138,745	29,068	..	.	..	"
Columbus to Birmingham	192,000	314,000	44,500	101,550	178,250	32,200	37,600	12	28	25	45	4,084	3,249	852,160	1,142,133	87,981	12,026	...	.		"
Southwestern Division	192,000	314,000	44,500	101,550	178,250	32,200	37,600	20	30	40	60	3,203	3,664	569,772	715,505	65,339	11,402	.....	.....	......	"

*The Mallett is now in use on Connellsville Division; weight, 334,000 lbs., on drivers, 55,600 lbs.
It should be understood figures for engine weights do not cover weights permissible on the different divisions, but weight of engines in use on B. & O. R. R.

TRAFFIC STATISTICS OF AMERICAN RAILWAYS USED IN CLASSIFYING TRACK—Continued.

NAME OF ROAD	Maximum weight of Locomotives in Freight Service without tender	Maximum weight of Locomotives in Freight Service including tender	Maximum single axle load of Locomotives in Freight Service	Maximum weight of Locomotives in Passenger Service without tender	Maximum weight of Locomotives in Passenger Service including tender	Maximum single axle load of Locomotives in Passenger Service	Maximum single axle load of Loaded Freight Car	Maximum schedule speed of Freight Trains	Maximum schedule speed of Passenger Trains	Maximum actual speed of Freight Trains	Maximum actual speed of Passenger Trains	Freight train miles per annum per mile of division	Passenger train miles per annum per mile of division	Revenue Tonnage passing over division per year	Approximate Gross Tonnage passing over division per year	Freight Car Mileage per annum per mile of division	Passenger Car Mileage per annum per mile of division	Per cent of live stock, refrigerator and fruit traffic	Per cent of merchandise traffic	Per cent of mineral traffic	No. of Tracks.
CENTRAL VERMONT																					
Northern Division	192,500	327,800	43,200	147,000	269,700	40,900	24,350	25	50	35	70	3,150	2,006	2,396,920	2,519,907	66,604	9,729	5.38	82.7	11.9	Single.
Southern Division	121,000	207,000	31,800	94,000	170,000	31,200	23,150	20	40	30	50	3,300	2,150	1,525,305	1,568,088	11,371	667	1.1	86.99	11.91	"
CHESAPEAKE & OHIO:																					
Old Point to Gladstone	186,225	303,625	41,720	147,000	229,500	38,400	35,500	25	50	30	65										Sin. & Dble.
Gladstone to Clifton Forge	186,225	303,625	41,720	147,000	229,500	38,400	35,500	18	40	30	60										Sin. & Dble.
Clifton Forge to Russell	186,225	303,625	41,720	190,000	313,400	44,000	35,500	20	40	30	60	4,032	2,080	13,304,791		133,692	10,436	1.53	31.19	67.28	Sin. & Dble.
Russell to Cincinnati	186,225	303,625	41,720	169,000	297,750	44,433	35,500	18	55	30	70										
Lexington to Prestonburg	99,000	170,900	26,000	76,900	158,400	24,800	35,500	17	35	30	60										Single
Whitcomb to Barton.	121,000	203,500	26,200	76,900	138,400	24,800	35,500	12	24	25	40										"
CHICAGO & EASTERN ILLINOIS																					
Chicago to Terre Haute	187,000	307,000	48,000	180,000	310,000	52,000	37,500	27	42	35	65	3,960	2,540	2,931,491	3,085,379	99,286	12,182				Double.
Chicago to St Louis	187,000	307,000	48,000	180,000	310,000	52,000	37,500	27	42	35	65	2,621	1,639	1,070,607	1,139,449	64,433	7,379				"
St Elmo to Thebes.	187,000	307,000	48,000	116,000	199,000	40,000	37,500	20	27	30	45	....									Single.
Momence to Brazil	187,000	307,000	48,000	116,000	198,000	40,000	37,500	20	27	35	55	1,580	850	517,827	514,506	16,865	2,500				"
CHICAGO & NORTHWESTERN																					
Galena Division	162,500	302,500	42,000	158,000	298,000	45,500	30,000	19	43	21	46	4,555	4,601		34,491	127,235	22,231		....		Double.
Iowa Division	162,500	302,500	42,000	158,000	298,000	45,500	30,000	18	42	19	44	4,845	3,302		43,196	115,870	24,941				"
Wisconsin Division	162,500	302,500	42,000	158,000	298,000	45,500	30,000	19	44	22	48	5,111	8,589		42,809	150,219	47,651		....		"
Madison Division	162,500	302,500	42,000	158,000	298,000	45,500	30,000	19	38	20	41	3,047	2,465		23,141	74,862	11,605				"
Peninsula Division	162,500	302,500	42,000	137,000	247,800	37,400	30,000	16	34	18	39	2,015	1,152		15,080	53,516	6,015		...		Single.
Ashland Division	162,500	302,500	42,000	109,200	247,800	43,500	30,000	14	31	16	34	2,161	1,410		12,199	43,552	6,434				"
Nebraska & Wyoming Division	139,100	240,700	34,300	139,100	240,700	43,500	30,000	15	29	16	33	1,667	877		7,087	27,553	3,186				"
Minnesota Division	125,900	234,100	34,100	126,900	208,300	34,100	30,000	17	27	19	34	2,031	1,262		9,954	32,329	7,092	...			"
Northern Iowa Division	88,550	170,550	28,400	88,550	170,550	28,400	35,000	13	25	15	30	2,330	860		11,191	15,290	3,294				"
Northern Wisconsin Division	153,000	263,800	39,450	88,550	170,550	28,400	35,000	15	33	18	40	2,559	1,927		19,110	71,011	10,234				"
CHICAGO, BURLINGTON & QUINCY																					
Galesburg Division	200,000	320,000	48,500	183,000	304,000	49,000	35,000	29	58	35	60	3,615	2,557	1,337,551	3,513,049	112,285	13,884				Double.
Beardstown Division	127,000	201,000	38,000		.		35,000	18	25	25	50	2,767	1,156	736,814	456,612	113,705	5,530				Single.
La Crosse Division	180,000	301,000	45,000		.	....	35,000	18	35	25	60	3,201	1,619	1,835,851	3,551,364	58,552	10,187				"
CHICAGO GREAT WESTERN																					
St Paul to Oelwein	192,300	310,300	48,500	177,700	300,300	47,825	27,820	18	37	40	60	2,600	4,000	571,920		40,000	21,400				Single.
Oelwein to Chicago	192,300	310,300	48,500	177,700	300,300	47,825	27,820	18	39	40	60	4,150	2,800	1,402,800		136,000	16,460				"
Oelwein to Kansas City	192,300	310,300	48,500	139,475	212,600	44,358	27,820	23	36	40	60	2,500	2,600	950,340		61,000	11,500				"
Oelwein to Omaha	192,300	310,300	48,500	112,600	203,700	47,825	27,820	16	38	40	60	1,450	2,700	656,476		29,500	9,300				"
CHICAGO, INDIANAPOLIS & LOUISVILLE																					
Chicago to Lafayette	180,700	333,700	42,000	167,500	295,000	46,750	38,000	19	41	30	70										Single
Lafayette to New Albany	184,600	314,600	38,000	157,500	257,000	42,000	38,000	19	32	30	70										"
Monon to Michigan City	184,600	314,600	38,000	157,500	257,000	42,000	38,000	13	29	30	50										"
Monon to Indianapolis	184,600	314,600	38,000	167,500	295,000	46,750	38,000	19	40	30	70			2,965,945		66,100	11,000				"
Bedford to Switz City	109,000	185,000	26,400	109,000	185,000	26,000	38,000	12	12	25	25										"
Orleans to French Lick	109,000	193,000	33,500	108,000	192,000	33,500	38,000	10	27	20	15										"
CHICAGO, ST PAUL, MINNEAPOLIS & OMAHA																					
St Paul to Elroy	167,400	279,850	40,450	189,700	318,700	41,534	26,425	20.5	32.5	35	50										
St Paul to Duluth	167,400	279,850	40,150	130,700	238,200	41,350	26,425	20.5	35	35	50	3,335	1,930	3,306,488	3,821,090	61,364	11,229	8	72	20	576 Sin. 29 Double.
St Paul to Sioux City	158,000	264,000	40,084	130,700	238,200	41,350	26,425	22	34	35	50	1,779	2,364	1,763,460	2,038,383	43,754	12,705	18	67	15	620 " 7 "
Sioux City to Omaha	146,300	251,600	36,934	92,500	166,100	30,506	26,425	21	29	35	45	1,384	1,133	440,865	599,597	21,837	5,664	30	58	12	277 " 1.7 "
CINCINNATI, NEW ORLEANS & TEXAS PACIFIC																					
Burgin to Somerset	200,000	320,000	45,000	122,000	220,000	28,000	28,000														Single
Ludlow to Somerset	122,000	216,000	26,800	122,000	220,000	28,000	28,000														"
Somerset to Chattanooga	...	.....					...	20	36.4	35	55	5,087	3,732			159,613	22,371				"
Cincinnati to Chattanooga	122,000	216,000	26,800	122,000	220,000	28,000	28,000	21	38.5	35	55	5,656	3,449	1,026,287	1,671,221	171,904	21,462				"

TRAFFIC STATISTICS OF AMERICAN RAILWAYS USED IN CLASSIFYING TRACK.—Continued

NAME OF ROAD.	Maximum weight of Locomotives in Freight Service without tender	Maximum weight of Locomotives in Freight Service including tender	Maximum single axle load of Locomotives in Freight Service	Maximum weight of Locomotives in Passenger Service without tender	Maximum weight of Locomotives in Passenger Service including tender	Maximum single axle load of Locomotives in Passenger Service	Maximum single axle load of Loaded Freight Car	Maximum schedule speed of Freight Trains	Maximum schedule speed of Passenger Trains	Maximum actual speed of Freight Trains	Maximum actual speed of Passenger Trains	Freight train miles per annum per mile of division	Passenger train miles per annum per mile of division	Revenue tonnage per mile of division per year	Approximate car tonnage per mile ... per year	Freight car miles per mile ...	Passenger car miles per annum per mile of ...	[illegible]	[illegible]	[illegible]	No. of Tracks
CINCINNATI, HAMILTON & DAYTON:																					
Cincinnati to Toledo	171,000	287,000	37,500	136,000	242,000	37,500	40,000	20	42	45	70	5,648	6,251	[illegible]		171,156	29,410				Sin. & Dble.
Hamilton to Indianapolis	171,000	287,000	39,500	136,000	242,000	37,500	40,000	20	42	45	70	3,770	4,121	1,164,930		96,565	20,455				Single
Indianapolis to Springfield	122,600	176,000	35,300	119,000	203,000	39,000	31,000	18	35	30	50	1,361	1,641	420,549		20,660	5,278				"
Dayton to Wellstown	122,600	176,000	35,300	119,000	203,000	39,000	31,000	18	35	30	50	4,214	919	1,302,126		84,307	3,996				
Dayton to Delphos	100,200	150,000	24,700	100,200	150,000	24,700	31,000	12	25	29	40	997	1,299	308,075		11,568	3,527				"
Findlay to Ft. Wayne	100,200	150,000	24,700	100,200	150,000	24,700	31,000	12	25	20	40	684	1,459	211,356		9,758	3,764				
COAL & COKE RAILWAY:																					
Charleston to Gassaway	185,000	285,000	31,250	102,000	174,000	38,000	31,000	10	20	15	30	805	1,288	[illegible]	[illegible]	[illegible]	3,313	2	[illegible]	12.4	Single
Leiter to Adrian	185,000	285,000	42,500	102,000	174,000	38,000	31,000	10	20	15	30										
Belington to Mabie	185,000	285,000	42,500	102,000	140,000	38,000	31,000	10	20	15	30	2,063		[illegible]	[illegible]	8,000	1,948	[illegible]	11.4	88.4	
COLORADO MIDLAND:																					
Colorado Springs to Divide	183,900	310,800	46,300	183,900	310,800	46,500	....	15	30	15	27										Single
Divide to Florissant	183,900	310,800	46,300	183,900	310,800	46,300	....	18	35	20	35										"
Florissant to Bath	183,900	310,800	46,300	130,450	220,000	39,225	...	15	17	15	15										"
Bath to Leadville	156,150	266,400	43,100	130,450	220,000	39,225	.....	15	22	15	20										"
Leadville to Basalt	156,150	266,400	43,100	135,450	223,150	37,650	...	20	19	20	17	1,325	1,354	[illegible]	[illegible]	24,844	5,655	4.5	19.9	75.6	"
Basalt to New Castle	156,150	266,400	43,100	119,600	205,700	35,100		11	35	10	35										"
New Castle to Grand Junction	128,300	221,500	38,175	119,600	205,700	35,100		18	40	15	37										"
Cardiff to Spring Gulch	128,300	221,500	38,175	....	......	....		10	10	10	10										"
Basalt to Aspen	128,300	221,500	38,175	......	......	......		18	18	18	18										"
COLORADO SPRINGS & CRIPPLE CREEK DISTRICT	170,000	276,000	38,000	170,000	276,000	38,000	25,000	12	23	12	30	1,734	1,776	418,124	1,166,822	15,190	5,395	0.5	6.8	92.[illegible]	"
COPPER RANGE	168,000	268,300	40,000	140,000	224,000	40,000	27,000	15	30	30	60	1,910	4,24[illegible]	1,835,842	1,830,000	19,309	1,822	1	9.9	90	"
CUMBERLAND & PENNSYLVANIA	174,000	257,200	45,500	146,500	208,750	34,250	36,125	20	40	10	30	15,084	2,482	[illegible]	[illegible]	68,797	6,783		4.1	95.9	"
CUMBERLAND VALLEY:																					
Martinsburg to Harrisburg	195,000	339,000	46,000	113,700	183,400	39,200	37,500	30	60	45	70	6,132	5,269	1,774,402	[illegible]	180,749	23,120	1.2	28.8	20	72 Sin., 22 Double
Winchester to Martinsburg	108,000	168,000	24,000	113,700	183,400	39,200	37,500	20	50	35	60	623	1,872	[illegible]	[illegible]	165,861	19,409	0.8	24.8	74.4	
DELAWARE, LACKAWANNA & WESTERN:																					
Binghamton to Washington	200,000	320,000	51,333	201,000	321,000	46,500	34,300	19.3	41			7,917	3,809			55,596	8,369				Double
Buffalo to Binghamton	178,000	298,000	39,375	140,000	247,600	46,500	34,300	20	50			4,887	2,685			151,579	14,847				"
Binghamton to Oswego	115,000	185,000	33,330	102,500	180,000	37,650	34,300	15	33			2,361	3,269	[illegible]		[illegible]	16,184	[illegible]	[illegible]	[illegible]	Single
Chenango Forks to Utica	118,000	192,300	34,230	112,000	189,000	40,000	34,300	15	33			3,128	964			61,844	20,953				"
Hoboken to Washington	186,000	306,000	51,333	201,000	321,000	46,500	34,300	20.4	30			6,478	4,198			158,038	63,526				Double
Portland to Easton	130,000	200,000	33,800	84,000	150,500	36,000	34,300	15	21			1,726	1,467			36,583	1,147				Single
DULUTH, SOUTH SHORE & ATLANTIC AND MINERAL RANGE:																					
Sault Ste. Marie to Marquette	100,000	162,000	28,000	95,000	150,000	29,000	22,500	14.5	30	20	34	1,356	1,356	420,000	250,000	22,000	6,500				Single
Marquette to Houghton	100,000	162,500	28,000	95,000	150,000	29,500	22,500	14	25	20	35	2,756	2,100	750,000	300,000	36,000	8,500				"
Nestoria to Duluth	96,600	155,000	26,000	95,000	150,000	29,000	22,500	13	28	20	31	1,356	1,356	200,000	120,000	25,000	5,000				"
Houghton to Calumet	193,000	308,000	44,000	95,000	150,000	29,000	30,000	14	25	20	30	2,100	2,100	150,000	150,000	36,000	3,500				"
EL PASO & SOUTHWESTERN	224,000	369,500	47,330	153,000	252,800	39,330	37,000	23	38	30	60	1,225	887	[illegible]	[illegible]	[illegible]	[illegible]		10	[illegible]	"
ERIE:																					
Jersey City to Port Jervis	202,000	369,000	47,000	182,900	319,900	45,000	37,700	20.6	40.2	[illegible]	[illegible]	[illegible]	[illegible]	8,582,617	9,257,130	623,049	105,217				Double
Port Jervis to Susquehanna	209,000	339,000	47,000	182,900	319,900	45,000	37,700	22.3	39.1	24.1	41.7	11,258	[illegible]	7,575,084	8,222,061	510,213	37,049	...			"
Susquehanna to Hornellsville	202,000	339,400	47,000	151,900	267,800	44,200	37,700	21	42.4	27.5	42.7	12,708	[illegible]	[illegible]	9,405,899	563,139	39,514				"
Hornellsville to Salamanca	200,700	337,700	47,700	151,500	267,500	44,200	37,700	19.1	37	20.7	39.3	[illegible]	[illegible]	[illegible]	4,728,561	284,982	31,552				Single
Salamanca to Meadville	200,700	337,700	47,700	186,700	323,700	48,400	37,700	24	40.5	29.3	42.7										"
Meadville to Kent	200,700	337,700	47,700	186,700	323,700	48,400	37,700	20.1	[illegible]	[illegible]	40.1	[illegible]	[illegible]	4,801,797	[illegible]	259,929	[illegible]				"
Kent to Galion	202,000	339,000	47,000	186,700	323,700	48,400	37,700	20.5	37.6	23	40										
Galion to Huntington	202,000	339,000	47,000	186,700	323,700	48,400	37,700	21.2	37.8	21.7	[illegible]	[illegible]	[illegible]	[illegible]	4,555,036	182,332	19,715	...			Sin. & Dble.
Huntington to Chicago	202,000	339,000	47,000	186,700	323,700	48,400	37,700	19.4	37.2	22.5	39.8	6,118	3,488	[illegible]	[illegible]	195,195	23,441				Single
Youngstown to Cleveland	202,000	339,000	47,000	186,700	323,700	48,400	37,700	12.1	41.2	13.3	45.4	12,507	7,364	9,457,556	9,860,281	344,216	40,666	....			Double

TRAFFIC STATISTICS OF AMERICAN RAILWAYS USED IN CLASSIFYING TRACK.—Continued.

NAME OF ROAD	Maximum weight of Locomotives in Freight Service without tender	Maximum weight of Locomotives in Freight Service including tender	Maximum single axle load of Locomotives in Freight Service	Maximum weight of Locomotives in Passenger Service without tender	Maximum weight of Locomotives in Passenger Service including tender	Maximum single axle load of Locomotives in Passenger Service	Maximum single axle load of Loaded Freight Car	Maximum schedule speed of Freight Trains	Maximum schedule speed of Passenger Trains	Maximum actual speed of Freight Trains	Maximum actual speed of Passenger Trains
EVANSVILLE & TERRE HAUTE											
Evansville to Terre Haute	160,900	260,900	38,500	[illegible]	243,500	42,000	35,000	19	51	48	65
Straight Line Jct. to Spring Hill	100,000	165,000	29,000	[illegible]	117,800	21,200	28,500	15	34	35	48
Mt. Vernon Jct. to Mt. Vernon	100,000	165,000	29,000	[illegible]	117,800	21,200	28,500	14	23	36	36
FORT WORTH & DENVER CITY	158,000	274,000	17,700	[illegible]	220,700	16,333	23,825	18	31	25	45
GRAND RAPIDS & INDIANA											
Richmond to Mackinac City	165,900	280,300	49,000	[illegible]	224,330	36,175	36,250				
Richmond to Grand Rapids	..		......	....				14	18	30	55
Grand Rapids to Mackinac City			......	....				20	35	40	63
Richmond to Fort Wayne			......	....							
Fort Wayne to Grand Rapids		......	......	....			....	...		...	
GRAND TRUNK RAILWAY SYSTEM	161,976	292,832	47,264	[illegible]	308,028	47,264	35,950	25	48.5	35	60
GREAT NORTHERN											
Duluth to Cass Lake	197,000	320,000	45,000	1?2,000	272,000	40,000	37,000	13.2	29.6	30	60
Wayzata to Willmar	182,000	289,000	37,500	164,000	278,000	44,500	31,000	14	31.6	30	60
Willmar to Larimore	182,000	289,000	37,500	164,000	287,000	44,500	31,000	16.2	33.2	30	60
Larimore to Minot	195,500	318,500	45,000	1?4,000	287,000	44,500	31,000	13.6	39.8	30	60
HALIFAX & YARMOUTH	85,000	132,000	28,500	85,000	132,000	28,500	20,000	25	25	35	35
HOCKING VALLEY	152,800	254,800	33,000	1?5,700	243,800	29,250	30,000	15	41	25	70
ILLINOIS CENTRAL											
Chicago Division	188,000	335,600	48,475	2?1,800	349,400	51,000	37,125	20	41	40	75
St. Louis Division	221,450	329,050	46,200	1?8,000	335,600	51,000	37,125	20	41	40	75
Springfield Division	188,700	335,600	47,475	149,700	237,700	40,500	37,125	20	41	40	75
Freeport Division	188,000	335,600	48,475	188,000	335,600	51,000	37,125	20	41	40	75
Dubuque Division	157,200	259,200	40,723	188,000	335,600	51,000	37,125	20	41	40	75
Omaha Division	126,000	206,000	35,466	149,700	237,700	41,950	37,125	20	41	40	75
Louisville Division	157,200	259,200	40,723	149,7??	237,700	38,953	37,125	20	41	40	75
Tennessee Division	188,000	335,600	48,475	188,000	335,600	51,000	37,125	20	41	40	75
Mississippi Division	137,300	217,300	35,466	188,000	335,600	51,000	37,125	20	41	40	75
Louisiana Division	126,000	206,000	35,466	149,700	237,700	38,933	37,125	20	41	40	75
INTERNATIONAL & GREAT NORTHERN											
Longview to Galveston	170,000	284,000	43,200	148,000	262,000	34,600	35,000	20	35	30	60
Palestine to Laredo	150,000	264,000	34,600	148,000	262,000	34,600	35,000	20	35	30	60
Fort Worth to Spring	170,000	284,000	43,200	88,000	174,000	27,000	35,000	15	35	20	45
IOWA CENTRAL:											
Albert Lea to Albia	166,000	274,000	43,200	10?,000	180,000	32,000	37,500	17	23	45	55
Oskaloosa to Keithsburg	114,000	192,000	32,000	102,000	180,000	32,000	37,500	16	3?	40	50
Keithsburg to Peoria	111,000	192,000	32,000	102,000	180,000	32,000	37,500	15	26	40	45
Hampton to Belmond	84,000	162,000	27,000	84,000	162,000	27,000	37,500	20	20	35	35
Belmond to Algona	84,000	162,000	27,000	84,000	162,000	27,000	37,500	20	20	35	35
Marshalltown to Story City	84,000	162,000	27,000	84,000	162,000	27,000	37,500	12	20	30	35
Newburg to State Center	84,000	162,000	27,000	84,000	162,000	27,000	37,500	14	14	30	30
Grinnell to Montezuma	71,400	138,400	21,900	71,400	138,400	21,000	37,500	20	20	35	35
New Sharon to Newton	84,000	162,000	27,000	84,000	162,000	27,000	37,500	15	15	30	30
LAKE SUPERIOR & ISHPEMING, MARQUETTE & S. E., AND MUNISING RAILWAYS											
Presque Isle to Ishpeming	205,000	347,000	45,500	1?5,700	175,200	32,600	35,500	15	2?	[illegible]	[illegible]
West Yard to Lawson	148,000	218,600	37,300	1?5,700	175,200	32,600	30,000	12	2?	[illegible]	30
Munising to Little Lake	148,000	218,600	37,300	1?5,700	175,200	32,600	30,000	10	25	[illegible]	30
LEHIGH & HUDSON:	125,800	287,800	40,400	1?0,000	172,000	33,500	28,000	12	35	20	45
LONG ISLAND:	175,000	271,350	46,400	1??,000	271,350	51,300	31,500	30	52	40	70
LOUISIANA & ARKANSAS	146,800	315,780	54,900	[illegible]	105,000	19,000	23,975	10	23	15	35

NAME OF ROAD	Freight train miles per annum per mile of division	Passenger train miles per annum per mile of division	Revenue tonnage per [illegible]	Approximate Gross Tonnage passing over division per year	Freight Car Mileage per annum per mile of division	Passenger Car Mileage per annum per mile of division	Per cent of live stock, refrigerator and fruit traffic	Per cent of merchandise traffic	Per cent of mineral traffic	No. of Tracks.
EVANSVILLE & TERRE HAUTE										
Evansville to Terre Haute	2,013	2,194	1,848,795	5,546,379	47,376	10,171	5.5	41.6	49.9	Single.
Straight Line Jct. to Spring Hill	870	1,295	385,834	1,157,502	11,772	3,360	5.2	32.9	61.9	"
Mt. Vernon Jct. to Mt. Vernon	500	549	..	.....	5,264	1,130	...	...	.....	"
FORT WORTH & DENVER CITY	1,607	1,326		1,032,852	37,989	7,009	16.8	46.4	36.8	"
GRAND RAPIDS & INDIANA										
Richmond to Mackinac City	..	.	2,978,73?	5,425,710	......	.....	6.8	49.5	28.3	"
Richmond to Grand Rapids	......				......	...			...	"
Grand Rapids to Mackinac City	2,570	2,358			44,130	10,699				"
Richmond to Fort Wayne	2,012	2,267			11,384	15,802				"
Fort Wayne to Grand Rapids	3,356	3,188			76,394	11,187				"
GRAND TRUNK RAILWAY SYSTEM	3,388	2,288	14,615,031	17,947,041	94,423	10,742	11	86	3	23 % Double.
GREAT NORTHERN										
Duluth to Cass Lake	2,283	1,148	5,2??,416	9,459,618	101,910	4,368				" "
Wayzata to Willmar	2,452	2,145	1,512,396	3,222,912	104,183	10,709				Single.
Willmar to Larimore	977	816	3,405,984	7,616,678	29,596	4,355				"
Larimore to Minot	1,363	1,339	5,716,074	13,052,088	49,358	7,920				"
HALIFAX & YARMOUTH	741	720	9,334	9,334	3,000	2,000	....	100	100	"
HOCKING VALLEY	7,443	3,125	6,977,000	9,807,000	250,000	13,000	1	23	76	Sin. & Dble.
ILLINOIS CENTRAL										
Chicago Division	5,016	6,138	7,636,475	8,787,630	228,901	32,007				Double.
St. Louis Division	4,431	2,135	4,473,212	5,102,367	126,231	13,233				½ "
Springfield Division	2,441	1,956	1,799,832	2,784,215	55,471	9,068				Single
Freeport Division	3,688	2,060	1,892,042	2,?20,189	88,804	9,941				"
Dubuque Division	4,075	2,160	1,386,791	1,814,345	91,406	12,235				"
Omaha Division	2,033	2,105	707,084	913,215	70,722	9,327				"
Louisville Division	3,891	1,941	1,?00,61?	1,960,024	68,216	8,201				"
Tennessee Division	7,383	2,600	3,978,540	4,760,892	180,054	16,71?				Double.
Mississippi Division	4,056	1,906	1,339,337	1,661,740	81,849	14,171				Single
Louisiana Division	6,043	3,413	1,?39,?94	2,185,35?	1?0,395	21,943				½ Double.
INTERNATIONAL & GREAT NORTHERN										
Longview to Galveston	1,245	1,269	1,183,392		42,748	6,246				Single
Palestine to Laredo	1,641	1,547	876,533		13,947	8,912	7.4	84.7	28.9	"
Fort Worth to Spring	1,309	1,088	717,685		41,540	3,593				"
IOWA CENTRAL:										
Albert Lea to Albia	?,128	1,960	1,287,188	1,4?0,048	7?,?72	7,116				Single
Oskaloosa to Keithsburg	?,163	1,388	?3?,84?	903,??7	?3,523	1,310				"
Keithsburg to Peoria	3,583	1,083	1,031,042	1,1?0,288	63,273	1,450				"
Hampton to Belmond	1,157	155	61,000	63,373	5,820	1,230				
Belmond to Algona	1,158	157	41,946	43,795	3,226	1,24?	8.?	40.77	47.1	
Marshalltown to Story City	1,241	885	[illegible]	20,726	5,011	3,039				
Newburg to State Center	483	161	?,900	26,066	2,645	646				
Grinnell to Montezuma	1,226	469	11,446	11,697	1,891	1,855				
New Sharon to Newton	1,105	368	11,351	11,372	5,244	1,497				
LAKE SUPERIOR & ISHPEMING, MARQUETTE & S. E., AND MUNISING RAILWAYS										
Presque Isle to Ishpeming	1,786	772	1,207,931	1,207,931	66,6?4	1,611		4	96	Single.
West Yard to Lawson	803	660	509,305	509,305	19,429	1,555		73	27	"
Munising to Little Lake	900	410	400,228	400,228	8,967	1,481		91	9	
LEHIGH & HUDSON:	2,755	915	976,976	1,007,518	63,056	3,423		34.5	61.3	"
LONG ISLAND:	920	7,520	2,335,448	...	57,518	37,238	7	60	33	4, 3, 2 & 1 T
LOUISIANA & ARKANSAS	.		909,502	974,239	18,440	1,911	1	99.2	.7	Single.

TRAFFIC STATISTICS OF AMERICAN RAILWAYS USED IN CLASSIFYING TRACK.—Continued.

NAME OF ROAD	Maximum weight of Locomotives in Freight Service with tender	Maximum weight of Locomotives in Freight Service in ... tender	Maximum single axle load of Locomotives in Freight Service	Maximum weight of Locomotives in Passenger Service without tender	Maximum weight of Locomotives in Passenger Service including tender	Maximum single axle load of Locomotives in Passenger Service	Maximum single axle load of Loaded Freight Car	Maximum schedule speed of Freight Trains	Maximum schedule speed of Passenger Trains	Maximum actual speed of Freight Trains	Maximum actual speed of Passenger Trains	Freight train miles per annum per mile of division	Passenger train miles per annum per mile of division	Revenue Tonnage passing over division per year	Approximate Gross Tonnage passing over division per year	Freight Car Mileage per annum per mile of division	Passenger Car Mileage per annum per mile of division	Per cent of live stock, refrigerator and fruit traffic	Per cent of merchandise traffic	Per cent of mineral traffic	No. of Tracks
LOUISIANA RAILWAY & NAVIGATION COMPANY	[illegible]4,000	174,000	28,000	86,000	148,000	26,000	28,000	12.5	22.1	12.5	22.1	609	647	160,736	360,000	7,700	2,067				Single
MEXICAN INTERNATIONAL																					
Diaz to Monclova	199,000	359,000	44,750				30,267	21.7	27.4	27.4	55.8	2,907				49,573					Single
Monclova to Jaral	146,275	261,135	36,376				30,267	21.7	27.4	27.4	55.8	4,630				79,564					
Jaral to Torreon	109,569	200,839	25,169				30,267	21.7	27.4	27.4	55.8	2,352				48,596					
Monterey to Reata	146,275	261,135	36,376				30,267	21.7	27.4	27.4	55.8	1,628				33,852					
Diaz to Torreon				9?,207	185,848	31,002							927	1,056,349	1,296,349		5,302				
Torreon to Tepehuanes	146,275	261,131	36,376				30,267							240,418	31?,418						
Torreon to Durango				9?,160	186,113	28,990															
Reata to Monterey				102,845	181,769	24,747															
MICHIGAN CENTRAL																					
Buffalo to Detroit	198,000	306,000	50,000	221,000	332,000	50,000	40,000	29	54	34	67	8,812	5,847			364,784	80,122				Both
Detroit to Jackson	198,000	306,000	50,000	221,000	332,000	50,000	50,000	26	45	28	48	7,050	6,818			341,947	81,437				Double
Jackson to Niles	198,000	306,000	50,000	221,000	332,000	50,000	42,000	19	41	23	47	9,363	7,326			321,440	82,41?				Both
Niles to Chicago	198,000	306,000	50,000	221,000	332,000	50,000	50,000	18	39	20	41	7,465	9,034			244,240	83,36?				Double
Jackson to Bay City	198,000	186,000	36,000	98,000	160,000	36,000	36,000	20	32	15	33	3,217	2,246			5?,581	10,576				Single
Bay City to Mackinaw	126,000	220,000	36,000	126,000	220,000	36,000	36,000	20	37	31	44	2,?68	1,395			7?,292	10,877				
Detroit to Bay City	126,000	220,000	36,000	126,000	220,000	36,000	36,000	18	35	23	37	3,778	2,613			81,332	14,421				
Detroit to Toledo	198,000	308,000														207,059	17,130				
MINNEAPOLIS & ST. LOUIS																					
St. Paul to Minneapolis	147,500	241,850	39,650	146,000	248,200	38,000	37,500	21	36	45	60	1,975	3,598	111,642	111,955	21,913	20,682				Double
Minneapolis to Albert Lea	141,500	241,850	39,650	146,000	248,200	38,000	37,500	21	36	45	60	2,465	2,437	1,340,711	1,468,276	70,409	14,166				Double
Albert Lea to Angus	141,500	241,850	39,650	146,000	248,200	38,000	37,500	12	29	40	50	675	1,301	232,765	255,530	10,325	6,862				Single
Hopkins to Morton	141,500	241,850	39,650	146,000	248,200	38,000	37,500	16	27	40	50	1,114	1,673	426,130	476,379	28,773	8,131	6.9	[illegible]	8	
Morton to Watertown	141,500	241,850	39,650	146,000	248,200	38,000	37,500	12	28	40	50	427	1,050	197,417	207,411	8,534	4,013				
Winthrop to Storm Lake	109,560	188,860	36,275	109,560	188,860	36,275	37,500	12	27	40	45	616	1,052	199,734	226,800	7,341	3,259				
MINNEAPOLIS, ST. PAUL & SAULT STE. MARIE																					
Minneapolis to Sault Ste. Marie	210,000	334,550	40,000	156,830	269,630	40,070	24,150	12	33	25	50	1,795	90,495	187,468	576,993	50,848	4,968				Single
Minneapolis to Portal	210,000	334,550	40,000	156,830	269,630	40,070	24,150	12	33	25	50	1,186	83,498	770,807	923,413	30,947	5,490				
MISSOURI PACIFIC																					
St. Louis to Kansas City	204,000	334,000	45,000	184,000	308,000	50,000	35,000	19	38			2,143	2,293	5,744,007	6,843,795	49,754	12,940				Single
Kansas City to Omaha	162,200	270,600	41,333	126,000	210,800	30,200	35,000	15	26			1,444	1,378	2,306,571	2,561,368	26,148	5,403				
Kansas City to Hoisington	204,000	334,000	45,000	114,800	243,600	37,333	35,000	15	33			2,752	1,651	2,911,029	3,146,681	61,124	8,071				
Hoisington to Pueblo	162,200	270,600	41,333	147,200	340,000	35,200	35,000	21	37			2,869	1,484	722,614	872,691	50,170	8,0?7				
Southern Kansas Division	115,000	185,000	23,750	100,000	192,000	29,000	37,000	17	29			1,349	1,109	2,499,608	2,718,381	20,583	3,928				
East St. Louis to Thebes	162,200	270,600	41,333	80,000	146,000	25,600	35,000	14	27			1,196	419	791,158	994,467	13,556	962				
St. Louis to Hoxie	204,000	334,000	45,000	185,000	302,000	39,333	35,000	14	32			3,329	2,778	*4,668,071	*5,247,373	91,494	18,091				
Hoxie to Texarkana	208,200	326,600	43,000	184,000	308,000	50,000	35,000	16	38			1,904	2,391	3,608,605	3,805,855	57,962	14,738				
Little Rock to Coffeyville	208,200	326,600	43,000	125,000	230,000	40,200	35,000	15	30			2,997	1,381	1,716,728	2,250,712	90,017	6,477				
Little Rock to Alexandria	162,200	270,600	35,500	115,000	193,000	30,000	35,000	13	24			1,517	1,050	1,891,627	1,959,883	47,749	3,110				
MOBILE & OHIO																					
East St. Louis to Cairo	129,000	222,000	34,100	128,000	221,000	34,200	28,500	30	40		55	6,417	1,913	1,939,433	2,240,469	121,003	10,148	4	82	14	Single
Cairo to Mobile	167,500	309,000	43,600	128,000	221,000	34,200	28,500	30	40	35	58	4,853	1,601	2,364,432	2,685,865	112,298	9,964	6	90	4	
Artesia to Montgomery	120,800	190,800	36,300	90,000	160,000	30,000	28,500	30	35	35	50	2,186	852	802,090	853,816	13,064	2,955	2	67	31	
NASHVILLE, CHATTANOOGA & ST. LOUIS																					
Chattanooga to Nashville	163,200	270,200	44,800	148,000	256,100	40,600	36,000	28	45	35	60	8,000	3,518			185,276	21,902				Single
Nashville to Hickman	163,200	270,200	38,250	148,000	256,100	40,600	36,000	28	39	35	60	4,576	2,261			79,124	14,368				
Atlanta to Chattanooga	163,200	270,200	38,250	148,000	256,100	40,600	36,000	30	45	35	60	6,649	2,560			183,339	15,824				
Paducah to Memphis	104,500	178,000	28,000	104,500	175,300	33,100	30,000	22	32	35	50	1,646	1,353			28,108	5,489				
Decherd to Columbia																10,450	4,089				
Elora to Gadsden	94,500	178,000	28,000	104,500	175,300	33,100	30,000	25	27	35	50	545	903			6,631	3,070				
Tullahoma to Ravenscroft																17,1??	1,322				

TRAFFIC STATISTICS OF AMERICAN RAILWAYS USED IN CLASSIFYING TRACK—Continued

NAME OF ROAD	Maximum weight of Locomotives in Freight Service without tender	Maximum weight of Locomotives in Freight Service including tender	Maximum single axle load of Locomotives in Freight Service	Maximum weight of Locomotives in Passenger Service without tender	Maximum weight of Locomotives in Passenger Service including tender	Maximum single axle load of Locomotives in Passenger Service	Maximum single axle load of Loaded Freight Car	Maximum schedule speed of Freight Trains	Maximum schedule speed of Passenger Trains	Maximum actual speed of Freight Trains	Maximum actual speed of Passenger Trains	Freight train mile per annum per mile of division	Passenger train mile per annum per mile of division	Revenue Tonnage per annum division per year	Approximate Gross Tonnage passing over division per year	Freight Car Mileage per annum per mile of division	Passenger Car Mileage per annum per mile of division	Per cent of live stock, refrigerator and fruit traffic	Per cent of merchandise traffic	Per cent of mineral traffic	No. of Tracks
NEW ORLEANS & NORTHEASTERN																					
New Orleans to Meridian	144,500	254,500	39,770	145,500	245,900	36,350	31,000	16.3	37	35	60	3,236	2,427	1,590,596	1,164,505	79,365	14,201	05.1	86.7	08.1	Single
Ala. & Vicksburg Ry.	112,900	197,900	31,100	125,900	215,900	34,450	31,000	17.5	35.8	35	60	2,367	2,126	725,756	802,141	51,978	10,797	01.5	77.3	18.1	"
V., S. & P. Railway	111,500	201,500	30,500	113,100	212,600	34,500	31,000	16.3	33.7	35	60	1,691	1,766	722,226	746,291	38,737	10,914	04.9	84.6	10.4	"
NEW YORK & PENNSYLVANIA	112,000	178,000	23,500	80,000	142,000	24,500	32,500	10	20	10	20	677	1,364	108,657	115,000	5,657	2,700	8	73	19	"
NEW YORK CENTRAL & HUDSON RIVER																					
Hudson Division	175,000	289,000	45,700	200,000	324,000	55,000	32,560	25	60	40	75	13,144	23,736			393,156	176,129				Double & Three
Harlem Division	157,100	265,100	35,800	168,000	288,700	48,600	29,610	20	40	35	65	2,344	10,538			26,271	17,124				Sin. & Dbl.
West Shore—River Division	120,000	192,000	35,800	134,700	228,100	44,300	29,610	20	40	25	13	7,221	8,024			190,701	43,729				"
New York & Putnam Division	120,000	192,000	35,800	98,500	169,200	33,700	29,610	30	56	35	60	1,284	9,649			6,116	28,141				"
Mohawk Division	220,200	357,700	51,000	215,000	342,000	48,000	32,560	24	54	31	70	12,085	10,972			527,317	79,829				" & Four
West Shore—Mohawk Division	120,000	192,000	35,800	176,000	290,000	48,400	29,610	19	33	23	41	12,085	10,972			527,317	79,829				Double
M. & M. and St. L. & A. Division	155,800	263,800	34,400	168,900	282,900	44,000	32,560	15	30	20	15	1,668	2,830			28,019	12,016				Single
Western Division	220,200	357,700	51,000	215,000	342,000	48,000	32,560	21	54.5	33	70	6,765	7,717			273,137	11,475				" Dbl. & Four
R. W. & O. Division	155,800	263,800	34,100	17[illegible],000	289,000	45,700	32,560	16.67	35.64	13	15	2,015	1,187			47,731	14,125				Single
Pennsylvania Division	225,[illegible]00	362,500	51,000	124,000	210,100	41,500	32,560	20	45	30	60	4,681	1,602			187,377	4,761				Sin. & Dbl.
NEW YORK, CHICAGO & ST. LOUIS																					
Buffalo to Chicago	160,000	280,000	36,500	1[illegible],700	234,700	41,300	31,000	20	37	35–40	55–60	7,986	2,302	5,147,411	[illegible]612,610	237,718	15,766	14.2	62	23.8	Single
NEW YORK, PHILADELPHIA & NORFOLK																					
Cape Charles to Delmar and Chrisfield, Md.	146,200	266,200	40,430	113,200	185,200	31,300	35,000	21	34	29	41					11,197	1,219				Single
NORFOLK & WESTERN																					
Norfolk to Roanoke	175,000	265,000	43,000	163,000	281,000	47,000	37,500	25	60	30	76	6,452	2,749	4,273,301	5,575,568	248,142	14,904				7% Double,
Durham to Lynchburg	124,000	208,000	32,000	142,000	216,000	36,000	32,500	18	30	23	45	1,249	849	199,823	625,239	22,214	3,072				Single
Hagerstown to Winston Salem	175,000	265,000	43,000	156,000	244,000	43,000	37,500	24	40	29	76	2,939	1,630	1,011,214	1,968,221	83,027	7,068				
Roanoke to Bluefield	186,000	290,000	44,000	163,000	284,000	47,000	37,500	25	50	30	60	11,351	2,959	6,646,188	9,450,350	140,725	19,258				
Radford to Bristol and N. C. Ext.	175,000	265,000	43,000	163,000	284,000	47,000	37,500	22	45	27	[illegible]	2,715	1,258	860,090	1,490,143	70,076	8,744	[illegible]	24	[illegible]	70% Double,
Pocahontas to Williamson	186,000	290,000	44,000	156,000	244,000	43,000	37,500	20	35	25	45	6,020	1,864	2,480,641	5,846,750	159,181	10,106				1%
Graham to Norton	138,000	222,000	36,000	132,000	216,000	36,000	32,500	15	30	20	45	1,797	1,445	1,038,829	2,198,15[illegible]	93,348	6,020				40%
Williamson to Columbus	175,000	265,000	43,000	163,000	284,000	43,000	37,500	20	30	25	60	7,425	1,977	3,721,936	5,357,559	240,752	11,048				Single
Portsmouth to Cincinnati	124,000	208,000	32,000	124,000	208,000	34,000	32,500	15	15	20	15	2,954	1,864	583,780	1,336,830	17,187	5,549				6% Double, Single
NORTHERN PACIFIC																					
Seattle Division	137,000	221,000	34,000	100,000	170,500	32,000	37,075	12	23.2	30	50	1,036	921	2,526,658	5,340,715	18,517	3,944	4	73	23	Single
Pacific Division	198,000	309,800	44,625	196,000	319,400	44,000	37,075	18	28.4	45	60	2,211	1,618	6,474,743	13,408,362	57,667	11,671	4	73	23	"
Idaho Division	190,050	293,050	47,933	196,000	319,400	44,000	37,075	16	35	30	45	2,874	1,472	7,860,876	16,563,150	86,548	10,980	4	76	20	"
Rocky Mountain Division	259,000	405,500	58,000	196,000	319,400	44,000	37,075	15	31.7	40	60	2,161	1,163	5,251,342	11,248,084	76,380	6,413	5	77	18	"
Montana Division	210,000	322,400	46,500	210,000	347,000	49,200	37,075	14.4	39.7	25	45	1,855	1,206	7,133,443	15,555,765	65,701	9,481	8	80	12	"
Yellowstone Division	271,000	417,500	55,000	160,400	254,400	38,800	37,075	16.8	40.8	40	65	2,958	1,528	4,855,714	11,066,785	193,137	14,105	8	80	12	"
Dakota Division	194,000	305,800	43,000	155,500	249,500	38,800	37,075	16.6	35.6	45	65	1,006	663	4,114,987	8,997,628	37,147	5,541	8	89	10	"
Minnesota Division	172,500	261,500	42,000	155,500	249,500	38,800	37,075	16.3	41.2	35	50	[illegible]	1,117	4,326,429	8,436,107	56,498	7,018	6	86	8	"
Lake Superior Division	164,400	263,400	40,670	150,700	232,900	37,000	37,075	15	40	40	65	4,57[illegible]	3,557	7,474,111	14,970,712	143,567	16,794	1	76	23	
St. Paul Division	172,500	264,500	42,000	155,500	249,500	38,800	37,075	15.4	37.7	[illegible]	75	2,550	1,742	4,992,174	9,318,810	75,410	12,904	6	84	10	
OREGON SHORT LINE																					
Green River to Ogden	204,800	320,598	45,300	186,020	314,553	48,553	37,125	12.5	31.6	17.3	40	4,025	2,715			129,883	20,027				Single
Granger to Pocatello	195,120	323,650	43,050	196,000	328,840	52,500	37,125	14.8	37.5	17.6	30	3,005	1,464			117,374	9,984	14.6	18.4	67	"
Pocatello to Huntington	176,650	290,650	48,000	196,000	328,840	52,500	37,125	15.6	34.2	18.6	60	2,442	1,[illegible]			80,298	12,441	16.4	45.8	37.8	"
Pocatello to Silver Bow	207,000	339,840	48,000	186,020	314,553	48,553	37,125	15.[illegible]	31.4	17.6	35	1,561	1,140			53,801	6,787	15.2	15.8	69	"
Ogden to Carlin	166,320	288,635	48,040	222,000	354,840	47,000	37,125														"
Carlin to Sparks	183,350	306,000	47,440	187,350	306,000	47,440	37,125														"
Salt Lake to Pocatello	131,200	218,300	34,466	131,200	218,473	34,466	37,125														"
Ogden to Sparks								14.6	2[illegible]	1[illegible]	45	1,78[illegible]	2,039			47,984	13,173	17.6	32.4	50	"
Silver Bow to Butte								13.[illegible]	38.8	17.7	[illegible]	[illegible]	664			117,936	27,822				"
Pocatello to Ogden								15.3	31.4	17.6	35	1,228	863			12,720	1,617				"

NAME OF ROAD	Maximum weight of Locomotives in Freight Service without tender	Maximum weight of Locomotives in Freight Service including tender	Maximum single axle load of Locomotives in Freight Service	Maximum weight of Locomotives in Passenger Service without tender	Maximum weight of Locomotives in Passenger Service including tender	Maximum single axle load of Locomotives in Passenger Service	Maximum single axle load of Loaded Freight Car	Maximum schedule speed of Freight Trains	Maximum schedule speed of Passenger Trains	Maximum actual speed of Freight Trains	Maximum actual speed of Passenger Trains	Freight train miles per annum per mile of division	Passenger train miles per annum per mile of division	Revenue Tonnage passing over division per year	Approximate Gross Tonnage passing over division per year	Freight Car Mileage per annum per mile of division	Passenger Car Mileage per annum per mile of division	Per cent of live stock, refrigerator and fruit traffic	Per cent of merchandise traffic	Per cent of mineral traffic	No. of Tracks.
OREGON R. R. & NAVIGATION CO.																					
Portland Division	204,800	329,800	52,700	214,500	347,100	45,900	37,500	16.4	33.9	16.5		1,607	1,552	...	...	57,145	11,847	6.31	61.07	29.62	Single
Pendleton to Spokane	144,400	246,900	40,900	136,350	222,000	37,650	37,500	15.5	32.9	16.7		900	764			16,452	4,291	6.31	61.07	29.62	"
Ashland to Portland	161,600	257,300	41,600	108,400	178,000	33,000	37,500	11.7	32.1	17.6		1,346	1,353			14,250	9,149	8.2	85.1	6.7	"
PENNSYLVANIA RAILROAD (LINES EAST OF																					
Philadelphia to Pittsburg	193,500	336,500	49,050	183,100	315,600	61,500	38,000					10,705	5,956			1,552,172	160,551	1.85	31.04	67.11	...
New York to Philadelphia	193,500	336,500	49,000	182,000	314,500	60,000	38,000					6,290	14,901	...		817,362	330,156	2.57	37.04	60.39	...
Sunbury to Erie	193,500	336,500	49,000	138,000	218,000	50,400	38,000					5,578	2,768			283,913	18,523	1.44	32.78	65.79	...
Pittsburg to Buffalo	193,500	336,500	49,000	183,100	315,600	61,500	38,000					3,848	2,863			129,255	15,765	1.84	47.50	50.60	...
Baltimore to Sunbury	193,500	336,500	49,000	183,100	315,600	61,500	38,000			...		6,807	4,637			121,167	19,180	3.60	42.03	54.37	...
Philadelphia to Washington	165,900	308,900	49,000	182,000	314,500	60,000	38,000					3,984	7,234		...	272,667	152,849	6.96	56.24	36.81	...
Philadelphia to Cape May and Atlantic City	163,000	275,000	48,700	182,000	314,500	60,000	38,000					1,274	6,059	1,671,341	5,178,609	46,867	67,739	4.58	52.85	42.57	....
PERE MARQUETTE:																					
Ludington to Saginaw	181,500	305,500	47,700	160,000	279,100	44,000	40,000	20	45	35	65	2,465	1,343			70,493					Single.
Bay City to Toledo	181,500	305,500	47,700	160,000	279,100	44,000	40,000	20	45	35	65	3,528	2,580			126,297					"
Saginaw to Port Huron	181,500	305,500	47,700	160,000	279,100	44,000	40,000	20	45	35	60	1,886	1,176			10,867	...				"
Port Huron to Port Austin	119,700	201,000	31,700	91,800	162,500	27,000	31,250	20	35	25	45	8,521	1,192			12,297					"
Chicago to Grand Rapids	181,500	305,500	42,000	160,000	279,100	44,000	40,000	20	45	35	65	2,676	1,883			54,932					"
Grand Rapids to Petoskey	151,000	246,000	39,000	151,000	246,000	39,000	40,000	20	40	35	60	2,305	1,387			48,263					"
Grand Rapids to Detroit	181,500	305,500	47,700	160,000	279,100	44,000	40,000	20	45	35	65	4,168	2,370			82,302					"
Grand Rapids to Saginaw	181,500	305,500	47,700	104,500	184,300	33,600	31,250	20	40	35	60	1,415	1,177			19,157					
Allegan to Pentwater	151,000	246,000	39,000	95,000	171,000	30,150	40,000	20	35	35	45	1,327	1,287	...		20,736					"
Walkerville to St. Thomas	181,500	305,500	47,700	160,000	279,100	44,000	40,000	20	35	35	60	2,866	1,508			*57,087					"
PHILADELPHIA & READING:																					
Philadelphia to Pottsville	166,000	296,300	41,600	159,300	267,700	49,000	37,500	30	60	40	70	38,942	14,742	3,977,488	4,306,008	1,243,600	60,180		26	74	Double
Allentown to Harrisburg	166,000	296,300	41,600	159,300	267,700	49,000	37,500	30	60	40	70	22,230	7,232	4,039,274	4,217,670	603,833	31,871		52	48	"
Tamaqua to Newberry Jct.	171,100	301,100	41,900	107,000	193,400	37,500	37,500	30	46	30	60	26,151	6,241	3,093,184	3,315,424	470,502	23,260		38	62	"
Reading to Columbia and Wilmington	120,000	228,400	34,000	122,500	208,900	44,000	37,500	15	30	20	40	3,518	2,938	215,377	261,239	11,055	8,265		66	34	Single.
Philadelphia to Bound Brook	171,100	304,100	44,900	182,100	302,100	49,700	37,500	25.53	59.19	33	78	15,296	39,458	1,894,657	1,959,253	36,246	153,775		48	52	Double
Philadelphia Division	137,600	246,100	35,000	95,000	181,400	31,500	37,500	16.58	24.72	24	36	1,666	2,207	156,075	165,417	241,646	6,418		53	4	Both
Camden to Atlantic City and Cape May	121,700	230,100	37,200	182,100	302,100	49,700	37,500	25	66	30	75	2,140	10,687	126,531	142,542	17,499	47,334		...	25	Double
PITTSBURG & LAKE ERIE:																					
Youngstown to Brownsville & New Haven	196,800	336,800	45,800	168,000	313,000	56,200	36,900	20	60	25	75	7,668	4,863	23,131,969	24,172,133	456,662	23,630	0.57	20.20	79.23	[illegible]
PITTSBURG, CHICAGO, CINCINNATI & ST. LOUIS:																					
Pittsburg to Columbus	193,500	336,500	46,000	183,150	326,950	61,600	36,525	20	46			11,568	5,817	16,226,238	16,601,751	298,150	18,875	15	55	30	84.6 m S. 209.06 m D
Columbus to Indianapolis and Richmond	193,500	328,200	46,000	183,150	326,950	61,600	31,390	18.1	42.7	...		8,456	5,611	5,288,737	6,012,287	230,250	28,037	17	50	34	31.65 miles Double
Columbus to Cincinnati	193,500	236,500	46,000			61,600	38,900	20	42			4,344	5,677	2,751,217	3,028,670	.	30,201	4.19	65.25	30.56	1.50 m S. 50.3 m D
Ind. & Camb. City to Louisville & Mad.	108,500	178,300	32,800	112,200	188,000	38,950	38,400	22.23	42.52			2,773	3,311	...	3,116,631	55,586	11,366				Single.
Cincinnati to Logansport	147,200	235,500	45,100	138,000	220,000	47,650	27,500	20.5	38.31			4,800	3,960	2,779,170	2,830,093	85,156	15,510	..			"
Trimway to Morrow	124,800	204,087	31,300	91,900	168,688	31,300	38,600	25	37			1,827	2,463	306,460	361,420	28,172	5,879	2	51	17	"
Bradford to Chicago	193,500	336,500	46,000	183,150	326,950	61,600	40,800	20.47	43.20	...		6,474	3,391	5,461,446	5,921,018	203,862	18,175	16.1	32.2	51.5	204 m S. 80 m D
PITTSBURG, SHAWMUT & NORTHERN	204,000	314,000	46,000	90,500	155,500	29,000	29,700	18	30	...		1,220	1,075	1,246,664	1,291,664	10,365	1,675	1	35.8	60.2	Single.
QUINCY, OMAHA & KANSAS CITY:																					
Quincy to Milan	118,000	231,000	29,600	90,000	162,000	22,500	34,000	10	24	45	45	1,856	748	808,087	1,735,794	22,734	1,180	9	26	65	Single.
Milan to Kansas City												1,795	749	841,748	1,800,740	26,211	4,379	9	26	65	"
RUTLAND	165,000	284,000	45,000	154,000	272,000	38,300	31,250	20	38	25	55	1,842	2,742	1,554,169	1,554,169	38,709	10,569	4.71	61.72	33.54	"
SAN ANTONIO & ARANSAS PASS	88,000	154,000	24,300	86,000	144,000	25,275	22,000	30	30	45	45	1,477	960	199,161	249,599	23,808	1,548	12.10	77.68	9.92	"
SANTA FE RAILWAY:																					
Chicago to Shopton	164,000	261,000	48,670	216,100	354,900	51,700	36,500	21.6	47.4	35	80	5,125	3,903	......		166,323	27,025	12.54	57.40	30.06	201 Sin. 31 Dbl
Shopton to Kansas City	216,100	354,900	51,700	201,500	366,000	54,850	36,500	17.4	41.3	35	70	5,491	1,372	...	...	162,319	21,001	12.54	57.40	30.06	7 Dbl. 206 Sin.
Kansas City to Emporia	211,000	353,700	45,000	201,500	366,000	54,850	36,500	18.2	43.6	30	70	6,178	1,900	....		162,422	28,923	12.54	57.40	30.06	62 Sin. 50 Dbl
Emporia to Newton	162,200	262,200	42,430	201,500	366,000	54,850	36,500	22.3	44.3	35	80	3,062	2,865			121,797	19,461	12.54	57.40	30.06	25 Sin. 44 Dbl
Newton to La Junta	210,190	322,790	50,180	193,760	333,760	50,710	36,500	18.4	43.2	33.3	55.1	3,150	2,510			108,676	19,960	19.6	62.7	17.7	Single
La Junta to Albuquerque	287,240	445,740	53,960	216,100	354,900	51,700	36,500	14	47.6	18.2	45.5	3,969	2,086			126,965	17,981	30	30	40	335 Sin. 11 Dbl
La Junta to Denver	199,250	316,650	47,700	216,100	354,900	51,700	36,500	21.4	48.7	35	60						...	12	8	80	Single.
SANTA FE, PRESCOTT & PHOENIX RY. CO.	132,000	231,500	36,000	148,600	256,900	40,200	25,250	24	40	24	40	1,040	752	204,577	708,326	21,721	3,305	3.37	49.45	47.18	"

TRAFFIC STATISTICS OF AMERICAN RAILWAYS USED IN CLASSIFYING TRACK.—Continued.

NAME OF ROAD	Maximum weight of Locomotives in Freight Service without tender	Maximum weight of Locomotives in Freight Service including tender	Maximum single axle load of Locomotives in Freight Service	Maximum weight of Locomotives in Passenger Service without tender	Maximum weight of Locomotives in Passenger Service including tender	Maximum single axle load of Locomotives in Passenger Service	Maximum single axle load of Loaded Freight Car	Maximum schedule speed of Freight Trains	Maximum schedule speed of Passenger Trains	Maximum actual speed of Freight Trains	Maximum actual speed of Passenger Trains	Freight train miles per annum per mile of division	Passenger train miles per annum per mile of division	Revenue Tonnage passing over division per year	Approximate Gross Tonnage passing over division per year	Freight Car Mileage per annum per mile of division	Passenger Car Mileage per annum per mile of division	Per cent of live stock, refrigerator and fruit traffic	Per cent of merchandise traffic	Per cent of mineral traffic	No. of Tracks
St. Louis & North Arkansas																					
Seligman to Leslie	135,000	255,000	38,333	99,000	129,000	24,750	31,500	18	22	20	35	517	849	61,720	86,720	6,230	2,549	4.7	76.7	18.6	Single.
St. Louis & San Francisco																					
St. Louis to Monett	189,400	322,800	47,800	193,550	327,000	44,200	31,500	23	38	40	65	5,019	4,323	1,231,730	2,005,763	108,242	28,728				
Monett to Paris	173,500	307,500	45,700	132,100	218,700	36,100	31,500	15	33	35	60	2,171	1,857	591,326	1,080,182	35,500	9,871				
Monett to Wichita	121,000	196,000	38,000	96,000	168,000	31,000	31,500	16	30	35	60	2,759	1,824	720,395	1,506,477	46,561	10,651				
Monett to Oklahoma City	173,500	307,500	45,700	145,000	235,000	42,400	31,500	20	30	35	50	2,461	2,012	522,861	1,340,266	46,068	12,293				
Sapulpa to Sherman	173,500	307,500	45,700	145,000	235,000	42,400	31,500	16	29	35	50	2,037	1,888	438,831	1,146,858	41,481	11,671				
Kansas City to Springfield	189,400	322,800	47,800	143,700	251,900	51,500	31,500	26	42	40	65	5,117	3,379	1,862,378	4,235,004	136,088	18,289				
Springfield to Memphis	173,500	307,500	45,700	143,700	251,900	51,500	31,500	20	36	40	65	4,521	2,246	1,438,650	2,662,944	90,805	10,917				
Memphis to Birmingham	173,500	307,500	45,700	134,000	225,700	46,000	31,500	19	33	35	55	4,218	2,044	1,014,123	2,267,016	74,919	10,174				
St. Louis to Big Creek	173,500	307,500	45,700	93,000	162,000	30,600	31,500	15	26	25	40	1,230	1,240	476,567	938,916	28,864	4,656				
St. Louis Southwestern																					
Texarkana to Bird Point	164,800	268,800	43,433	127,100	231,000	43,050			35												
Texarkana to Fort Worth	158,300	258,300	41,433	127,100	231,000	43,050			26												
Spokane Falls & Northern																					
Spokane to Northport	130,000	165,400	28,750	94,100	128,500	28,050	28,750	15	28	30	45	600	708	145,060	176,042	12,904	4,253	4.3	59	37.7	Single
Southern																					
Washington to Monroe	200,000	320,000	45,000	220,200	340,200	52,000	36,500	13.5	35.75	35	65	3,801	6,647	901,475	1,104,302	77,114	18,763				78 Double 82 Sin.
Monroe to Spencer	200,000	320,000	45,000	220,200	340,200	52,000	36,500	13.0	35.75	45	72	4,907	5,463	2,263,079	2,029,638	113,711	34,879				Single
Spencer to Atlanta	170,200	290,200	37,800	171,400	271,400	47,200	36,500	11.53	35.99	40	70	3,861	3,847	1,893,881	2,400,206	91,497	21,325				"
Knoxville to Jellico	200,000	320,000	45,000	166,000	274,000	45,000	36,500	10.05	20.66	30	40	4,737	1,946	1,999,652	2,368,698	95,072	8,457				"
Bristol to Chattanooga	200,000	320,000	45,000	166,000	274,000	45,000	36,500	16.90	30.19	30	50	4,161	3,069	2,760,317	3,933,622	101,530	17,005				"
Chattanooga to Atlanta	159,000	259,000	35,000	166,000	274,000	45,000	36,500	18.16	35.70	30	60	3,812	2,116	1,732,972	1,895,308	91,269	12,970				"
Morristown to Asheville	200,000	320,000	45,000	166,000	274,000	45,000	36,500	13.22	32.73	30	45	6,025	2,531	1,534,343	2,187,926	153,182	12,344				
Birmingham to Atlanta	200,000	320,000	45,000	166,000	274,000	45,000	36,500	15.40	31.85	25	50	4,574	2,939	1,258,411	1,633,714	97,904	11,100				"
Charlotte to Columbia	159,000	259,000	35,000	66,000	274,000	45,000	36,500	15.37	33.42	30	55	2,372	2,519	578,069	612,194	48,260	13,625				"
Atlanta to Brunswick	159,000	259,000	35,000	166,000	271,000	45,000	36,500	16.78	32.33	30	60	2,198	2,130	1,056,599	1,215,406	48,018	11,476				"
Southern Pacific—Pacific System																					
Coast Division	207,000	339,840	54,340	196,000	330,800	53,000	38,000	17.6	40.1	21	42	1,552	1,092	523,044	1,825,030	44,239	21,100				561 Sin. 50 Double
Western Division	176,640	302,150	54,340	196,000	330,800	53,000	38,000	16.5	40.8	20	45	2,325	3,439	781,837	1,981,068	56,941	20,170				841 Sin. 13 Double
San Joaquin Division	207,000	339,840	51,340	183,350	306,020	47,760	38,000	16.7	38.4	20	45	2,044	1,775	747,391	2,085,334	55,085	9,404				Single
Los Angeles Division	208,000	344,700	54,340	196,000	330,800	53,000	38,000	16.7	37.7	20	40	1,731	2,233	863,474	2,183,253	70,913	12,053				502 Sin. 19 Double.
Tucson Division	208,000	344,700	54,340	196,000	330,800	53,000	38,000	16.6	40.5	21	44	2,422	1,789	1,104,422	2,705,733	78,724	11,917				Single
Sacramento Division	207,000	339,840	48,000	207,000	339,840	49,000	38,000	16.0	30.4	18	35	2,299	2,210	708,830	2,000,181	53,186	15,561				735 Sin. 3 Double
Southern Pacific—Atlantic System																					
T. & N. O. R. R. Main Line	146,000	246,924	12,000	137,425	259,740	45,837	37,500	13.2	33.8	18.1	35.2	1,805	3,130	2,485,681	7,215,378	156,129	22,576				4 Dble. balance Sin.
T. & N. O. R. R. Branches	111,000	195,000	28,000	97,300	167,950	31,600	37,500	11.8	22.9	11.8	25	1,128	893	1,463,374	5,360,908	18,967	1,078				Single
G. H. & H. Ry	146,000	216,924	42,000	118,000	204,200	37,350	37,500	13.2	31.2	15.4	33.4	2,074	1,700	1,558,555	3,321,657	105,621	8,406				"
G. H. & S. A. Ry.—Main Line	176,640	298,215	51,266	137,425	259,740	45,837	37,500	17	33	17.3	36.1	5,880	1,437	1,874,571	5,254,071	93,150	10,705				"
G. H. & S. A. Ry.—Branches	111,000	195,000	28,000	104,400	175,400	33,200	37,500	19	30	15.7	34.5	978	738	809,085	2,262,435	11,165	2,156				"
G. H. & S. A.—El Paso Division	207,000	339,840	46,000	196,000	328,840	52,500	37,500	17.2	29.8	20.7	34.2	2,609	820	1,035,168	2,760,961	64,422	6,494				"
Victoria Division	84,500	153,380	22,400	97,900	167,950	31,600	32,500	18.2	27.4	11.4	30.2	561	1,017	372,920	1,357,752	9,983	3,493				"
H. & T. C.—Houston to Denison	135,000	231,000	34,000	119,300	209,300	39,250	37,500	17	34	19	36										"
H. & T. C.—Garrett to Fort Worth	135,000	231,000	34,000	119,300	209,300	35,250	37,500	17	26	19	28										"
H. & T. C.—Hempstead to Austin	108,000	184,800	27,666	80,000	158,000	26,500	37,500	16	26	18	28										"
Austin to Llano	108,000	181,800	27,666	80,000	138,000	26,500	30,000	13	25	15	27										"
H. E. & W. T.—Houston to Shreveport	125,700	215,700	31,433	106,000	198,000	21,133	37,500	9.1	24.2												"
M. L. & T. Ry.—Algiers to Lafayette	80,000	132,000	33,333	120,000	200,000	45,847	16,500	15.8	32.3	16.7	35.2	4,894	3,100	239,842,532	583,748,730	130,818	21,763				Sin. except 40.00
L. W. Ry.—Lafayette to Sabine River	80,000	132,000	33,000	120,000	200,000	45,837	16,500	14.4	33.6	17.3	35.9	3,980	2,361	142,327,773	355,507,822	105,545	18,055				Single.
Tennessee Central																					
Nashville to Harriman	122,300	218,300	27,000	142,000	240,000	36,760	28,000	19	27.5	20	50	319,400	303,665	486,717	No record	37,223	913,798	7.6	43.2	19.2	Single.

Special Committee on Classification of Track.

TRAFFIC STATISTICS OF AMERICAN RAILWAYS USED IN CLASSIFYING TRACK.

TRAFFIC STATISTICS OF AMERICAN RAILWAYS USED IN CLASSIFYING TRACK.—Continued.

NAME OF ROAD.	Maximum weight of Locomotives in Freight Service without tender	Maximum weight of Locomotives in Freight Service including tender	Maximum single axle load of Locomotives in Freight Service	Maximum weight of Locomotives in Passenger Service without tender	Maximum weight of Locomotives in Passenger Service including tender	Maximum single axle load of Locomotives in Passenger Service	Maximum single axle load of Loaded Freight Car	Maximum schedule speed of Freight Trains	Maximum schedule speed of Passenger Trains	Maximum actual speed of Freight Trains	Maximum actual speed of Passenger Trains	Freight train mile per annum per mile of division	Passenger train mile per annum per mile of division	Revenue Tonnage passing over division per year	Approximate Gross Tonnage passing over division per year	Freight Car Mileage per annum per mile of division	Passenger Car Mileage per annum per mile of division	Per cent of live stock, refrigerator and fruit traffic	Per cent of merchandise traffic	Per cent of mineral traffic	No. of Tracks
ON PACIFIC																					
Omaha to Cheyenne	185,200	317,400	51,340	222,520	355,570	53,800	35,000	24.7	46.1	35	60	5,660	4,100	2,004,200	5,126,300	156,665	32,130				51 Miles Double
Cheyenne to Green River	204,800	320,600	49,700	222,520	355,570	53,800	35,000	17.9	35.3	35	60	5,330	2,260	2,820,900	6,821,000	189,940	24,430	...			43 "
Kansas City to Cheyenne Wells	200,000	306,000	46,000	131,200	248,100	35,800	35,000	21.8	40.3	35	60	2,340	2,000	864,900	2,175,000	64,740	17,840				Single
Cheyenne Wells to Cheyenne via Denver	204,808	320,600	49,700	222,520	355,570	53,800	35,000	19.6	46.4	35	60	1,750	1,510	717,000	1,759,500	48,880	10,520				
ION RAILROAD OF PITTSBURG																					
Bessemer to North Bessemer	250,300	391,400	59,400	...	...	... ...	37,500	15		25		6,830	.	6,500,000	10,000,000	237,230	...	...	33	67	Double
NDALIA																					
Indianapolis to Ill. State Line	182,500	327,300	54,500	184,000	326,820	55,500	37,500	23.59	43.62	36.05	53.85	6,905	6,787	2,871,625	4,365,516	151,678	44,007	7.9	44.4	47.7	Single.
Ill. State Line to East St. Louis	182,500	327,300	54,500	184,000	326,820	55,500	37,500	21.41	50.27	26.72	58.64	4,399	6,536	1,976,464	2,844,288	110,413	44,601	8.7	49.1	42.2	"
Terre Haute to South Bend	128,740	208,740	33,400	103,600	176,950	32,800	37,475	15	30	40	60	2,862	2,48[illegible]	1,393,786	1,521,774	57,761	8,080	2.6	45.8	51.6	
Logansport to Butler	128,740	208,740	33,400	103,600	176,950	32,800	37,475	15	20	40	50	1,308	998	316,363	324,760	16,643	3,955	6	62	32	
Indianapolis to Vincennes	131,175	194,875	35,600	96,700	170,050	31,100	37,500	14.6	29.8	40	60	2,933	1,600	1,330,295	1,372,174	60,138	5,199	7.3	11.8	80.9	
Terre Haute to Peoria	128,600	208,600	37,500	92,300	159,100	29,700	38,750	15	29	30	50	1,608	1,562	661,732	697,373	35,377	5,291	2.1	68.6	29.3	
ASH																					
Detroit to Chicago	148,500	270,000	47,000	193,000	323,000	52,800	37,000	26	46	31	65			1,137,692	1,373,819						1.03% Double
Toledo & Montp. to Tilton	149,500	270,000	47,000	198,000	328,000	56,500	37,000	22.75	44	35	65			3,386,956	1,674,817						2.44% "
Tilton and Chicago to E. St. Louis	155,500	253,00	41,000	198,000	328,000	56,500	37,000	23	54	30	65	3,021	3,221	1,771,037	2,138,613	76,630	15,000				12.41% "
Decatur to Hannibal and Keokuk	123,500	220,000	37,600	87,000	162,500	30,000	37,000	17	35	40	60			1,031,003	1,244,987						Single
St. Louis to Des Moines and Ottumwa	132,000	209,000	30,000	162,000	282,000	41,000	37,000	21	38	30	60			851,538	2,235,823						1.50% Double
Moberly to Omaha and Kansas City	132,000	209,000	30,000	120,000	225,000	32,600	37,000	24.1	40.4	55	65			1,459,600	1,762,658		....				Single.
HEELING & LAKE ERIE																					
Toledo to Massillon	190,000	307,700	42,300	139,500	258,000	47,750	34,825	18	43	25	60		..			..					Single
Massillon to Wheeling	190,000	307,700	42,300	139,500	258,000	47,750	34,825	18	43	25	60									....	"
Cleveland to Zanesville	120,800	202,200	32,200	95,700	175,700	31,200	34,825	18	43	25	60									...	"
Toledo to Wheeling	... ..	....	..	.	.... .	......						5,179	2,314			141,720	8,590			.	"
Cleveland to Zanesville	.	......			......	.... ..	..					1,930	2,147			34,940	7,136			....	"

DISCUSSION.

The President:—The next business in order is the report of the Special Committee on Classification of Track, of which Mr. Chas. S. Churchill is chairman. The report of this Committee represents a large amount of work. The collection of statistical information has been difficult to secure and to tabulate, and the sheets attached to the report will indicate the immense amount of work the Committee has had to perform. Mr. Churchill will present the report.

Mr. Chas. S. Churchill (Norfolk & Western):—By way of explanation, it may not be out of place to review somewhat the work of the Committee. The Board of Direction appointed a special committee to recommend a division of steam railroad track into three classes for use as a basis for fixing standards. The need for this action was the fact that the Association as a body had been quietly adopting important standards, many of which are very high, and are above the general practice of but a small fraction of all the railroad mileage of this country. The Association is on record as recommending that all railroads should have a roadbed twenty feet wide, and other standards promulgated were on the same ideal basis. This Committee was asked to differentiate, or at least give a means for easily classifying districts of a railroad, so that on portions of any railroad or even on the whole of some lines lower standards of roadbed track and other items of railroad construction may consistently be used.

Your Committee has endeavored to formulate, for the guidance and information of the members of the Association, some rules of easy reference and application for this purpose. The plan used by the Committee in order to reach a conclusion was as follows: At the outset, individual members of the Committee and others of the Association had ideas that possibly size of locomotive, maximum axle loads, character of traffic, gross tonnage, revenue tonnage, train mileage, speed of trains or car mileage of districts were governing features. Some thought one of these, some thought another of them would be found most important.

Your Committee therefore asked for and collected from many railroads important data under every one of these heads, as shown in detail in the tables attached to the report. It has been through a careful study of these statistics that your Committee discarded the size of a locomotive used on a district as being in itself a ruling feature in this question of district classification. Size of locomotives are often determined by ruling grades alone and the heaviest types are often used on branch lines. All districts must gradually be gotten in shape to carry high axle loads under our method of general interchange of cars, hence the tabulated statement does not reveal strongly marked differences in this respect. Gross tonnage over a district is the true measure of the wear and life of rails, and, to a certain extent, of the track superstructure as a whole; but this data is not regularly kept nor easily secured.

However, the car mileage per annum per mile of a district is found to vary closely enough for our purpose, with gross tonnage, revenue tonnage, or train miles of that district. It is a figure always of record; and it is an item always considered in determining if any district shall have additional main tracks.

Hence your Committee concluded that car mileage along with the actual speed of trains is a proper unit for use in the proposed classification.

Actual car mileage and speed of trains can be applied under the rule to any district of a railroad for determining the standard to be used or corresponding prospective data can be advantageously used in the same manner for railroads under construction in determining the advisable standards of such construction.

With these few introductory remarks I think that the recommendations of the Committee become clear, and you will see that the aim of the Committee has been to make them as simple as possible. The underlying note, if you want to read between the lines, is that we shall not make the figures so high as to prevent many districts of our railroads from adopting the highest standards; on the other hand, we thought it advisable not to make the limits too low.

The President:—The Committee's report is before the convention, and we would like some discussion on it. The chairman suggests that each clause be taken up in its order, and we will therefore take up "Class A," which reads as follows: "Class A shall include all districts of a railway having more than one main track, or those districts of a railway having a single main track with a traffic that equals or exceeds the following: Freight car mileage passing over district per year per mile, 150,000; or, passenger car mileage per annum per mile of district, 10,000; with maximum speed of passenger trains of 50 miles per hour."

Mr. W. F. Tye (Canadian Pacific):—It seems to me the Committee has set this standard for Class A very low. I notice in some of the statistics that the freight car mileage per annum per mile of track runs up in one case to 1,550,000; in another case, 1,243,000; several cases, 600,000, 700,000 and 800,000. How are you going to classify such track as that? It seems to me that where the actual work done is ten times as great as the standard, the standard is either very low or another standard should be set.

Mr. Churchill:—There is nothing to limit what a railroad can do in the way of business, and it is not for us to limit them. The very fact that a railroad has grown big enough to have more than one track we argue should put it in line for adopting our highest standards, whatever they may be.

Mr. Tye:—That is the point I wish to make. That is a single track mileage. With that mileage you would necessarily have a single track, and not a double track. The standard is not set high enough for a double track.

Mr. Churchill:—You will find from the definition that Class A includes all railroads having more than one main track. If a district of a railroad has enough business to require more than one track, that district is regarded as one which should adopt the highest standards of this Association—Class A. It is for this Committee to designate the lower limit—the point at which it is wise for any railroad to decide that a given district on that road shall adopt the highest standards. We say, after going over this table, and comparing the roads and knowing the roads as the members of the Committee do pretty well, that we think that 150,000 freight car miles or 10,000 passenger car miles is this low limit. For anything below that it would be wise to adopt the next lower standard.

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis):—I did not understand it was the purpose of the Committee to undertake to pick out what roads were to be classed as first, second and third class. I understand that what they have published is merely incidental to their work of fixing three classes of roads in order that this convention may fix construction standards applicable to these different classes, and although a railroad happens to be so fortunately situated that it has such tremendous traffic as Mr. Tye has called attention to, it does not follow that a railroad which has not that traffic has not a track good enough to warrant taking care of it.

Mr. Tye:—If they have not got this tremendous traffic, they do not want as high a standard. If they have such tremendous traffic, they certainly want a higher standard.

Mr. McDonald:—If a road has a train running at the rate of 50 miles an hour, and only one train a day, it must have its track in condition to take care of it.

Mr. A. M. Shaw (Civil Engineer):—I think the Committee's report can be considered consistent in that the variable element due to the different conditions of traffic is not touched on, the amount of labor and material, etc., that would be required for repairs.

Mr. C. H. Ewing (Philadelphia & Reading):—I want to ask the Committee if they have made any computation as to the percentage of roads that would be first class under the proposed classification. I refer to the list of roads they have furnished.

Mr. Churchill:—No; we did not follow that line exactly. You noticed we asked the roads to give us the information by districts. I think that nearly all our railroads will have one or more districts which will not meet our requirements for Class A. We do not want to rule out all single track railroads, simply because a double, three and four-tracked railroad runs a million cars per mile. We think that many of the single track railroads should be made first class in their standards. Therefore, we must place the limit low enough to let in districts of single track railroads whose business is of such a character, either passenger or freight, as to warrant them in having a first-class roadbed, and in adopting first-class standards. It is for that reason we thought it wise not to place the limit too high, and so we made it 150,000 car miles. One trunk line represented on our Committee—and our Committee are practically a unit on this report—has fast trains, many of them merchandise freights, and there are some districts of his road where the fast trains run in greater numbers than on other sections. That district of the road should use the highest standards, and they should consistently have a reason from our Committee for their belief, and this same argument will apply to many other roads.

While I am on my feet I want to mention another matter. This tabulated statement which has been prepared only with great trouble, as has been remarked by the President, was arranged very largely by Mr. E. H. Fritch, our Assistant Secretary. He astonished me by the painstaking work he has done on this report all the way through. Several errors in the original returns were discovered and corrected by him. He even set the type from which these tables were printed. I think the Association should recognize the efforts of Mr. Fritch in this respect.

Mr. Robert Moore (Consulting Engineer):—The remarks of the chairman discloses the fact that the real criterion is the quality rather than the volume of traffic. If you have one high-speed train, requiring heavy locomotives, it would be sufficient to indicate that you should have a first-class track.

Mr. H. J. Slifer (Contracting Engineer):—A person considering this report might be led to believe that he should adopt Class A standards if he was hauling 150,000 car miles a year. Eliminating everything except freight tonnage from consideration, 150,000 car miles would represent ten trains a day over that district. The district would naturally be about 100 miles, which is the length of an ordinary district. It seems to me the limit, so far as the tonnage is concerned, has been placed too low by the Committee. I believe it should be placed higher, or an extra class should be provided. I do not know any road, with five trains in each direction, over 100 miles long, that would necessarily have to adopt such a high classification for its tracks.

Mr. L. C. Fritch (Illinois Central):—The Committee has tackled a very difficult subject, and one which the railroads will hesitate to adopt, I think, for legal reasons. The question is, if we set up various standards of track, and the attorneys get hold of it, whether or not it will not work to our detriment. It is a very delicate subject, and a number of executives think we should consider it very carefully before we adopt it. The Committee's work, however, has been thoroughly done, because if you apply it to any trunk line you will find that it fits present conditions very closely. If districts of a road are not admitted to the different classes on the freight car mileage, they may be admitted on the passenger car mileage, so that it actually works out very closely. The Committee has considered that very thoroughly, and when applied in practice it will be found to work in almost nine cases out of ten. I think, however, that one thing is not as clear as it might be. In Class A, where it says that "a railway having more than one main track, or those districts of a railway having a single main track that equals or exceed the following," etc., does the Committee intend to include any part of the district where there is a double track—whether that should be considered as Class A? It may extend over only a few miles of the district; that is not quite clear. There is also another feature—perhaps the maximum speed of passenger trains at 50 miles an hour would allow almost any road to enter that class, because at some time a passenger train may run faster than the maximum schedule speed, which is usually limited to 40 or 45 miles an hour.

As to the question of the dense traffic over the Eastern lines, it must be remembered that the Pennsylvania and New York Central are three and four-track railroads. When the dense traffic is distributed over three or four tracks, or the total traffic divided by the total number of tracks, you will find the traffic is not greater per track than that shown by the Committee's maximum. I think the Committee has approached pretty closely to the proper limit. If you change the maximum, 150,000 miles, you will exclude roads which should come under the classification.

Mr. Churchill:—The Secretary mentioned legal matters. That subject has been brought up many times as a sort of bugbear before this Association, but whenever the matter has been threshed out, it has generally been dropped as not very important. I wish to make clear the point I referred to in my opening remarks—that this Association has done something much more serious three or four years ago when they stated that railroads should have a twenty-foot roadbed, and again the thickness of ballast, when there was but a small fraction of the railroad mileage that had any such conditions. We are now preparing the basis for a lower set of standards. We are improving the situation and making it possible for the Association to put itself in better shape legally, and do it in such a modest way, if you please, that we think that the sharpest lawyer cannot make very much use of the proposed limits for standards. While we may not have covered the subject in the best possible manner, and would like suggestions, nevertheless we had in mind the questions of the Secretary from the outset.

Secretary Fritch spoke also of the speed of trains. We discussed that question, whether it should be schedule speed or not, and we have used here simply the word "speed," meaning the allowable speed on the district, which generally appears on the time table; it is the speed for which the road is built.

Mr. Tye:—I do not want to be understood as saying that a road with a car mileage of 150,000 miles could not have a good roadbed or track or anything of that kind. What I object to is this—up to 150,000 car miles per mile of track, you have three different standards; and further up—to 1,500,000 miles—you have nothing else. For the lower one-tenth you have three standards, and for the upper nine-tenths you have nothing else. I do not think you can induce a Board of Directors to spend the same amount of money to get a good track where you had 150,000 car miles that you could if you had 1,500,000 car miles.

Mr. W. M. Camp (Railway and Engineering Review):—A freight car mileage of 150,000 per year per mile of track amounts to about ten trains per day, figuring fifty-car trains. Some locomotives can haul more, but does the average locomotive haul fifty cars to the train? When we consider 1,500,000 freight car miles, that means five thousand cars a day. Can you get five thousand freight cars a day over a single track? If you can, you will have close work for the passenger trains. Secretary Fritch suggested that that traffic should be divided over four tracks. If you do this, you will not have the proportion of one-tenth. The item 150,000 freight car miles refers to one track, or 500 cars per day. That would mean twenty trains of twenty-five cars each. I do not think, considering general conditions, that we should assume as heavy trains as fifty cars.

So far as establishing standards of track is concerned, I do not think this Committee has done it—other committees have had to do with that. As I understand, the Roadway Committee and the Ballasting Committee have already established standards of track. It seems to me that that criticism applies to the other committees.

Mr. A. L. Buck (Canadian Pacific):—There is one division on the road with which I am connected that I believe handles more than a thousand cars in one day on a single track. It seems to me that we have got to meet this operating condition. It is a difficult matter to prevent the operating department from putting on power to haul the trains. The tendency is to heavy tonnage and it requires heavy engines to haul it. If a road is mostly equipped with heavy engines, there will be times when it will be convenient to run these over the less important lines; besides many of the heaviest loaded cars will be hauled over these lines from time to time, and they are nearly as trying on the track as an engine. The tendency is to heavy trains, and a track that has to maintain one heavy train per day or one fast passenger train comprising coaches and sleeping cars has to meet conditions requiring strength in the track to a much greater ratio than that represented by the tonnage or number of fast trains. The direct proportion item applies more nearly to the cost of repairs; but heavy loads require heavy rails, sound ties and good ballast.

Mr. R. C. Barnard (Pennsylvania Lines):—It seems to me the Committee should designate whether they mean schedule or actual speed of passenger trains. In their tables attached to the report they have given both, and in the case of probably fifty per cent. of the passenger trains the actual speed is their maximum limit. In order to avoid confusion, they should say whether they refer to schedule or actual speed.

Mr. H. T. Porter (Bessemer & Lake Erie):—I would like to ask for a little information. The freight car mileage is fixed at 150,000 car miles, and the passenger car mileage is fixed at 10,000 miles. On this basis one passenger car mile is equal to fifteen freight car miles. If a road had five thousand passenger car miles, and 75,000 freight car miles, should they be in Class A? The sum of the two makes 150,000 miles.

Mr. Churchill:—Our intention was not exactly that. It is, as stated, to make the 150,000 car miles a freight requirement. As passenger trains run at greater speed, we think that 10,000 car miles is the limit between Classes A and B. We might conceive of a condition of this kind—140,000 freight car miles over a district and 11,000 passenger car miles. I would recommend, in a district of that kind, under the action we have suggested, that that district use the Class A standards on the basis of the passenger car mileage.

Mr. Porter:—Suppose the road had 145,000 freight car mileage and 9,000 passenger car miles?

Mr. Churchill:—That is under in both cases. Of course, the management can do as it pleases.

Mr. Porter:—We are trying to get at the correct meaning of the Committee's clauses. That is the only point.

Mr. Churchill:—I would put that road in Class B.

Mr. Slifer:—I have considered the Committee's report more particularly from an operating standpoint than an engineer's standpoint. Something has been said by the chairman of the Committee with reference to the recommendations of the Committee on Roadway. The Roadway Committee's report, as adopted last year, was that there should be three widths of roadbed—14, 16 and 20 feet—so that 20 feet is not necessarily the standard of the Association. Now we are preparing to recommend to the operating department conclusions with reference to the class of track which should be built for their traffic, and it does not appear to me that 150,000 car miles of freight would necessarily call for the highest grade of track. You can run ten trains over a single piece of railroad in twenty-four hours, and they do not necessarily need to be high class merchandise trains with high speed; they might be slow freight trains, for ore or coal. I appreciate the fact that all classes of merchandise are high-class, if the man shipping it can "get next to" the traffic department. I do not believe that the Association can afford to say to the managers of the railroads of this country that if they have a piece of track handling ten trains a day—five in each direction—that they ought to build Class A track. I think it would be a mistake for the Association to say that they should. Our train mileage, so far as freight is concerned, should be placed higher than 150,000 miles.

Mr. L. C. Fritch:—The last speaker loses sight of the fact that that would be the average throughtout the year. As a matter of fact, the heavy business over any railroad is usually limited to about four months. In that case one would have more trains to contend with than an average throughout the year; and he also loses sight of the passenger trains in addition to the freight trains. We would have, say, 500 loads per day passing over a district, and that would mean at an average of forty cars, about 12 to 13 freight trains, and in addition probably four passenger trains each way a day, and that would make about twenty trains a day. That makes quite a busy piece of railroad. I think we should use great care in raising the figures, for the reason that it will close some of the important lines out of this classification.

Mr. McDonald:—In answer to another part of Mr. Slifer's statement I would suggest that perhaps he has not looked at the personnel of this Committee. In place of our being in the attitude of saying to our General Managers what classification we want, we are rather in the attitude of having a message from the General Managers as to what they think about it.

The President:—Does the convention desire to make any further expression upon the first clause? If there is no objection, this paragraph will be considered adopted. The Secretary will read the second paragraph.

The Secretary:—"Class B shall include all districts of a railway having a single main track with a traffic that equals or exceeds the following: Freight car mileage passing over district per year per mile, 50,000; or, passenger car mileage per annum per mile of district, 5,000; with maximum speed of passenger trains of 40 miles per hour."

The President:—Is there any discussion on Class B? If there is no objection, that will be considered adopted.

The Secretary:—"Class C shall include all districts of a railway not meeting the requirements of Class A or B."

The President:—Is there any discussion on Class C? If not, it will be considered adopted.

Mr. McDonald:—What will be the effect of receiving these classifications and publishing them in the Proceedings? Does it authorize our committees in preparing standards hereafter to refer to Classes A, B and C?

The President:—The chair would like to hear some discussion from the floor on that question.

Mr. McDonald:—I move that the report of the Committee be adopted by the Association and published in the Manual.

Mr. L. C. Fritch:—I would amend that motion by referring it to a vote by letter-ballot by the membership of the Association.

(The amendment was carried.)

Mr. W. B. Storey, Jr. (Atchison, Topeka & Santa Fe):—I call attention to the fact that Class B includes also Class A, where it states "Class B shall include all districts of a railway having a single main track with traffic that equals or exceeds the following." It should read "under Class A."

Prof. W. D. Pence (Purdue University):—Unfortunately, "Under Class A" has two meanings. Do you not mean "beneath Class A?" The words "under Class A" might also be understood to include Class A. I would suggest that it be made to read, "below Class A."

The President:—If there is no objection, it will be made to read, "less than the minimum prescribed for Class A."

(No objection being made, the amendment was adopted.)

REPORT OF COMMITTEE NO. I—ON ROADWAY.

To the Members of the American Railway Engineering and Maintenance of Way Association:

In preparing the original draft of glossary to accompany the report of your Committee on Roadway, we selected every word that might be referred to in the text and submitted our definitions at the last annual meeting. Your consideration of our specifications consumed so much of the time of the convention that the glossary was referred back to the Committee, and in accordance with President Kelley's circular letter of April 3d, we received a number of suggestions, all of which have been carefully considered.

GLOSSARY.

GROUP A—GENERAL.

CLASSIFICATION.—Separating the material into groups according to its character.

CONTRACT.—A written agreement between two or more parties specifying terms, conditions, etc., under which certain obligations must be performed. (Specifications are a part of the contract.)

ESTIMATE (noun).—(a) A statement of work performed or material delivered, according to which payment is to be rendered.

(noun).—(b) A statement showing the probable cost of a proposed piece of work.

(verb).—The act of making an estimate.

QUANTITIES.—The amount of material to be handled, expressed in the usual units.

SPECIFICATION.—That part of the contract describing the details of construction.

UNIT PRICES.—The price per unit of the various quantities specified in a contract for which a certain work is to be done.

GROUP B—RIGHT-OF-WAY, ETC.

RIGHT-OF-WAY.—The land or water rights necessary for the roadbed and its accessories.

ROADBED.—The finished surface of the roadway upon which the track and ballast rest.

ROADWAY.—That part of the right-of-way of a railroad prepared to receive the track.

STATION GROUNDS.—Property to be used for station purposes.

GROUP C—TECHNICAL.

ALINEMENT.—The horizontal location of a road with reference to curves and tangents.

CENTER LINE.—A line marking the center of an excavation, embankment or of a track.

CONTOUR.—The line of intersection between a horizontal plane and a given surface.

CROSS-SECTION.—A section through a body perpendicular to its axis.

CENTER STAKES.—Stakes marking the center line.

ELEVATION OR HEIGHT.—The distance of any given point above or below an established plane.

FINISHING STAKES.—Final stakes set for the completion of work.

GRADE (verb).—To prepare the ground for the reception of the ballast and track.

GRADE-LINE.—The line on the profile representing the tops of embankments and bottoms of cuttings ready to receive the ballast.

GRADIENT.—The rate of inclination of the grade-line from the horizontal.

PLAN.—A drawing furnished for guidance of work.

PROFILE.—The intersection of a longitudinal vertical plane with the ground or established gradients; or a drawing representing the same.

SLOPE.—The inclined face of a cutting or embankment.

SLOPE STAKES.—Stakes set to mark the top or bottom of a slope.

SUBGRADE.—The tops of embankments and bottoms of cuttings, ready to receive the ballast.

TOP OF SLOPE.—The intersection of a slope with the ground surface in cuts, and the plane of roadbed on embankment.

TOE OF SLOPE.—The intersection of a slope with the ground surface in embankments, and the plane of roadbed in cuts.

GROUP D—CLEARING, ETC.

BRUSH.—Small trees, shrubs or branches of trees that have been cut off.

CLEARING.—Removing natural and artificial obstructions to grading.

GRUBBING.—Removing the roots.

GROUP E—DRAINAGE, ETC.

BOG.—Wet or spongy ground.

CHANNEL.—The depression or cut in which a stream is confined.

CULVERT.—An arched, circular or flat covered drain of timber, iron, brick, or masonry, carried under the roadbed for the passage of water.

DRAIN.—An artificial waterway for conducting water from the roadway.

DRAINAGE.—The interception and removal of water from, upon or under the roadway.

DITCH.—An open artificial waterway for providing drainage.

INTERCEPTING DITCH.—An open, artificial waterway for preventing surface water from flowing over the slopes of a cut or against the foot of an embankment.

SUBDRAIN.—A covered drain, below the roadbed or ground surface, receiving the water along its length by absorption or through the joints.

TRENCH.—A narrow, shallow excavation, to receive a structure.

WATERWAY.—A channel, either natural or artificial, for conducting the flow of water.

GROUP F—GRADING, ETC.

AVERAGE HAUL.—The mean distance that material must be hauled.

AVERAGE TOTAL HAUL.—The average total distance that material must be hauled.

BENCHED.—Formed into a series of benches.

BERME.—An approximately horizontal surface between the top or toe of a slope and a boundary line, ditch or other excavation, for the protection of the slope.

BORROW (verb).—To take material from a borrow pit.
(noun).—Material removed from a borrow pit.

BORROW PIT.—An excavation made for the purpose of obtaining material.

EMBANKMENT (or fill).—A bank of earth, rock or other material constructed above the natural ground surface.

EXCAVATION (or cutting).—(a) The cutting down of the natural ground surface.
(b) The material taken from cuttings, borrow pits or foundation pits.
(c) The space formed by removing material.

FOUNDATION PIT.—The excavation in which the foundation of a structure is laid.

HAUL or FREE HAUL.—The distance within a given limit that material is hauled in constructing the roadbed.

OVERHAUL.—The distance beyond a given limit that material is hauled in constructing the roadbed.

SHRINKAGE.—The contraction of material.

STEPPED.—Formed into a series of steps.

TAMPED (or packed).—Packed down by light blows.

TOTAL HAUL.—The total distance that material must be hauled.

WASTE.—Material in excess of that required to make an embankment of given cross-section.

WASTE or SPOIL BANKS.—Excavated material not used to form embankments.

GROUP G—TUNNELS, ETC.

CURB.—A broad, flat ring of wood, iron or masonry, placed under the bottom of a shaft to prevent unequal settlement, or built into the walls at intervals for the same purpose.

ROCK.—A solid mass of mineral substance.

SHAFT.—A pit or well sunk from the ground surface above into a tunnel for the purpose of furnishing ventilation or for facilitating the work by increasing the number of points from which it may be carried on.

TUNNEL.—An excavated passageway under ground or water.

WELL or SUMP.—A cistern or well into which water may be conducted by ditches to drain other portions of a piece of work.

INDEX OF NAMES.

BEING A LIST OF REFERENCES TO WRITINGS OR DISCUSSIONS ON THE SUBJECT OF "EARTHWORK OVERHAUL" CONTAINED IN THIS REPORT.

Note.—References in Index are as follows:

(Com.)—Refers to statements by members of the Committee on Roadway concerning suggested alternate clause.

(Int.)—Refers to historical introduction to "Review of Literature."

Numerals, where used alone, refer to articles or references in the "Review of Literature."

A (6)—Refers to the sixth entry in the tabulated digest of replies from Association members, designated "A."

AB (10)—Refers to the tenth entry in the tabulated digest "A" and the corresponding remarks (if any) by the same person in the summary of discussion, designated "B."

INTRODUCTORY.

Your Committee has not been able to accomplish very much during the past year, during which time several meetings were held, in addition to which the various matters assigned to us have been handled by correspondence.

At the meetings held in the office of the Association in Chicago, August 21 and December 12, 1905, it was evident that there were many views as to the proper wording of an overhaul clause, both as to defining the manner of payment and also method of computing overhaul. In fact, your Committee at this time is not of sufficient unanimity of opinion to submit definite conclusions, and has taken the liberty of presenting to the Association the various views held by the members.

At the meeting held in December it was concluded to submit to the Association for adoption the following:

"The contract prices per cubic yard cover any haul found necessary within the limit of an average free haul of ....(....) ft. All haul on material beyond this average free limit of haul will be estimated and paid for on the basis of the following method of computation, viz.: The length of the gross haul shall be fixed by determining the distance between the center of gravity of the excavation and the center of gravity of the embankment built therefrom. From this distance of gross haul shall be deducted the average free haul, ...(....) ft., and the remainder will represent the net or paid haul distance; which, multiplied by the total yardage of the excavation, will represent the yardage to be paid for."

The Chairman submitted the foregoing to the members for an expression of views, and the replies are as follows, viz.:

G. H. Bremner (Engineer Maintenance of Way, Chicago, Burlington & Quincy—by letter):—"Referring to the suggested clause for overhaul, I do not believe we have made the meaning of it perfectly plain, nor are the methods described by Mr. Berg perfectly plain. I have referred this to a few of our engineers as to how they interpret the meaning of it, and do not get the same explanation from each of them. I have drawn up a clause, which is, of course, subject to improvement, which I have attached. While this method of paying for overhaul is not a general practice, I believe we should make it so if we can.

"'The contract prices per cubic yard cover all material hauled where the distance from the center of gravity of the excavation to the center of gravity of the embankment built therefrom does not exceed .... (....) ft. All material, where the distance between the center of gravity of the excavation and the center of gravity of the embankment built therefrom exceeds ....(....) ft., shall be allowed overhaul for this distance between the centers of gravity in excess of .... (....) ft. The total yardage to be paid for as overhaul is obtained by multiplying the total yardage of the excavation by this distance between the centers of gravity in excess of .... (....) ft.' "

J. F. Burns (Roadmaster, Louisville & Nashville—by letter):—"As the clause proposed seems to agree with the most common practice, I shall be inclined to favor it, though personally I should prefer a clause according to Mr. Berg's third method, which seems to me to be more consistent and also more in line with the method in which the overhaul is taught in the schools. I am enclosing a copy of the overhaul clause as used by the Louisville & Nashville Railroad Company in its specifications:

" '11. Haul.—All material from excavations, except when otherwise directed by the Engineer, shall be deposited in the embankments. The cost of hauling and depositing or placing excavated materials in embankments, when the average haul is not more than five hundred (500) ft., shall be considered as paid for in the price paid for excavation.

" '12.—Extra haul shall be estimated and paid for as follows: Whenever material from any cut is necessarily hauled a greater average distance than five hundred (500) ft., there shall be paid, in addition to the price of excavation, the price of extra haul per one hundred (100) ft. for each one hundred (100) ft. of average haul in excess of an average haul of five hundred (500) ft. Fractional parts of one hundred (100) ft. of extra haul shall be paid for at a proportional rate.

" '13.—Average haul shall be computed for each cut separately, and short haul from one cut shall not offset long haul from another cut. The average haul from any cut shall be the distance between the center of gravity of that portion of the cut hauled and center of gravity of the fill which the material hauled from the cut makes.

" '14.—In tunnel work the haul shall be computed from the portal of the tunnel or center of shaft to the center of gravity of the embankment or spoil bank, and from a distance between these points there shall be taken the free haul of five hundred (500) ft.' "

F. R. Coates (Contracting Engineer):—Verbally supports the resolution as suggested.

C. Dougherty (Superintendent, Illinois Central—by letter):—"I do not perceive any changes that could be made in the wording of the proposed alternate clause that would improve it, although I think that, as worded, it still leaves an opportunity for controversy as to the meaning of the term 'average free haul' or 'average free limit of haul,' as applied to any piece of excavation and embankment. I am satisfied, however, to let the suggested clause go in as proposed."

W. D. Pence (Professor of Civil Engineering, Purdue University—by letter):—"Before I went to the recent Committee meeting I favored method 'C,' but voted in favor of method 'B,' chiefly because I thought the Committee should be a unit. However, since my review of the opinions of the Association members, obtained in response to the circular of inquiry, I am disposed to return to my former position in favor of Mr. Berg's method, 'C.' The matter is sure to have a full discussion on the floor at the annual convention, and I should rather see our Committee submit well-worded alternate clauses covering methods 'C' and 'B,' and also providing for Mr. Rohwer's suggestion for overhaul from borrow pits alongside of tracks (perhaps by a separate paragraph), for the open discussion and decision of the Association at its annual convention. Our position might be strong in one sense should we make a definite choice; but there is always a tendency, I have noticed, to support the recommendation of a standing committee 'on general principles,' and this is a matter of such general dispute that I should like to see it decided on its merits."

H. Rohwer (Consulting Engineer, Missouri Pacific—by letter):—"I desire to say that the wording of the clause to be submitted by the Committee on Roadway fully expresses the practice in use on this road, and it worked well. I approve of same as far as hauling material from *cuts* into *fills*. But when material is being obtained from borrow pits along the embankment and *runways have to be constructed*, the *haul* should be determined by the distance the team is bound to travel. And the overhaul and material thus hauled or moved should be: One-half the 'round' minus 'free haul;' the runways to be established at distances of good working practice in conformity with the approval of the engineer in charge."

A. M. Shaw (Chief Engineer, Northern Illinois Electric—by letter):—"I have not the report of the last meeting of the Committee at hand, so cannot reply fully, but will state that I am still decidedly in favor of the overhaul clause as submitted by our Committee last season, in which it was specified that, in computing overhaul, all work done within the limit of free haul should first be cut out, and then overhaul shall equal the distance between center of gravity of remaining masses of excavation and embankment, minus length of free haul. I will not take up your time with a discussion of the subject, as it would practically be a repetition of Mr. Berg's arguments of three years ago, with which I believe that you are familiar."

A. K. Shurtleff (Assistant Engineer, Chicago, Rock Island & Pacific—by letter):—"I have received the overhaul clause agreed to at the last meeting of the Roadway Committee. I am positively opposed to any such clause as this, as I have always thought Mr. Berg's third method was the only just method for estimating overhaul. The contractor should receive the benefit of all short hauls less than the maximum free haul. My ideal overhaul clause is as follows:

"'When the length of the haul necessary to remove material from excavations and borrow pits and deposit it as directed by the Engineer exceeds ....(....) ft., the contract price per cu. yd. for overhaul will be paid in addition to the contract price for excavation, for each one hundred (100) ft. in length of haul in excess of the .... (....) ft.

"'The amount of excavation and embankment required to make the maximum free haul is to be first accurately determined, the contractor receiving the benefit of all haul less than the specified limit. Then the distance between the center of gravity of the remaining portion of the excavation and the center of gravity of the embankment to be made therefrom, less the length of free haul, shall determine the length of the overhaul.'

"While this may not have the best wording, I believe it fully covers Mr. Berg's third method, and I would be glad to see the Association adopt such a clause, although I am personally in favor of entirely eliminating the pay for overhaul."

J. G. Sullivan (Assistant Chief Engineer, Isthmian Canal Commission—by letter) :—"I will say in connection with this matter that before leaving Winnipeg I spent a little time in working up a plan I have lately used in computing overhaul, but since coming down here I have been so busy nothing further has been done, and now that the matter is brought up again I cannot find the papers that I had in Winnipeg, but wish to say that I think you know that I am a firm believer in the policy of paying for overhaul. I am not, however, very particular as to the limit of free haul or the method of computing overhaul.

"In connection with the former, I have worked on roads where we had a classification for material hauled less than 300 ft., another classification for material hauled between 300 and 1,000 ft., then overhaul beyond a distance of 1,000 ft., so much per cu. yd. per 100-ft. haul. Later, on the Canadian Pacific, we worked entirely with one flat distance of 500 ft. free haul. Personally, I preferred the former method. It was a means of getting us a pretty low price for any material which was wasted or borrowed from the side.

"Now, as to the limit of maximum haul, it has usually been the practice where I have worked to place a limit between 2,000 and 3,000 ft., usually the point where the cost of overhaul balances the cost of earth borrowed, but I can say that in work where there are very large cuts, this limit is not sufficient, and for the last two years I have been doing work with a clause in the contract under which this heavy work was done, that there was no limit to the haul and that, when the price of overhaul equals the price of earth excavation, there would be a flat rate paid for all material hauled beyond these limits, i. e., we were paying 23 cts. for earth excavation with a 500-ft. free haul; we paid 46 cts. a yard for all material hauled over 2,800 ft. (1 ct. per cu. yd. was our price for overhaul). Under some of these contracts we hauled material two miles and it worked very satisfactorily.

"Now, as to the measurement of overhaul, it is rather immaterial whether the quantities are measured in fill or in excavation in ordinary work, but when it comes to rock work, there are so many factors which enter into this that I do not think that it is just, reasonable or logical to multiply the total yards of excavation by the distance of overhaul, unless you qualify excavation in several ways. First, a few roads say that no material taken out beyond slopes should be paid for; then we know that rock will expand between 50 and 100 per cent., therefore, I do not see why we should not pay the contractor for hauling a yard of loose rock 100 ft., even though it is taken out of a rock cut, the same price as if it was taken out of a loose rock cut. Therefore, in computing overhaul from rock cuts, I have always taken into account expansion and the material excavated outside of the slopes.

"Now as to the method of computing overhaul; I had this worked up, as I have said before, but cannot find the papers. I am rather too busy just now to go over the matter again, but will explain so that I think my idea will be plain.

"Take a piece of common profile paper, plate 'A,' starting at the beginning of a cut at zero and plot the quantities, using the natural scale of 400 ft. to the inch for distance, and the vertical scale of about 2,000 cu. yds. to the inch, plotting both fill and cut above the datum line; that means, of course, adding the yards in one station to the total that you had up to that station, and plotting accordingly. When you get through with the cut, the vertical from the base line equals the total number of yards of the cut. If it is a rock cut, it would equal the total number of yards taken out with a percentage for expansion added, which would have been checked up on the amount of fill made. Then find with a scale of 400 ft. to the inch where the distance between the two lines between cut and fill equals 500 ft. or whatever may be the free-haul limit, and this would be the amount of yardage of free haul. Draw a line at this point. The next step, draw a line where the distance between these curves is the free haul plus 50 ft., then draw a line where the distance between these curves is 100 ft. greater than the latter, that is, 150 ft., 250 ft., etc., plus the free haul. Now, the yardage indicated between the free haul and the first line, multiplied by 25 ft., the mean that the yardage was hauled, will give you the equivalent number of yards hauled 100 ft.; the yardage between the 50 ft. plus free haul and the 150, multiplied by 100 ft., is the equivalent yardage of 100 ft.; the yardage between the 150 ft. plus the free haul and the 250 plus free haul, multiplied by 200, gives you the equivalent yardage, and so on.

"There are so many factors in computing overhaul that this method I consider to be far more correct than some of the factors that enter into the computation. It is very simple and easily understood by any field engineer. If there is any error of judgment in taking the exact number of yards between the lines they should about balance when you get through. The total number of yards that you have, multiplied by the different factors, will equal the yardage in the fill, or the yardage in the cut, if it be a rock cut, plus the shrinkage after the free haul has been deducted. I think you will agree with me that there can be no great error in this method.

"If a second cut or fill should intervene between the limits of haul, you simply balance that cut or fill if it is less than the free haul and draw a straight horizontal line on your plotting to the limits of the balance as above mentioned. Then add your cut or fill as before."

H. M. Waite (Superintendent, Cincinnati, New Orleans & Texas Pacific—by letter):—"We believe the proposed alternate clause is all right."

L. H. Wheaton (Chief Engineer, Halifax & South Western—by letter):—"I agree with the clause proposed, and with a free haul of 500 ft. It was formerly the practice in this part of the country to have 1,000 ft. as the limit, but during the last ten years it has been uniformly 500 ft. at 1 ct. per cu. yd. per 100 ft., with the method of computation as per the proposed clause mentioned."

R. C. Young (Chief Engineer, Lake Superior & Ishpeming—by letter):—"I submit herewith an overhaul clause which does not conform exactly to the one submitted in the circular but which I have changed as little as possible and still have it conform to my ideas of what such a clause should be.

"'The contract prices per cubic yard cover any haul found necessary within the limit of an extreme free haul of .... (....) ft. All haul on material beyond this extreme free limit of haul will be estimated and paid for on the basis of the following method of computation, viz.: The length of the gross haul shall be fixed by determining the distance between the center of gravity of the excavation and the center of gravity of the embankment built therefrom, such excavation and embankment not having been included in the said free haul limit. From this distance of gross haul shall be deducted the extreme free haul, ... (....) ft. and the remainder will represent the net or paid haul distance, which multiplied by the total yardage of overhaul excavation will represent the yardage to be paid for.'

"I object in the first place to an average free haul, as it does not really limit the free haul and makes it possible on some profiles to extend such free haul so as to work an injustice to the contractor. I also think it is always policy to have such clauses read so that there can be no possible misunderstanding of the meaning intended."

R. C. Barnard, Vice-Chairman—(by letter):—"I have your letter of the 24th inst., enclosing copy of the overhaul clause proposed by the Committee. As you know, I am opposed to overhaul in our specifications; but, as I understand it, this is an alternate clause, and as such I am willing to vote in favor of its adoption."

H. J. Slifer, Chairman:—Favors the clause as suggested.

Careful investigation of current literature indicated that no one author has presented a complete discussion of the subject of overhaul, and it was decided to gather together all information that could be found and arrange it for the information of the members of the Association. Through the voluntary offer of Prof. Pence, we are able to present the following historical summary of the treatment of overhaul by engineers and by authors, both in America and Europe, from the earlier days of railroad construction to the present time. It is believed that this compilation may serve a useful purpose at the present time, when an attempt is being made by this Association to unify and simplify practice in the treatment of this vexatious question of overhaul; and it is quite sure to be of practical value for reference purposes for the younger members of the profession and others who are called upon to deal directly with the matter of overhaul. Certain portions of the review appear now for the first time. Some repetition has been necessary for the sake of completeness. Specific references to the sources of information are supplied in all cases, so that the original may be consulted if desired.

(I.) REVIEW OF PRACTICE IN THE TREATMENT OF OVERHAUL IN EARTHWORK CONSTRUCTION.

HISTORICAL.

It is quite certain that so important a matter as earthwork haul and the related question of the economical disposition of materials of construction received careful consideration from the able engineers who, previous to the era of railroad building, were engaged in the construction of roads and canals and other works involving the transportation of earth; for very early in the period of active construction of railroads methods were developed which are essentially those employed to-day, both in Europe and America.

European Practice.—Gayffier (1844) discussed the economics of haul in earthwork construction according to the practice of the French engineers, and stated the principles of "average haul" as it has since been recognized.

According to Culmann (1866), the Germany authority, the use of the "mass diagram" or "profile of quantities" was introduced previous to 1847 by Bruckner, engineer of the Bavarian state railways, and used by him for the graphical study of the distribution of earthwork and for the solution of haul problems. The graphical method then introduced is essentially the same as that subsequently adapted to American practice by Reineker (1871-1873).

Prelini (1905) states that "Lelanne's Curve" was used by French engineers previous to the general use of "Bruckner's Curve" in Germany. His description of European practice, given elsewhere in the review of the literature of the subject, also includes the method usually followed by Italian engineers.

The German practice has also been described for the benefit of American engineers in the pages of technical journals and before engineering societies by Thiange and Rudiger (1883), Berg (1883), Specht (1885), and Fisher (1885, 1891), references to which are given in the review of literature.

The method employed by German engineers at the present time is fully described by Tscherton (1899), the process being very similar to that introduced by Bruckner (1847) and described by Culmann (1866).

American Practice.—Among the earliest references to the haul element in earthwork construction is to be found in a paper presented in 1841 to the Franklin Institute by Ellwood Morris on the "Cost of Embankments." In this paper Morris derives a formula for calculating the cost per cubic yard of earthwork, involving a term which he designates "average haul of the embankment, in stations of 100 ft. each." The haul unit, "cubic yard-station," thus introduced by Morris, and still in general use, was probably suggested in part by his observation that "the number of feet of trip traveled by each cart per minute equals 100 ft. or 200 ft. lineal actually moved over." The term "average haul" is used several times by Morris in this paper, which was, perhaps, the earliest attempt by an American engineer to analyze the cost of earthwork.

Gillespie (1847) discussed the subject of earthwork haul quite fully and quoted both from Morris's paper and from the French treatise by Gayffier, issued three years previously. No reference to the subject, however, is to be found in the treatises by the following authors: Scribner (1847), Henck (1854), Byrne (1855), and Cross (1857).

The following statement, by Mr. Octave Chanute, member of the Association, concerning the early methods of treating overhaul in this country, is of especial interest, because of his long familiarity with American engineering practice:

"My experience reaches back to 1850, at the beginning of railroad building on an extensive scale. Some efforts were made then to let grading work with clauses providing for the payment of overhaul. These clauses led to subsequent disputes with the contractors, who, not being scholars, claimed that they were being unjustly treated in the engineer's computations. This brought, in many instances, a change in methods, and the grading was let in short sections (1 to 3 miles) with no clause about overhaul; the bidding contractors being required to estimate for themselves how much the overhaul added to the uniform price per cubic yard. This resulted in some diversity of prices; adjoining sections containing the same class of materials, being let at different figures, in consequence of overhaul. A further result was that the contractors were allowed to 'waste and borrow,' i. e., wasting part of the cuts and purchasing borrow pits from which to make part of the embankments. This further developed a practice of 'paying both ways,' i. e., a specified price per cubic yard for cuts, and a specified price for embankments, and some very cheap grading was done under this method, particularly in the prairie country of Indiana and Illinois.

Slight attempts were made to lay the grades so as to equalize the cuts and fills accurately, the principal effort being to get the grading done as cheap as possible. About 1865 the practice of dealing directly with the small contractors began to change, and grading was let in long stretches to powerful firms or individuals, who were well equipped with tools, money and energy. These sublet the work in sections to the small contractors, did the difficult grading themselves, and greatly simplified the task of the engineers to keep the work moving and to settle disputes. I do not know how the overhaul question was handled in grading the trans-continental lines."

Trautwine (1871) made no reference to the subject of haul in his work on the calculation of earthwork, but in the article on the cost of earthwork in his pocketbook, issued in the same year, a definition of "average haul" is given which conforms to that found in the literature issued previous to 1850. Vose (1872) also used the same term in discussing estimates of cost of earthwork, but Shunk (1879) makes no reference to the subject.

Beginning with Searles (1880), the subject of overhaul has received increasing attention from authors of standard treatises, including Allen (1889, 1894), Godwin (1890), Nagle (1897), Webb (1899, 1903), Philbrick (1901), Molitor and Beard (1902), and Gillette (1903). Frost's reprint (1891) of Cross's field book was the first American work to present the German graphical method of attacking problems in earthwork haul, consisting of a reproduction of Fisher's adaptation of Bruckner's method, after Reineker (1871-1873). The graphical method was extensively used on the South Pennsylvania Railroad in 1882-1885.

Among those who have discussed the subject of overhaul in the engineering journals and society proceedings are Thiange and Rudiger (1883), Berg (1883), Fisher (1885, 1891), Wellington (1888), Walker (1889), Russell (1891), Brown (1891), Allen (1895) and Webb (1897).

Perhaps the most complete discussion of the subject of overhaul, as regards American practice, is to be found in the Association Proceedings for 1903, reproduced in the review of literature. From a careful study of that discussion and of the replies obtained from the circular of inquiry recently sent to the members of the Association by the Roadway Committee, it appears that a considerable number of representative roads have abandoned the practice of paying for overhaul, as such; and that on those roads which still adhere to the practice of estimating and paying for overhaul, two methods of calculation are chiefly used, differing mainly as to the basis for determining the free haul limit or distance. In one of these methods the free haul limit is taken as an *extreme* or *"out to out"* distance, and in the other method it is assumed to be an *average* distance which is to be deducted from the distance between the centers of gravity of the excavation and the embankment built therefrom to obtain the overhaul. The two methods also differ as to the yardage to which the overhaul distance is applied. In the former, overhaul is allowed on that portion of the excavation yardage beyond free haul limits; and in the latter method on the entire excavation yardage hauled. The net or overhaul distance in both methods is, of course, equal to the gross or total haul less the free haul distance. The length of the free haul limit varies widely on different roads. Some prefer to calculate the overhaul by numerical processes and others graphically. The full range of practice is indicated in the chronological review of the literature of the subject, given in the following pages, and in the digest of current practice of the members of the Association which follows the review.

REVIEW OF LITERATURE OF OVERHAUL.

1. Ellwood Morris, "The Cost of Embankments of Earth when made with Carts," in paper before Franklin Institute, 1841 (Jour. Frank. Inst., Vol. 32, pp. 164-174) discusses the cost of earthwork and derives a formula for calculating the cost per cubic yard, involving as one term the "average haul of the embankment, in stations of 100 feet each," and as another the "number of feet of trip traveled by each cart per minute equal to 100 feet, or 200 feet lineal actually moved." Here appears, perhaps for the first time, the haul unit, "cubic yard-station," which is still in use among American engineers.

2. Gayffier, "Manual of Bridges and Roads," ("Manuel des Ponts et Chaussées," Paris, 1844), pp. 122-142, discusses the problem of haul with respect to the mean distance of transport and develops a scheme for the economical disposition of the materials in earthwork construction. His methods formed the basis of Gillespie's discussion (Reference No. 3).

3. W. M. Gillespie, "Manual of Road-Making," (New York, 1847), pp. 123-124, 149-153, discusses the subject of earthwork haul as follows:

"The equality of the masses of excavation and embankment is not the only consideration. The distances to which it is necessary to transport the earth which is moved, must be taken into the account. Suppose that a mass of earth whose surface is ABCD, Fig. 1a, is to be removed to the embankment whose surface is EFGH, and which has a thickness sufficient to make the two masses equal. The mean distance of transport is required. Conceive the mass ABCD divided into a very great number of smaller masses. The sum of the products of these portions, by the distance which each of them is actually moved, will equal the product of the sum of the portions (i. e., of the whole mass) by the mean distance. The mean distance therefore equals the above sum of products divided by the whole mass (Gayffier, p. 122). In such cases as usually occur on a road, in which the cubes of excavation and embankment are comprised between two parallel planes, whose horizontal traces are ABEF and DCHG, Fig. 1, and in which sections made by other planes, parallel to the first, cut off equal partial volumes, we know, from the principles of mechanics, that the mean distance desired is equal to the distance of the centers of gravity of the two volumes. In the simple example above, the mean distance of transport would be the distance between the centers of the two rectangles. The methods of apportioning the excavations among different embankments, which ought to be adopted in more

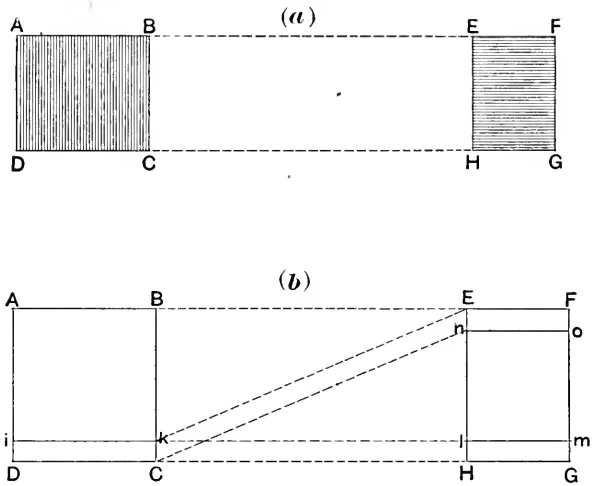


FIG. 1.

complicated cases of various distances of transport, in order to attain the minimum of labor and expense, will be considered in the next chapter, which treats of actual construction."

The further discussion is as follows:

"The problem which is to be solved, both in theory and practice, is, 'To remove every portion of earth from the excavation to the embankment by the shortest distance, in the shortest time, at the least expense.' It must also be deposited so as to form a consolidated mass, and so that not a particle of it will need to be again removed. The problem is very important in practice, for upon its mode of solution depends a large portion of the cost of the work; and in theory, it requires the aid of the higher calculus, since, to satisfy its conditions, the sum of the products, arising from multiplying all the elementary volumes of earth into the distances which they are carried, must be a minimum. We have seen that in the simplest case, that in which the whole of one excavation is to be carried into one embankment, we may use the product of the entire mass multiplied by the distance of the centers of gravity of its two positions. But when certain portions of a cutting are to be deposited in spoil banks; others to form part of an embankment, of which the remainder is to be obtained from side cuttings, etc., it does not appear *a priori* what arrangement would give a minimum expense. In a few cases the proper course is evident; as, if a hill is to be cut down, and its materials serve only to fill up a valley, and are in excess, the excavation from its summit is clearly the portion to be deposited in spoil bank; if the materials are insufficient to form the embankment, it is the part most distant from the hill which should be formed from a side cutting; if the excavation is to be carried in two different directions and is in excess, it is the part of the middle which should be rejected and deposited in spoil bank.

"One general principle of transport may be readily deduced. Let ABCD, Fig. 1b, represent the plan of an excavation from which the embankment EFGH is to be formed. If the volume CDik, instead of being taken to BHlm, should be transported to EFon, it follows that the embankment GHlm must be obtained from the portion of the excavation beyond the line ik, and that the paths of the two volumes will cross each other, which is therefore a disadvantageous disposition, since it increases the distances passed over. Any such crossing of the paths of the volumes transferred, either horizontally or vertically, may be generally avoided by conceiving the solid of excavation and embankment to be intersected by parallel planes, such as DCHG, ik, lm, etc., and by transferring the partial solids in the manner indicated by the boundaries marked by these planes."

The remainder of Gillespie's discussion is directed to a theoretical application of the principle just stated to the case of a borrow pit from which the earth is to be hauled to two embankments, the method being that adopted by Gayffier, the French authority (Ref. No. 2).

4. K. Culmann, "Graphical Statics," ("Die graphische Statik," Zurich, 1866), pp. 142-150, presents the graphical method developed previous to 1847 by Bruckner, engineer of the Bavarian state railways. The German technical term, "Massennivellement," which is used as a chapter heading in Culmann's treatise, meaning literally the "leveling of the masses," relates to the distribution or disposition of the earthwork from excavation to embankment, wasting and borrowing, etc. The graphical representation or diagram of the earthwork quantities introduced by Bruckner and elaborated by Culmann has received two designations by American translators, viz., the "profile of quantities" used by Reineker, Fisher and others; and the "mass diagram," used by Allen and Webb. The lengthy translation closely following the original text of Culmann is here omitted, and reference is made to Reineker's abstract translation (Ref. No. 5).

5. F. Reineker, Principal Assistant Engineer, Pennsylvania Co., (1871-3), first introduced Bruckner's "Profile of Quantities" into American practice. The following translation, prepared by Reineker, follows the text of Culmann only in a general way and may be regarded as an abstract of the original, or an adaptation of Bruckner's method to American conditions. A copy of this abstract was obtained through the courtesy of Mr. S. B. Fisher, Chief Engineer, Missouri, Kansas & Texas Ry., who obtained a copy of the translation from Mr. Reineker in 1873, and who was among the first engineers in this country to employ the method in routine work.

"The 'Profile of Quantities' is a diagram, showing the quantities requiring hauling in the grading of a railroad or other line of earthwork. It shows at one view not only the actual quantities between stations or aggregates of cuts, but also the distances to which the same have to be hauled for disposal in embankments or spoil banks. It further affords means of determining the relative value of different sections, and can be used to great advantage in ascertaining the actual cost of the work.

"This system is the invention of Bruckner, a Bavarian civil engineer, but has been more fully developed and described by K. Culmann in his 'Graphic Statics,' a work of the greatest value. No engineer who has once attained experience in drawing up the 'Profile of Quantities' will attempt to do without it, on account of its great value in saving time, in aiding the proper distribution of material at the least expense, in sensibly dividing a division into sections, and for giving an exact knowledge of where and how to commence work in order to aid its completion in the shortest time.

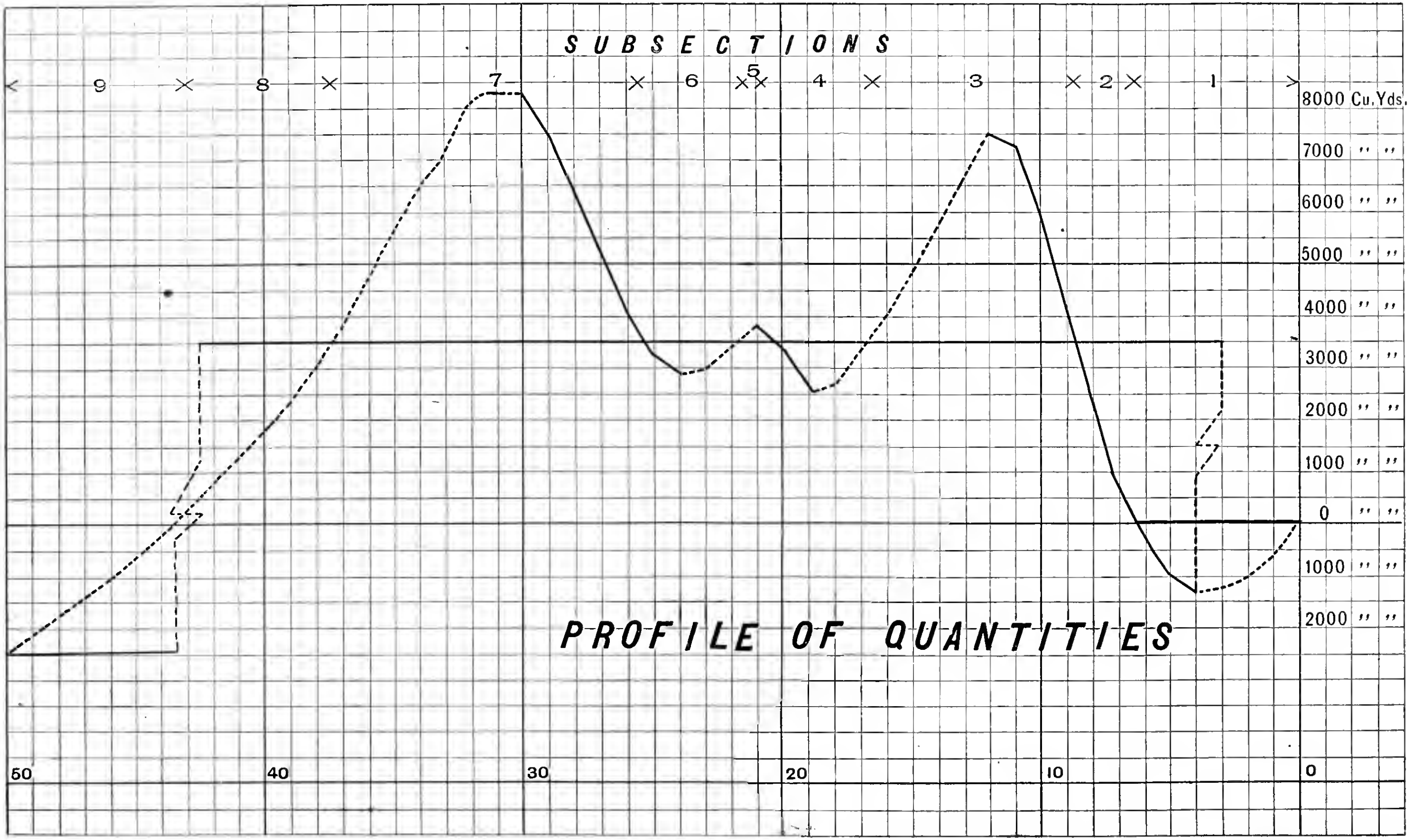
"The 'Profile of Quantities' differs from an ordinary profile, in that instead of showing the elevations at every station, it states the algebraic sum of all quantities up to each station. The quantities are summed up for it by prefixing the algebraic sign '—' for embankments, and the sign '+' for cuts. The difference between any two ordinates will always show the surplus of cut or embankment between the corresponding stations. A line connecting all the points of profile, is ascending in cut, and is descending in fill; the ascending line being indicated in blue and the descending in red. The 'Profile of Quantities' will present a series of 'hills' and 'valleys,' if such terms are allowable. These do not represent elevations or depressions of the ground, but appear such to the eye accustomed to the ordinary profile. The so-called 'grade points,' where cuts end and embankments begin, are minima or 'valleys.' The line of the profile is steepest where the quantities between stations are greatest; and where quantities between consecutive stations are the same, the profile will be straight. Between all stations whose elevation is common, so to speak—i. e., are on the same level, on the 'Profile of Quantities'—there will be no surplus of cut or embankment.

"The area of the 'hills' and 'valleys' are proportionate to the total cost of the work, representing as they do quantities hauled, Σ cubic yards multiplied by Σ length hauled—compound of matter and force—work in its true sense, combined material and labor. Each 'hill' and 'valley' represents a subsection, every 'hill' being a subsection hauling forward, and every 'valley' one hauling backward, according to the direction in which the station numbers run. A section must begin and end with the beginning and ending of subsections and no subsection can be partly in two sections. If in the stations quantities both of cut and embankment are to be accounted for, then only the difference of the two, with the sign of the larger, can be shown on the profile; the remainder is to be accounted for separately, either as casting, or as haul below the limit, as it generally will not exceed 100 ft.

"Borrow pits and spoil banks are marked on the profile by dotted lines. Their best location will generally have to be determined by the cost of land and other circumstances; but in case this should be the same for two different places, then that requiring the short haul, can easily be found with the aid of the 'Profile of Quantities.' Should a borrow pit be required, then the location of its center, or that point over which all the material has to be hauled, is first marked on the profile. The station just opposite the borrow pit can be supplied with the shortest, and generally with the same haul; and the line representing borrow pit in relation to this haul will be parallel to the line of profile, and at the same horizontal distance from this line that the borrow pit is situated from the center of gravity of cross-section. Its location will be determined by the direction of haul. The haul for all the other points along the road will increase in arithmetical progression, and the line representing the borrow pit, will therefore be a straight line, and in most cases a vertical line. Spoil banks are represented on a similar principle. Borrow pits and spoil banks will also represent subsections, and are to be classified as 'hills' and 'valleys' in the manner above described.

"With the 'Profile of Quantities,' the limit of haul can easily be found. If the difference in height between the lines of 800 feet and 1,000 feet, for instance, is very small, it will be preferable to make 800 feet the limit, and pay an extra price for such difference. But if this difference is comparatively large, it will be more profitable to use 1,000 feet as the limit. The 'hills' are separated from the 'valleys' by a horizontal line, the great importance of which will be evident when it is considered that it determines the haul for each subsection, and it should be drawn so as to make the cost of haul a minimum. The rule for this is: The aggregate length of 'hills,' and the aggregate length of 'valleys,' must be equal to each other. A few words will show the correctness of this rule. To make the total cost of haul a minimum, the aggregate area of 'hills' and 'valleys' must be a minimum. If the dividing line is moved upwards over an infinitely small space $\triangle$, then the area of all 'hills' will be diminished by $\triangle$ times the aggregate length of 'hills,' and the area of 'valleys' will be correspondingly enlarged by $\triangle$ times the aggregate length of all 'valleys.' The actual decrease is therefore $\triangle$ times the difference of aggregate length of 'hills' minus 'valleys.' Should then the location of the dividing line already be such as not to admit of any decrease in the area of 'hills' and 'valleys,' then, of course, the difference between 'hills' and 'valleys' must be equal to zero, or the aggregate length of 'hills' must be equal to the aggregate length of 'valleys,' as stated above. When a break occurs in the dividing line, on account of the 'hill' becoming too long, or for other reason, such break must be made by a borrow pit or spoil bank, as the case may be.

"To exhibit the operations necessary in making the 'Profile of Quantities,' the following specimen has been prepared. The following table shows in the first columns the quantities as calculated from cross-sections. The next two columns contain the difference of quantities in sta-



NOTE.—In Reineker's original diagram the ascending line, representing excavation quantities, was shown by a blue line, and the descending line, — — representing embankment quantities, was shown in red.

FIG. 2.

tions where both cut and embankment occur, divided up in quantities which need only casting, and such as require hauling only within limit of length of station.

"The last columns contain ordinates, which may be plotted on a sheet of profile paper, in the same way as elevations of ground surface on an ordinary profile. It will at once be observed that in the beginning a surplus of cut will be required to be wasted, and at the end a surplus of embankments will have to be taken from a borrow pit. First, the balancing line was drawn, to show which station the cut must be excavated to from the first embankment. This line is of course in the zero line, and subsection number is thereby ascertained to be station zero to $6 + 30$. Supposing that all the material wasted from the first cut had to be hauled to the beginning of the cut, and could be deposited there in a spoil bank of the same cross-section, and supposing that this spoil bank would consume in a 100-ft. length 3,500 cu. yds., the dotted zig-zag vertical line was drawn. After ascertaining from map and cross-sections that opposite Sta. 43 a borrow pit could be opened to advantage, and that the same would be 200 ft. long, and situated 50 ft. distant from and parallel to center line, a horizontal line was drawn through station 43, and a distance of 50 ft. marked off on the same in opposite directions. The borrow pit for 100 ft. from station 43 extends both ways; the dotted zig-zag line representing the same for this distance is of course parallel to the respective parts of the line of profile. As all the material from the borrow pit is to be hauled directly to the road and thence over the new embankment to various places of disposal, the distance for all these points will increase in the same ratio as the distance to the new road, and the borrow pit for such be represented by vertical lines. In applying such spoil banks and borrow pits, care should be taken to represent them in the correct direction of haul. The next step is the establishing of the balancing line for the main part of the profile, which will be done by measuring the difference of average length of hauls and values on assumed lines, until such location for the balancing line is found, on which the aggregates are equal to each other. In this operation both borrow pits and spoil banks are accounted as follows: The last subsection No. 9 will have its balancing line through station 50, the area of which subsection has now to be determined, and will represent a certain number of yards hauled 100 ft., or any other unit that may be assumed, representing thereby the amount of work to be performed to deposit the excavated material. The actual number of cubic yards excavated in each subsection is represented by its largest ordinate above or below the balancing line. The separation into different classes of haul can easily be accomplished, and the area for each can be determined without difficulty. This was omitted in the accompanying profile in order to avoid confusion incidental to a great number of lines.

"Assuming the cost of excavating and loading only of the material to be 20 cts., and the haul for each 100 ft. to be 1 ct. per cu. yd., the value of each subsection has been determined as stated below.

"To the costs found in Table 2 must be added the cost of the quantities disposed of by casting or haul inside the same station where excavated, in order to show the total cost."

TABLE I.

STATION	Quantities		Deposited in same Station		Ordinates For Profile of Quantities	
	Cut	Fill				
	(Blue Ink)	(Red Ink)	By Casting	By Haul	(Blue Ink)	(Red Ink)
0	....	....	....	....	....	....
1	....	610	....	....	....	610
2	....	480	....	....	....	1,090
3	....	190	....	....	....	1,280
4	70	110	....	70	....	1,320
5	350	40	40	....	....	1,010
6	690	30	30	....	....	350
7	400	10	10	....	740	....
8	1,580	....	....	....	2,320	....
9	1,710	....	....	....	4,030	....
10	1,920	....	....	....	5,950	....
1	1,360	....	....	....	7,310	....
2	330	120	20	100	7,520	....
3	170	1,090	50	120	6,600	....
4	40	1,660	30	10	5,580	....
5	....	860	....	....	4,720	....
6	....	790	....	....	3,930	....
7	....	720	....	....	3,210	....
8	....	630	....	....	2,580	....
9	20	150	20	....	2,450	....
20	850	10	10	....	3,290	....
1	421	40	20	20	3,660	....
2	50	400	10	40	3,210	....
3	....	440	....	....	2,870	....
4	30	150	....	30	2,750	....
5	360	20	....	20	3,090	....
6	890	....	....	....	3,980	....
7	1,140	....	....	....	5,120	....
8	1,230	....	....	....	6,350	....
9	1,280	....	....	....	7,630	....
30	840	190	40	150	8,280	....
1	90	60	50	10	8,310	....
2	60	250	30	30	8,120	....
3	30	1,100	20	10	7,050	....
4	10	650	10	....	6,410	....
5	....	830	....	....	5,580	....
6	....	930	....	....	4,650	....
7	20	950	20	....	3,720	....
8	30	710	30	....	3,040	....
9	40	720	40	....	2,360	....
40	20	600	20	....	1,780	....
1	10	620	10	....	1,170	....
2	....	450	....	....	720	....
3	....	530	....	....	190	....
4	....	470	....	....	....	280
5	....	430	....	....	....	710
6	....	410	....	....	....	1,120
7	....	320	....	....	....	1,440
8	....	350	....	....	....	1,790
9	....	340	....	....	....	2,130
50	....	340	....	....	....	2,470
	16,730	19,200	510	610		

TABLE 2.

Subsection	Between Stations	Direction of Haul	Cubic Yards Excavated	Cost of Excavation	Cubic Yards Hauled 100 Ft.	Cost of Haul.	Total Cost per Cu. Yd.
No. 1	0 and 6+30	Backward	1320	$264	5540	$ 55.40	24.2 cts.
(Spoil Bank) 2	6+30 " 8+70	Backward	3600	720	14300	143.00	24.6
3	8+70 " 16+40	Forward	3920	784	16620	166.20	24.3
4	16+40 " 20+80	Backward	1150	230	2730	27.30	22.4
5	20+80 " 21+30	Forward	60	12	20	.20	20.3
6	21+30 " 25+50	Backward	850	170	2220	22.20	22.6
7	25+50 " 37+20	Forward	4710	942	32040	320.40	27.0
(Borrow Pit) 8	37+20 " 43	Backward	3410	682	7900	79.00	22.3
9	43 " 50	Forward	2660	532	9940	99.40	23.7

6. J. C. Trautwine, "Civil Engineer's Pocket Book," (1st Ed., Phila., 1871), p. 436, in the article on the "Cost of Earthwork," states in a footnote that "when an entire cut is made into an embankment, the *mean haul* is the distance between the centers of gravity of the cut and embankment." This footnote appears unchanged in the later editions of this work.

7. G. L. Vose, "Manual for Railroad Engineers," (Boston, 1872) p. 78, describes the method of calculating the average haul, as follows: "To find the cost of the movement of the earth upon any section of a road, we must know the character of the earth, total amount to be moved, and the average haul, the latter being the distance through which, if the whole amount of excavation upon a given length was transported, the product of that distance by the total amount of earth would be the same as the sum of the products of the partial amounts by their respective distances. To find this average haul, we first ascertain the distance, by inspection of the profile, between the centers of gravity of each mass before and after the removal; and next, we divide the sum of the products of the partial amounts by their respective hauls, by the total amount. Thus let Column 1, in the table below, represent the partial amounts in cubic yards; Column 2, the respective hauls in feet, and Column 3, the product of each amount by its haul.

1,000 × 200	equals	200,000
2,000 × 300	equals	600,000
5,000 × 400	equals	2,000,000
8,000 × 600	equals	4,800,000
16,000		7,600,000

Then 7,600,000 divided by 16,000 or 475 feet, is the average haul; or generally, if m, m', m'', m''', represent the partial amounts, and d, d', d'', d''', the corresponding distances, S being the total amount, and D the average haul, we have:

$$\frac{md + m'd' + m''d'' + m'''d'''}{S} = D$$

8. W. H. Searles, "Field Engineering," (Wiley, N. Y., 1880), pp. 243-245, gives the earliest discussion which appears in a treatise covering the method involving an extreme or "out to out" free haul limit, as follows:

"The cost of removing excavated material, when the distance does not exceed a certain specified limit, is included in the price per cubic yard of the material as measured in the cutting. But when the material must be carried beyond this limit, the extra distance is paid for at a stipulated price per cubic yard, per 100 feet. The extra distance is known by the name of '*haul,*' and is to be computed by the engineer with respect to so much of the material as is affected by it.

"The contractor is entitled to the benefit of all short hauls (less than the specified limit), and material so moved should not be averaged against that which is carried beyond the limit. Therefore, in all cuts, the material of which is all deposited within the limiting distance, no calculation of haul is to be made.

"On the other hand, the company is entitled, in cases of long haul, to free transportation for that *portion* of the cutting, no one yard of which is carried beyond the specified limit. Therefore, this portion is first to be determined in respect to its extent; and the number of cubic yards contained in it is to be deducted from the total content of the cutting, before estimating the haul upon the remainder. Find on the profile of the line two points, one in excavation, and the other in embankment, such, that while the distance between them equals the specified limit, the included quantities of excavation and embankment shall just balance. These points are easily found by trial, with the aid of the cross-sections and calculated quantities, and become the starting points from which the haul of the remainder of the material is to be estimated.

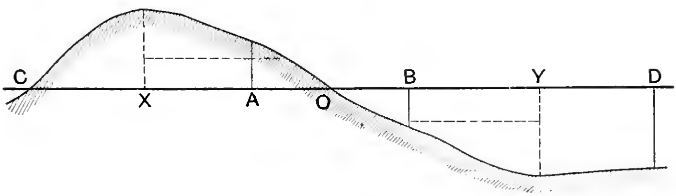


Fig. 3.

"The figure represents a cut and fill in profile. The distance AB is the limit of free haul. The materials taken from AO just make the fill OB and without charge for haul; but the haul of every cubic yard taken from AC, and carried to the fill BD, is subject to charge for the distance it is carried, less AB.

"It would be impossible to find the distance that each separate yard is carried, but we know from mechanics that the average distance for the entire number of yards is the distance between the centers of gravity of the cut AC, and of the fill BD which is made from it. If, therefore, X and Y represent the centers of gravity, the actual average haul is the sum of the distances (AX + BY), and this (expressed in stations) multiplied by the number of cubic yards in the cut AC, gives the product to which the price for haul applies.

"But the product of AX by the number of cubic yards in AC is equal to the sum of the products obtained by multiplying the contents of each prismoid in AC by the distance of its own center of gravity from A. The distance of the center of gravity of a prismoid from its mid-section is expressed by the formula

$$x = \frac{l^2(A - A')}{12 \times 27S}$$

"If we replace S by its approximate value, $\frac{l(A + A')}{2 \times 27}$, which will produce no important error in this case, we have

$$x = \frac{l}{6} \cdot \frac{A - A'}{A + A'}$$

in which A should always represent the more remote end area from the starting point A, in figure. Hence, x may be + or —, and it must be applied, with its proper sign, to the distance of the mid-section from the starting point A, before multiplying by the contents S. Each partial product is thus obtained.

"By a similar process with respect to the prismoids composing the mass BD, and using the point B as the starting point, we obtain finally a sum of the products representing this portion of the haul.

"If a cut is divided, and parts are carried in opposite directions, the calculation of each part terminates at the dividing line. If a portion of the material in AC is wasted, it must be deducted, and the haul calculated only on the remainder.

"The specified limit is sometimes made as low as 100 feet, sometimes as high as 1,000 feet. A limit of about 300 feet, however, is usually most convenient, as it includes the wheelbarrow work, and a large part of the carting, while it protects the contractor on such long hauls as may occur."

9. "Alpha," "A Method of Calculating Overhaul" (Engineering News, Vol. 9, p. 202 (June 12, 1882), in a contribution discusses a method of determining haul, an abstract of which is given by him in the discussion of the subject in Engineering News, Vol. 20 (Ref. No. 16). The discussion by "Alpha," in Vol. 9, Engineering News, was in response to an inquiry by "G. A. M." (p. 169). A similar method was described by "F. W. H." (p. 217).

10. E. Thiange and J. M. Rudiger, Jr., "Diagrams for Simple and Compound Railroad Earthwork Formations," in paper read October 6,

1883, before Engineers' Club of Philadelphia (Proc. Eng. Club of Phila., Vol. 4, pp. 67-92), describes the German method of "Massennivellement," which, literally translated, means "leveling of masses," the process being that described by Culmann.

An article by Mr. Thiange, entitled "Graphical Determination of the Distance of Haul" (Engineering News, Vol. 10, pp. 176, 177 (April 14, 1883), covering the graphical method practically as given in the joint paper by the two authors above referred to, appears to be the earliest published reference in America calling attention to the merits of the German method. As stated elsewhere, however, the method had been introduced by Mr. Reineker at least ten years previous to that time. (See Ref. No. 5.)

11. Walter G. Berg (Lehigh Valley Railroad), "Distribution of Material and Determination of Haul and Lift in Railroad Construction" (Railroad Gazette, Vol. 16, pp. 19-21, January 11, 1884), in contribution under date of November, 1883, describes a graphical method of determining haul and the distribution of materials in earthwork construction, the process being essentially the same as the Bruckner method. He also discusses the matter of lift of materials in hilly country. The substance of Mr. Berg's contribution is contained in his valuable discussion of the question of an overhaul clause in the 1903 Proceedings, quoted in full in this review and used in part as a basis for the recent canvass of the views of the Association members as to their practice in the treatment of overhaul.

12. G. J. Specht, "Notes on Earthwork," in a paper read in 1885 before the Technical Society of the Pacific Coast (Trans. Tech. Soc. Pac. Coast, May, 1885), (reprint in Engineering News, Vol. 14, pp. 114-118, August 22, 1885), describes German methods of handling contract work and haul problems, in part, as follows:

"In connection with the question of earthwork, a method may be mentioned which is in general use in Europe, though it is not known here apparently. In making estimates for railroads and inviting bids for contracts, the European custom is, that the railroad company makes a very detailed estimate; and the result of this—in detail, as well as in general—is made the basis for the contractor's bid. In the call for bids the cost estimated by the company is given, and contractors are invited to bid so many per cent. below or above it. This method requires a very carefully made estimate, based on detailed studies of the ground, assisted by trial pits; very often, especially in tunnel work and foundations, extensive trials are made. The results of all these studies are at the disposal of the contractors; they comprise a longitudinal profile, a complete set of cross-sections, a distribution profile, detail plans of all the bridges, culverts, road crossings, retaining walls, etc., a map of the railroad, list of prices for labor and material, as ascertained by the company; in fact, all papers and documents for an intelligent bid."

Among the documents is one called "Distribution of Masses" or "Distribution Profile." This is a graphical representation of how to dispose of the material gained in cuts and how to make embankments. A detailed description of the distribution diagram is given and illustrated by a typical example, similar to that presented by Berg, Reineker, Fisher and others.

13. S. B. Fisher, "Earthwork—the Profile of Quantities," in paper read September 15, 1885, before the Engineers' Society of Western Pennsylvania (Proc. Eng. Soc. Wes. Pa., 1885) (reprint in American Engineer, Vol. 10, pp. 137, 138, October 1, 1885), refers to a translation from Culmann's "Graphical Statics" on the "Profile of Quantities," which he had secured from a German engineer some years previously and had applied to his own practice in the treatment of haul problems. A concrete illustration of the processes involved is given similar to, but not so complete as, that presented in his paper on the subject, which appeared in Engineering News in 1891, reprinted elsewhere in this review (Ref. No. 20).

14. A. M. Wellington (Engineering News, Vol. 20, p. 228, September 22, 1888), in editorial, discusses the computation of overhaul as follows: "'A Method of Calculating Overhaul' was published by you from Pittsburg, Pa., June 12, 1882, by 'Alpha,' in order to use which it is necessary to find the 'center of mass' of cut and also of fill made from cut. Can you give me some quick method of finding the 'center of mass?'

"As quick a way as any is to plot the volumes of each solid as ordinates, as one would plot a profile, on stiff cardboard, cut out the area thus drawn and balance it on a knife edge; but a way that we can recommend as much the best and fairest of any, in competent hands, is to guess at it, throwing the benefit of a doubt for or against the contractor, according to the character of the haul and to some extent of the material excavated. The actual haul cannot fairly be taken at times as the crow flies, nor is it exactly fair that haul over good solid gravel should have only the same allowance as haul from a shallow cut through muck. As a contract is a contract and must be general, no considerable deviations on account of such contingencies as these are admissible, but no considerable ones are necessary, the limits of error in guessing at the 'center of mass' being very small and having reference to a small item of price, whereas the limits of error in one unavoidable kind of guessing, which is usually going on at the same time, that of classification, are very large and have reference to a very large item. This consideration alone ought to show the folly of any great hair-splitting in mathematical computations of the precise overhaul; but there is a certain class of minds who are never happy unless they can find some hair to split, and who will split it with just as much care, although there may be a log of wood alongside, which they cannot split, to which the right half of the hair is to be added. This tendency comes out not only in computations of overhaul, but of earthwork areas, frogs and switches, retaining walls, bridge strains and many other like details. It is a better tendency than the opposite one, and that is the best that can be said of it. It usually originates in a terrible lack of clear mental perspective.

"The better way, in our judgment, is to make no computations of, nor allowance for, overhaul whatever, and this is increasingly common in the best practice; to say to the contractor, in effect: 'Here is the work; what will you do it for?' and let him make his own allowances for overhaul, as he must for all other contingencies. It saves an immense amount of trouble and possible dispute and amounts in the end to much the same thing. Of course, in respect to masonry this is rarely possible, because the hauls are very long and can rarely be exactly foreseen, but a good contractor can understand a profile almost as well as an engineer, and can guess at the 'center of mass' with even greater practical exactitude than the engineer can compute it, because he takes into allowance the kind of haul as well as the length of it.

"Another thing that saves much trouble and work is to pay for both cut and fill, without allowance for shrinkage, but just as each measures in the work, leaving it to the contractor's choice, within reasonable limits, to either borrow and waste or haul the material. This saves all measuring of borrow pits and simplifies matters otherwise, and is quite common in the West, although still the exception in the East. There is sometimes a good deal of unnecessary tyranny in compelling contractors to haul material when they would rather waste and borrow, and in many cases it really makes no difference."

The foregoing editorial discussion was continued in the same volume, p. 329 (October 27, 1888), as follows: "We have received quite a number of communications, giving various ways of determining overhaul, one and all of which we have been obliged to decline, for the reason that we really cannot perceive that any of them show any method better or simpler than that which we outlined two weeks ago, viz., to plot the volume of each section as an ordinate on a base line on which horizontal distances are laid off as abscissas, or in the same manner as center-heights are plotted to make a profile; cut out the area thus constructed and determine its center of gravity mechanically, the part at each end included by the free haul stipulations being neglected, and the dividing line between haul to or from each direction being first determined in the usual simple manner by successive additions of the volumes of the computed solids until the required total to equal a given cut or fill (keeping in mind the proper allowance for shrinkage) has been obtained. As we previously stated, any attempt at mathematical exactitude is usually out of place in determining this allowance, and in our judgment it is nearly always much better to make no allowance for it at all, but to require comparative hauls to be estimated by the contractor in advance and allowed for in his bid. It would be even simpler, and leave less chance for error and dispute, to fix separate prices for separate cuts of any size in many cases.

"In most of the foreign text-books of engineers, and in some of the American, elaborate methods for computing the average haul and overhaul are given, and if absolute exactitude be required a good deal of mathematics can be used in determining it. Even when less precision is attempted, a variety of graphical and other methods can be devised, three of which, each differing slightly from the other, have been sent in, but the problem is so simple that it hardly seems to us necessary to give more than the above hint as to the proper method. A little ordinary ingenuity will enable anyone to determine by its aid the proper overhaul allowance within a few feet, and more than this does not seem to us worth while."

15. A. M. Van Auken (Engineering News, Vol. 20, p. 327, Oct. 27, 1888), in a communication dated Sept. 25, 1888, discusses methods of computing haul, as follows. "A common method in Colorado, where the free haul has usually been 100 ft., and where material was estimated as hauled until price of excavation and haul equaled waste and borrow, has been to get the distance where haul ended and find the distance you went into the cut and distance into the fill, which can be ascertained with one or two trials, then find what distance from half of this cut was the line of half the excavation and what distance of half the fill, the difference between these two points being the average haul; 100 ft. of free haul being subtracted from this gives the overhaul, and this by the number of yards in the cut gives the yards of overhaul."

16. "Alpha," "Determining Center of Mass of Earthwork" (Engineering News, Vol. 20, p. 286, Oct. 13, 1888), in a communication under date of Sept. 29, 1888, gives the following abstract of a method which he had described in Engineering News in June, 1882:

"The cubic yards between consecutive cross-sections, having been calculated and noted as usual, the center of mass of any cut or fill is easily found by the addition of the various amounts until a sum is reached equal to half the total cut or fill, at which point we may assume the center of mass. In a similar way the center of mass of any portion of an embankment or excavation may be found. This may be done roughly or exactly, as occasion requires, and has been found a rapid and simple method. In heavy work, or wherever it is necessary to allow for the extent of 'free haul,' the equal amounts in cut or fill to the 'limit of free haul' can be determined tentatively, and the summation for the center of mass begun from said limits."

17. M. Stixreed, "Determining Center of Mass of Earthwork" (Engineering News, Vol. 20, p. 346, Nov. 3, 1888), in communication under date of Oct. 22, 1888, briefly describes a graphical method of determining overhaul which is practically identical with the Bruckner curve.

18. G. M. Walker, Jr., "Overhaul" ("The Technic," University of Michigan, 1889, pp. 61-69), in a paper, discusses the theoretical and practical treatment of overhaul in railroad construction as follows:

"The theoretical determination of average haul is not difficult to understand, but it is not easy to find a practical method of calculating it. Overhaul may be defined as the distance through which the material is moved beyond a certain fixed limit; the fixed limit varying on different roads and under different engineers.

"At least three reasons may be given why material from cuts should be placed in embankments, or at least below grade: First, to save expense; second, to prevent waste banks above grade; third, to make a better embankment than could be made from borrow pits alone. The first is often the only one considered, but on first-class work the other two are more important. The *average* haul for each yard is the distance between the center of gravity of the portion of the cut in question and the center of gravity of the embankment made from it. The main features of the following demonstration are taken from 'Formulæ for Railroad Earthwork and Average Haul,' by J. W. Davis. If V represents a cubic yard of material, d the distance (in units of 100 ft.) moved, then Vd equals the equivalent number of yards moved 100 ft. If d d_1, etc., ...d_n represent the distance, each succeeding yard is moved (as above), the entire volume moved reduced to an equivalent volume moved 100 ft. equals V $(d + d_1 + d_2 + \text{etc.}, \ldots. d_n)$, or $V \Sigma d$. Or if we consider the volume divided into an infinite number of equal volumes and represented each by dV and the distance each volume is hauled to a plane transverse to the center line between cut and fill by the variable x, the total haul would be $\int x dV$. There must be a distance which, if each volume be considered as hauled that distance, will give the same as the above. Let this average distance be represented by x', then $x' \int dV = x dV$. Integrating the first member and dividing by V, it becomes $x' = \frac{\int x dV}{V}$. The second member of the last equation is the expression for the distance of the center of gravity from the plane. If the fill be calculated in the same way, the average haul of the excavation will be the distance from the center of gravity of the excavation to the center of gravity of the fill.

"In the free haul limit each yard is supposed to be placed as near as possible to its point of excavation, so that only the last yard is supposed to be hauled the full limit. This is the method usually employed by engineers to calculate overhaul. As it would be impossible to calculate each yard from the place of excavation to the place of deposit, it is necessary to adopt other methods. The corresponding prisms in cut and fill are not equal, hence the total haul of each prism cannot well be found. It may be obtained by taking some fixed point, say the center grade point or station nearest, calculating the distance from the center of gravity of each prismoid in the cut to this point, multiplying each distance by the number of cubic yards in its prism, and then from this point making the same calculations for each prismoid in the fill; the sum will be the required haul. The center of gravity of these prisms is not midway between the end sections, but always closer to the greater area, and in rolling country there is usually the same error in both cut and fill, the effect of which is to reduce the haul; since the larger areas are farthest from the grade point in both cut and fill (within haul limits). This is not usually a compensating but a multiplying error.

"The limits of haul are the first facts to be determined. This depends entirely upon the terms of the contract under which one is working. Some engineers prefer to fix arbitrary limits, and consider several classifications as follows: First, all material from excavation which can be deposited in embankment within *a* ft., shall be paid for in excavation alone, without haul; second, all material from excavation which can be deposited in embankment within *b* ft. (and not within *a* ft.) shall be paid for as excavation hauled, plus haul; third, all material, etc., within *c* ft. (and not within *b* ft.) may have a different price, and thus it may continue to the desired number of classifications. As there are different means used for hauling different distances, such as drag scrapers, wheel scrapers, wagons, carts, and cars, this seems to be a very just classification.

"Suppose the contract contains the following clause: 'In all cases work will be estimated so as to make the least cost; that is, earth from excavations will be estimated as having been hauled to such a point that the price for earth excavation *hauled,* plus the price for *haul of earth,* shall equal the price for *excavation wasted,* plus the price for *embankment borrowed;* the limits are then determined from the different prices paid. Overhaul may be paid for the entire distance hauled, or for the entire distance less the free haul distance. Probably the majority of engineers prefer the former, so this discussion will be confined to that case. The limit for earth may be found as follows: Let A = price of embankment borrowed, B = price of excavation hauled, C = price of excavation wasted, D = price of haul of earth; then A + C = B + D, or the limit of haul must $= \frac{A + C - B}{D}$. If C and B are equal, as they often are, this reduces to $\frac{A}{D}$. This does not take into consideration expansion, which is quite frequently omitted entirely. If loose rock expands 20 per cent. and solid rock expands 50 per cent., 100 yds. of loose rock would make 120 yds. of embankment, and 100 yds. of solid rock would make 150 yds. of embankment. In general, if X = 100 per cent. plus the percentage of expansion, the haul limit would then be $\frac{XA}{D}$. I have demonstrated this very simple proposition because a large number of engineers overlook expansion entirely and consider the limit in all cases as $\frac{A}{D}$. Another addition to this limit might be made from the fact that rock will stand at a much steeper slope than earth, thus giving a smaller cross-section for the embankment. But if a rock bank is topped out with earth, or if the two are thrown in together, the usual amount of expansion cannot be depended upon, as most of the interstices left by the rock are filled with earth. In high embankments made from borrow pits, only about 10 or 12 ft. of the bottom is hauled less than 100 ft. If all earth, whether in excavation or embankment, hauled more than 100 ft., be classed as 'embankment borrowed,' the tops of high embankments would not be paid for as 'embankment borrowed,' and thus another factor would enter into the determination of haul.

"It is sometimes claimed that the *average haul* should be $\frac{A + C - B}{D}$. This is evidently incorrect, for there is then an average amount paid for each yard moved equal to excavation wasted plus embankment borrowed, and there is no saving in expense. If part of a cut falls without the haul limit (or if the center of the cut lies between the limits calculated each way) the contractor may, according to the strict letter of the contract, be compelled to waste only that portion which falls without the haul limit; but as a heavy waste bank in a short space is usually worse than the same amount of material distributed along the entire length of the cut, the engineer often allows the top of nearly the entire length of the cut to be wasted, thus making a slightly longer haul for part of the material, but calculates the quantities according to the wording of the contract. Embankment may be calculated in the same way; that is, the base of the embankment for its entire length may be borrowed instead of borrowing just the quantity without the haul limit.

"In rock cuts with earth on top, the earth should always be removed first, so that the rock may be again cross-sectioned. In this case the haul of each should be calculated separately, as the two would naturally be kept separate in building the bank. There is no end to the number of specific cases that may arise, in which the engineer can follow no fixed rules, but must be guided by his own good judgment as to what is justice to all parties concerned.

"Mr. J. W. Davis in his 'Formulæ for Railroad Earthwork,' gives the following rules when part of the excavation is wasted and the balance placed in fill: 'In such a case determine the average haul l of the whole volume V, as before, as if every cubic yard had been transported to the ascertained center of gravity of fill. Let V′ denote the portion carried to the spoil bank as measured in monthly estimates. Let l′ be the distance from the center of gravity V′, also determined in monthly estimates, to the center of gravity of the waste bank. Let l″ be the distance from the center of gravity of V′ to center of gravity of fill and let l‴ represent the average haul of the portion of the cutting, V — V′, that was really carried to fill; then $lV = l''V' + l'''(V - V')$. This is the amount of haulage at first calculated; the true amount is $l'V' + l'''(V - V')$. Subtracting the false from the true we have for a correction $(l' - l'')V'$. This is naturally always negative. The true haulage is, therefore, $lV - (l'' - l')V'$. He gives the following formulas for finding the average haul when part of an embankment is borrowed: 'Knowing the quantity V′ brought to the fill from borrow pit, and its center of gravity, assume an axis. Let l′ be the distance of the center of gravity V′ from this axis. Let V represent the entire part of fill to which material from roadbed cutting has been carried, and whose center of gravity has been determined as before. Let l denote the distance of this point from the axis. Then V — V′ is the portion actually hauled from cut, and its center of gravity if distance for the axis $l'' = \frac{lV - l'V'}{V - V'}$. Since the center of gravity of V — V′ is the terminus of the average haul distance of roadbed cutting, measure off l″ from the axis, and from the point thus determined measure the distance of the center of gravity of the cut to obtain the true average haul. The above formulas are very nice as theories, but it seems there is too much machinery for practical purposes. If there is overhaul on the portion wasted the first formula fails, for that is only for that portion of the excavation placed in embankment. It might do very well when the waste is measured in the waste bank, but the only satisfactory way to measure that material is to measure the portion remaining. It would seem unnecessary to calculate the center of gravity of any besides the latter. The haul limit cannot be determined very well until the waste is taken off and the balance remeasured, and then it is simply a question of determining the center of gravity of the cut as finally measured. The formulas to be used when part of the fill is borrowed are a little more simple, but still open to objections.

"Having given some of the theories in regard to haul, I will give some of the methods used in actual practice. Having determined the limits of extreme haul from the contract, the first thing to do is to balance cut and fill or find the limits on the profile. This has to be done by trial. Suppose the limit to be 1,200 ft.; the problem is to find two points, one in cut and the other in fill, 1,200 ft. apart, such that the amount in cut will exactly make that portion of the fill to the limit, after corrections for expansion, etc., have been applied. If all of a cut is to be hauled, part each way, and the extreme limit is not reached, then it is simply a question of dividing it the most economically before calculating the haul. The only accurate way for calculating haul is the center of gravity method. One of the most inaccurate methods, and probably the one most commonly used in practice, is to find the center of quantity of cut and fill and to take the distance between the two as the average haul. In rolling country where cuts are divided near the summit, this always gives too large a result, for in a prism with unequal end areas the center of quantity is always farther from the smaller section than the center of mass. In rough work the errors may compensate to a certain extent. This is a very easy method, and, if only an approximation is desired, it is a very good one. Another common method is to take the center of each prismoid as the center of quantity. This, in the first class of work mentioned above, always gives too small a quantity, but as in the first method the errors in this also may compensate. It is probably more nearly correct than the former. Another method is to take each prismoid in the cut, see how much fill it will make, calculate the distance between centers, or centers of gravity, of the two prismoids, and multiply this distance by the number of yards. This seems unnecessary, for it may very properly be said that each cross-sectioned prismoid in cut never equals the corresponding prismoid in fill, and would, therefore, cause a large amount of unnecessary work.

"We will now look at some of the accurate methods. On page 244 of Searles' 'Field Engineering' is found the following: 'The distance of the center of gravity of a prismoid from its midsection is expressed by the formula $x = \frac{l^2(A - A')}{12 \times 27\,S}$. If we replace S by its approximate value $\frac{l\,(A + A')}{2 \times 27}$, which will produce no important error in this case, we have $x = \frac{l}{6} \cdot \frac{A - A'}{A + A'}$, in which A should always represent the more remote area from the starting point. Hence x may be + or — and must be applied with its proper sign to the distance of the midsection from the starting point before multiplying by the contents, S.'

"Prof. J. B. Davis gives the following formula for finding the center of gravity of a prismoid: $x = \frac{l}{2} + \frac{B - A}{A + B + 4C} \cdot \frac{l}{2}$, in which x equals the distance of the center of gravity from one end; A and B are the two end areas, C the middle area and l the length of the prismoid. This is more accurate than Searles' second formula, but not so simple. There has been a great deal of time spent in formulating rules for finding the center of gravity, both analytically and graphically, of a number of prismoids. In the case of haul there is no necessity for finding the center

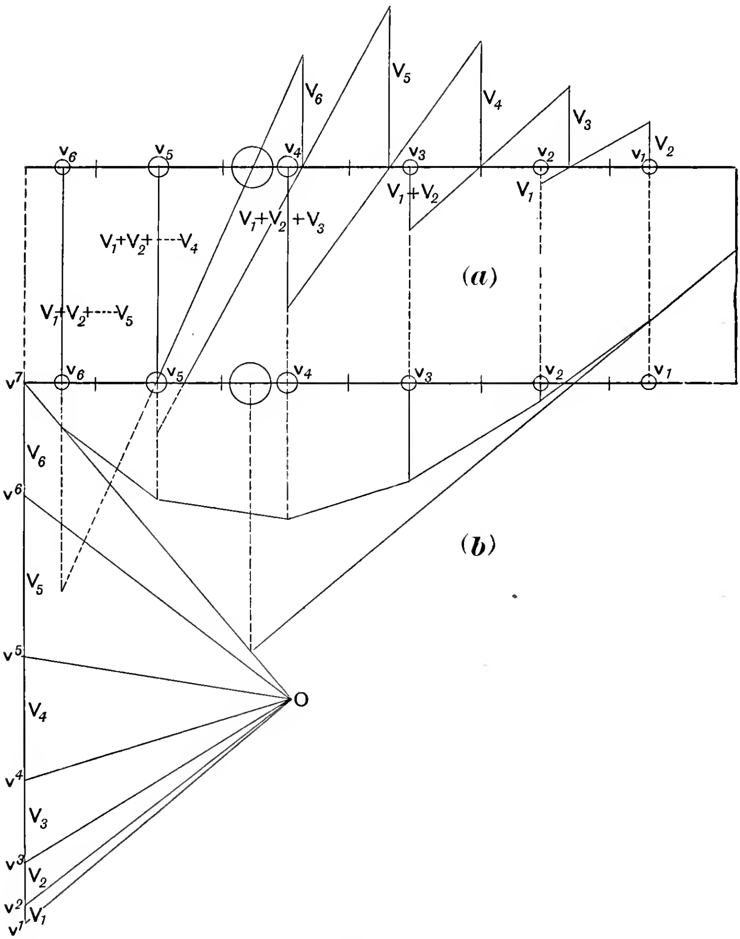


FIG. 4.

of gravity of all the prismoids. It is the total haul and not the average haul of the mass that is sought. To find the total haul when the center of gravity of each prismoid is known, pass an imaginary plane through any convenient point near the center grade point, multiply the mass of each prismoid in cut and fill by the distance (divided by the unit length of haul) of its center of gravity from the plane, and add the results. This sum is the equivalent number of yards hauled unit distance. The analytical expression for finding the center of gravity of a number of masses is well known to be: $x = \frac{\Sigma mx}{\Sigma m}$.

"Let us consider two graphical methods for finding the center of gravity of a number of masses lying in the same plane, the distance of the center of gravity of each from a point in the plane being known. We will suppose the center of gravity to lie in a line. The first method is due to Prof. J. B. Davis of the University of Michigan.

"In this special case (see Fig. 4a) represent the masses by V_1, V_2, V_3, V_4, V_5, V_6, and the positions of their centers of gravity by v_1, v_2, v_3, v_4, v_5, v_6. At v_2 draw a perpendicular below the line equal, by some scale, to V_1 from v_1 draw a perpendicular equal to V_2 above the line, connect the extremities of these two lines; where this line intersects the initial line draw a perpendicular above equal to V_3, at v_3 draw a line below equal to $V_1 + V_2$, connect the extremities of the last two lines and proceed as before, so that the last line will conneet V_6, drawn from v_5 above the line, with $V_1+V_2+V_3+V_4+V_5$ drawn from v_6 below the line. The intersection of this line with the initial line will be the center of gravity of the masses. If the center of gravity be thus found in cut and fill, the average haul of the entire mass will be the distance between the centers of gravity.

"The second is the equilibrium polygon method. This may be familiar to some, but it will do no harm to repeat it here for those who have not seen it. (For the demonstration see 'Trusses and Arches, Graphical Method,' by Prof. C. E. Greene, Pt. II., p. 23). (See Fig. 4b.)

"As above, represent the masses by V_1, V_2, etc., and the positions of their center of gravity by v_1, v_2, v_3, v_4, v_5, etc,; from these points let fall perpendiculars, indefinite in length. From any convenient point, at the right or left, lay off the masses, to scale, on a line perpendicular to the initial line in order from the top down as the masses occur, beginning with the one nearest the initial line, calling the points of division v^7, v^6, etc., . . . v'', v'. Assume any point o and draw lines from v^7, v^6, etc., v^1 to o. Beginning with the line at the outside of the end prism nearest the load line, draw a line parallel to ov^7 terminating at the perpendicular through v_6, from this point draw a parallel to ov^6, terminating at the perpendicular through v_5. Proceed in the same way, drawing lines parallel to each of the lines radiating from o; prolong the lines parallel to ov^7 and ov^1; at the point of intersection erect a perpendicular to the initial line, then the intersection of the last perpendicular and the initial line will be the center of gravity of the system of masses. As these are graphical methods, their degree of accuracy depends upon the accuracy of the drawing. Excellent results may be obtained if care is taken with the drawing and a sufficiently large scale be used. Cross-section paper may be used to advantage.

"I have assumed the following center heights in cut and fill and calculated the haul by three of the different methods, just to show the differences existing among them. Sta. 4, cut 22 ft.; 5, c. 20 ft.; 6, c. 16 ft.; 7, c. 14 ft.; 8, c. 8 ft.; 9, c. 6 ft.; 10, grade; 11, fill 4 ft.; 12, f. 6 ft.; 13, f, 10 ft.; 14, f. 14 ft.; 15, f. 16 ft.; 16, f. 18 ft.; 17, f. 20 ft.; this is the relative shape of cuts and fills often occurring in rolling country. The center of gravity of each prismoid was calculated by the formula

$$x = \frac{1}{2} + \frac{B - A}{A + B + 4C} \cdot \frac{1}{2}.$$

The center of gravity of the cut, by the formula $x = \frac{\Sigma mx}{\Sigma m}$, is 378.9 + ft. from an assumed plane at station 10; that of the fill is 351.2 ft. from the same plane.

"By the first graphical method, cut 378.9 ft.; fill 450 ft.

"By the second graphical method, cut 378.8 ft.; fill 450.8 ft.

"The number of cu. yds. between the limits of haul are 8,484.7, so we have 8,484.7 yds. hauled 830.1 + ft., equals 70,435 yds. hauled 100 ft. (The haul by the graphical methods has not been calculated, as they agree so nearly with the analytical method.) By taking the center of each prism as its center of gravity, we have 69,950 yds. By taking the distance between the centers of quantity of cut and fill as the average haul, we have 74,566 yds. The first two methods differ only by about 500 yds., while the last differs from the first by more than 4,000 yds.

"Since there is such a wide difference in the methods of calculating overhaul, would it not be well to specify in the contract how haul should be calculated? The contractor could then bid on the work accordingly. There is no doubt but that the center of gravity method is the only accurate one, theoretically, but how many division engineers have the time to go through such minute calculations for an item relatively small? It involves working a large number of areas where they are of no account whatever in computing the cubical contents, and in one of the formulas given, necessitates calculating the middle areas."

19. H. C. Godwin, "Railroad Engineers' Field Book," (Wiley, N. Y., 1890), pp. 136, 137, describes the method of extreme free haul limit like

Searles (Ref. No. 8), and quotes the editorial discussion on the calculation of haul from Engineering News, Vol. 20, p. 228 (Sept. 22, 1888). (Ref. No. 14).

20. S. B. Fisher (then (1891) Chief Engineer, Minneapolis, St. Paul & Sault Ste. Marie Ry.), "Estimating Overhaul in Earthwork by Means of the Profile of Quantities," (Engineering News, Vol. 25, pp. 98, 99, Jan. 31, 1891), (reprinted in Frost's "Engineers' Field Book," Engineering News Pub. Co., N. Y., pp. 118-122).

"No facile, practical and accurate method of calculating the overhaul of earthwork is as yet in common use. The problem itself, consisting of finding the relations between the centers of gravity of known volumes in known positions may be, from the mathematician's point of view, a comparatively simple one; but such a lack of readiness to solve it has the engineer shown that many a contract has been executed with the privilege of wasting and borrowing at the end of the haul. This practice results at times in waste of energy by the contractor, and still oftener in the waste of money to the other party to the contract. By the system of wasting and borrowing, material is paid for at the full price of excavation beyond the haul, but, with the judicious use of overhaul, in many cases the material may be hauled half a mile before its price is doubled. When, from the increase of the traffic of a railroad, for example, it becomes necessary to grade for a second track and, in so doing, to remove material wasted on the margin of a cut into an adjoining borrow pit along the neighboring fill, where it ought to have been deposited in the first place, it neither increases the respect of the later engineers for their predecessors, nor is it a credit to the profession.

"Overhaul, as commonly worked out, is done in an approximate manner, with the ordinary profile and the volumes in excavation and embankment. It takes longer to work it out with the 'Profile of Quantities,' of which a short example is engraved, but it is done completely and accurately.

"The method of the profile of quantities was originated by Bruckner, a Bavarian engineer. It was presented by Culmann in his "Graphical Statics" in 1868 and translated from that by F. Reineker, then (1871-1873) principal assistant engineer of the Pennsylvania Company at Pittsburg, Pa., for the use of his department. This translation was procured there by the writer and the method adapted to American practice in a great variety of railway work, and is here given with an example of work as actually executed.

"The subject is presented, for convenience and clearness, in three steps: (1) The Compilation of the Data. (2) The Plotting of the Profile. (3) The Taking Off of the Results.

"(1) Compilation of the Data:—The paper containing the data is ruled in five vertical columns, as in the following sample table:

SAMPLE TABLE OF COMPUTATIONS FOR CONSTRUCTING "PROFILE OF QUANTITIES."

O. & S. W. R. R. DATA FOR PROFILE OF QUANTITIES, SECTION 5, OCT. 1, 1889.

Station.	Incre-ments		Ordi-nates		Sta.	Incre-ments		Ordi-nates		Sta.	Incre-ments		Ordi-nates	
	+	−	+	−		+	−	+	−		+	−	+	−
213+34	....	......	....	....	231	.....	317	...	8,804	249	......	83	...	5,425
214	....	370	....	370	2	......	83	....	8,887	250	......	78	....	5,503
5	....	843	....	1,213	3	161	....	....	8,726	1	......	65	. ..	5,568
6	....	779	....	1,991	4	328	....	....	8,398	2	......	70	...	5,638
7	....	724	....	2,715	5	464	....	..	7,934	3	......	124	....	5.762
8	....	902	....	3,617	6	493	....	...	7,441	4	......	181	....	5,943
9	....	570	....	4,187	7	411	....	...	7,030	5	......	189	....	6,132
220	....	391	....	4,578	8	367	....	....	6,663	6	......	85	....	6,217
1	..	457	....	5,035	9	284	....	....	6,379	7	55	....	....	6,052
2	....	535	....	5,570	240	224	....	....	6,155	8	156	....	....	5,896
3	....	678	....	6,248	1	200	....	....	5,955	9	102	....	....	5,794
4	....	723	....	6,973	2	180	....	....	5,770	260	146	....	....	5,658
5	....	344	....	7,317	3	185	....	....	5,585	1	206	....	....	5,452
6	....	193	....	7,510	4	156	....	....	5,429	2	237	....	....	5,215
7	....	156	....	7,666	5	102	....	....	5,327	3	250	....	....	4,965
8	....	244	....	7,910	6	59	....	....	5,258	4	274	....	....	4,691
9	....	221	....	8,131	7	......	14	....	5,272	5	47	....	....	4,644
230	....	356	....	8,487	8	......	70	....	5,342	6	.....	6	. ..	4,650

"The first column contains the station numbers. In practice the elemental volume is the total excavation or embankment in a full station, whether the station distance is 100 ft., 66 ft. or a number of meters.

"Plusses are not used, excepting at an occasional beginning or end of a subsection, although the system is flexible enough to apply to any regular or irregular subdivision of these elemental volumes.

"In columns 2 and 3 are now entered the total increments or volumes of earthwork in excavation or embankment in successive stations. When excavation and embankment both occur within the limit of the same station the net amount only need be entered. If there is a special price for casting within the station another column may be introduced for it. Excavation is considered plus and embankment minus. The latter may be entered in red ink.

"Columns 4 and 5 are now filled up by algebraic addition of columns 2 and 3. The ordinate at any point of the 'Profile of Quantities' is equal to the algebraic sum of the volumes as far as to that point, and should be verified by use of this principle, at convenient points, as the summation proceeds.

"(2) The Plotting of the Profile:—The horizontal part of the plotting (Fig. 5) is the same as used in the ordinary profile, and it may be made on the same sheet of paper; but for the vertical part, instead of elevations being referred to the datum plane, at or below the lower edge of the profile paper, we have an initial line or axis of abscissas,

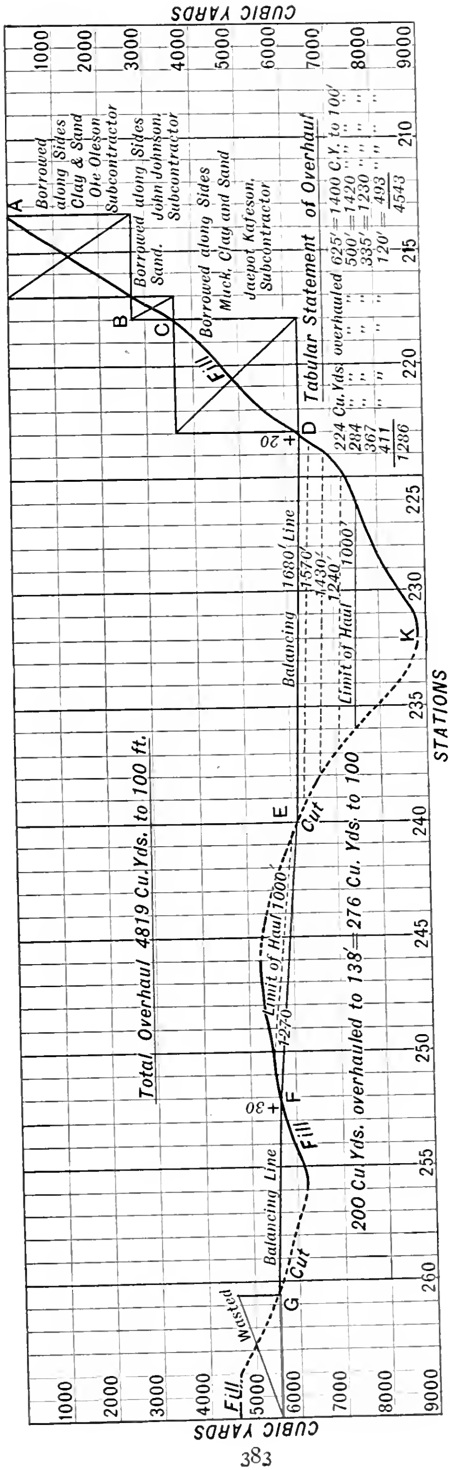

CUBIC YARDS
STATIONS
Borrowed along Sides Clay & Sand Ole Oleson Subcontractor
Borrowed along Sides Sand. John Johnson Subcontractor
Borrowed along Sides Muck, Clay and Sand Jaepot Kafeson Subcontractor
Tabular Statement of Overhaul
224 Cu. Yds. overhauled 625′ = 1400 C.Y. to 100′
284 " " " 500′ = 1420 " " "
367 " " " 335′ = 1230 " " "
411 " " " 120′ = 493 " " "
1286 4543
Balancing 1680′ Line
1570′
1430′
1240′
Limit of Haul 1000′
Total Overhaul 4819 Cu. Yds. to 100 ft.
200 Cu. Yds. overhauled to 138′ = 276 Cu. Yds. to 100
Limit of Haul 1000′
1270
Balancing Line
Fill
Cut
Wasted
A
B
C
D
E
F
G
K
+20
+30
210
215
220
225
230
235
240
245
250
255
260

Fig. 5.

located somewhere on the profile, from which the ordinates are measured above for plus and below for minus. Connecting the ends of these ordinates, we have a broken line which, in mathematical language, may be called a curve, resembling somewhat an ordinary profile, but wholly different therefrom, composed of the elements between the successive stations.

"If the increment, by the use of which any ordinate is formed from the previous one, is positive, this element of the curve will incline upward, will indicate excavation and be shown by a dotted or blue line. If the increment is negative, the element of the curve will incline downward, will indicate embankment and be shown in red or by a solid line. So that excavation on the profile of quantities is always shown by an ascending dotted or blue line, and embankment by a descending solid or red line.

"We now consider the balancing line. Some points of this line are always fixed by the patent conditions of the work, and occasionally all points are so fixed, but very often some points on it are indeterminate at first, so that each section is very likely to be a little problem by itself. The functions of the balancing line will most clearly be seen by referring to the engraved sample profile. We have here the first point of it, A, the beginning of the section; B, the end of Ole Oleson's job; C, the end of John Johnson's job; D, the end of Teapot Kofeeson's job; E, at station 240, the dividing point between backward and forward hauls in the cut; F, station 252 + 30; J, junction point of forward and backward hauls in the fill; G, the point where waste commences in the second cut, and H, the end of the section.

"(3) The Taking Off of Results:—From A to D there is no overhaul, but the nature of the material and any other items can be conveniently recorded there. The fill between D and K is made from the cut between K and E. We first fix the position of the limit of haul, which here comes between stations 226 and 236, and then draw the intervening lines of overhaul to each point of flexure of blue and red lines. We now read the elements of the cut between these lines of haul, from the profile m, or, if we desire great accuracy, from the data prepared for plotting the profile n, and tabulate them. Each of these elements multiplied by its respective distance overhauled will give equivalent quantities overhauled to one station; as, for example,

$$224 \text{ cu. yds.} \times \frac{1{,}680 + 1{,}570}{2} - 1{,}000 = 224 \times 6.25 = 1{,}390.$$

"The sum of these partial products will give the total overhaul for the cut. The tabulations should always be verified by seeing that the sum of the elements of the blue or red curve, as the case is, is equal to the difference between the extreme ordinates.

"If E — K is rock or D — K is a sinkhole, the line ED will be inclined and should be prolonged to an intersection with the horizontal through K. This intersection then becomes a pole, through which the lines of haul are drawn. The method is so flexible it can be applied to anything which can be executed in earthwork, and in addition gives a record of what has been done. It is also used to make the preliminary distribution of material before the work is begun."

The following further explanation of the foregoing method was given in Engineering News, Vol. 25, p. 130, (Feb. 7, 1891):

"As the method described in the article under the above title, contributed by Mr. Fisher to Engineering News, January 31, was not entirely clear to some of our readers, Mr. Fisher has favored us with the following fuller explanation of the process outlined in the last paragraph of his former article:

"Prolong that portion of the balancing line in the accompanying figure (Fig. 6), which passes through stations 230 and 240 to the point

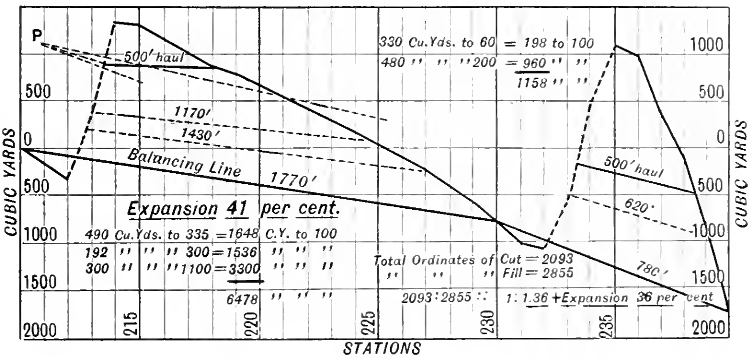


FIG. 6.

P, its intersection with the horizontal through 235; the lines of haul are drawn from this point to each point of flexure of the dotted and solid curves. The limit of haul is fixed by making the horizontal distance between the upper intersection 500 ft.

"The expansion and contraction of the material is shown by the relation between the extreme ordinates of the solid and dotted curves, as shown in the figure. The balancing line is nearly always more or less inclined. It is horizontal only when the volumes of the adjacent cut and fill are equal to each other. The point P will not usually come on the limits of the drawing, and it is only in the rare instances of great expansion or contraction of material that it is needed in practice. The inclination of the balancing line is generally so slight that the lines of haul can be drawn parallel to it or a trifle divergent."

21. "C. W. S.," "Estimating Overhaul," (Engineering News, Vol. 25, pp. 134, 135, Feb. 7, 1891), in a communication dated Jan. 31, 1891, discusses the graphical method of attacking haul problems as follows:

"In relation to the article on 'Estimating Overhaul in Earthwork by Means of the Profile of Quantities," I would state that the method was in extensive use on the South Pennsylvania Railroad in 1882-1885, on preliminary and location surveys, and also, later, during construction, for monthly estimates. Its flexible qualities and its many uses will suggest themselves in adapting mountain grade lines to the best ground (especially where the side slopes are very steep and the actual profile of the center line shows so little of the real amount and location of the material to be moved), for arranging the distribution of the quantities to the greatest advantage as to overhaul, waste, or borrow, and the fixing of section posts. In rock work, or where any mixed material is encountered, care must be exercised to allow for the proper shrinkage and swelling of the several materials, and the percentage so obtained must be embodied in the original algebraic summation of quantity before the ordinates are plotted on the profile or cross-section paper. The graphic method was mentioned in a paper published in the Proceedings of Engineers' Club of Philadelphia, Vol. 4, No. 2, May, 1884, by Edward Thiange and J. M. Rudiger, Jr.

22. W. E. Weston, "The Calculation of Overhaul," (Engineering News, Vol. 25, p. 255, March 14, 1891), in a communication under date of Feb. 18, 1891, discusses a method which "consists simply in figuring the overhaul on the excavation and embankment separately, figuring each as if it were drawn to the limit of free haul and there dumped." A case is worked out in tabulated form to illustrate the process.

23. "W. R. H.," "The Calculation of Overhaul," (Engineering News, Vol. 25, p. 255, March 14, 1891), in a communication under date of Feb. 20, 1891, describes the usual method of computing haul by taking out extreme free haul distance, like the Searles method (Ref. No. 8).

24. T. S. Russell, "The Calculation of Overhaul," (Engineering News, Vol. 25, pp. 254, 255, March 14, 1891), in a communication dated Feb. 9, 1891, says: "In your issue of January 31 a method of estimating overhaul by a profile of quantities, by S. B. Fisher, is published. I have used a method somewhat similar to that, which is illustrated in the accompanying diagram, Fig. 7. This method consists in plotting the quantities in the cuts and fills on ordinary profile paper, and preferably on the same paper on which the ordinary line profile is plotted, using the same horizontal scale, and placing the stations for the quantity profile directly above or below those on the ordinary profile, as in the diagram here given.

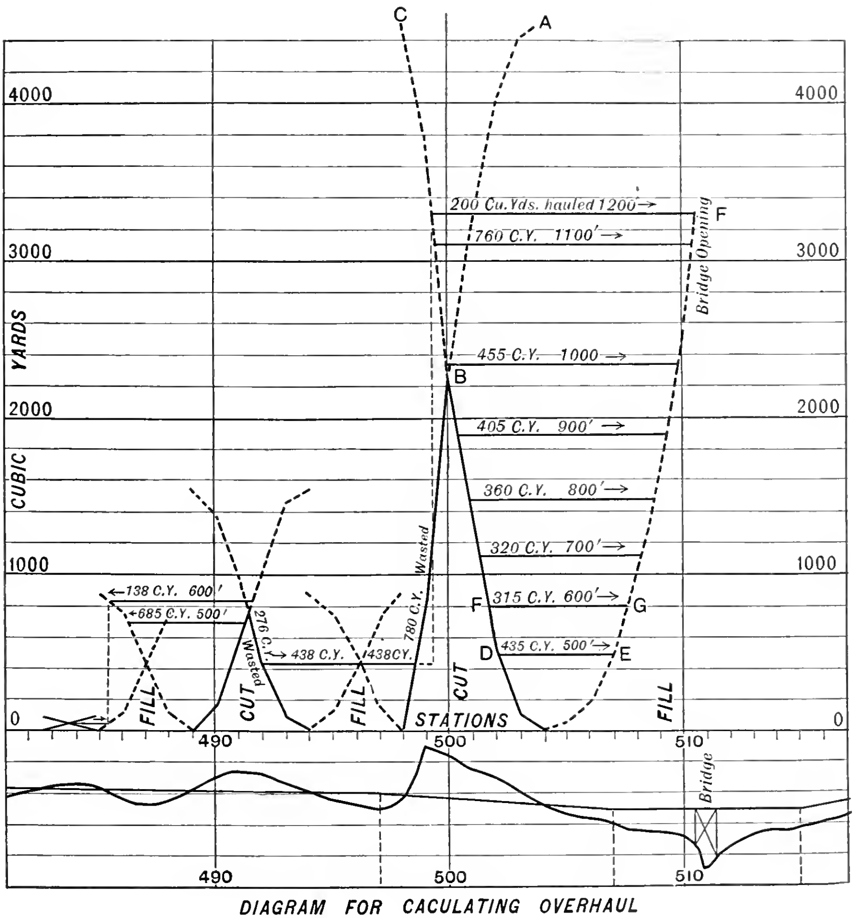

C
A
4000
4000
200 Cu.Yds. hauled 1200′→
F
760 C.Y. 1100′→
Bridge Opening
3000
3000
YARDS
455 C.Y. 1000→
B
2000
2000
405 C.Y. 900′→
CUBIC
360 C.Y. 800′→
320 C.Y. 700′→
Wasted
1000
1000
←138 C.Y. 600′
←685 C.Y. 500′
276 C.Y. Wasted
780 C.Y.
F
315 C.Y. 600′→
G
438 C.Y.
438CY.
D
435 C.Y. 500′→
E
FILL
CUT
FILL
CUT
FILL
0
STATIONS
0
490
500
510
Bridge
490
500
510
DIAGRAM FOR CACULATING OVERHAUL

FIG. 7.

"These quantities are final quantities calculated from the construction cross-section notes. Each cut and fill is plotted separately—cuttings in red (heavy solid lines in diagram) and fills in blue (heavy dotted lines); the origins or zero points being at the stations or plusses where the changes from cut to fill occur. From each of these grade points as an origin, the total quantity in each cut and fill up to each station is plotted opposite each station, so that in the curve of quantities thus produced an ordinate at any point represents the total quantity in the cut or fill from its beginning up to that point. By plotting backwards in the same manner we obtain two curves, which are symmetrical about a horizontal line through their point of intersection and which intersect in the center of gravity of each cut and fill. [Our correspondent here errs. It is not the center of gravity, but the center of mass. The moments of the equal masses on each side may be very different.—Ed. Eng. News.] The method of using this profile of quantities can be best understood by referring to the accompanying diagram, Fig. 7. The cut from Sta. 499 + 30 to Sta. 504 will be hauled into the fill from Sta. 504 to the bridge opening at Sta. 510 + 75. ABC^1 and A^1BC are the quantity curves for this cutting, plotted from the grade points in opposite directions. They intersect at B, at Sta. 500, which is, therefore, the center of gravity of the cutting. AEGF is the quantity curve for the fill. It is plotted one way only, because this fill can be made only by hauling one way, on account of the bridge opening. Supposing that earth is paid for at 16 cts. per cu. yd. up to 500 ft. of haul, with an additional 1 ct. per yd. for each additional 100 ft. of haul: First find, with a scale or pair of compasses, the two points, one on the curve ABC^1 and the other on AEGF, which are exactly 500. ft. apart on a horizontal line, and draw a line between them, the line DE. These points represent, on the horizontal scale, the stations between which the haul reaches 500 ft., and the ordinate at D or E represents the number of cubic yards hauled up to the 500-ft. limit. Now, find two points on these curves which are 600 ft. apart on a horizontal line, the points F and G. These mark the limits of the 600-ft. haul, and the vertical distance between the lines DE and FG gives the quantity of earth hauled 600 ft. In the same way the quantities hauled 700, 800, 900 ft., etc., can be determined, and the stations which mark the limits of these different lengths of haul are found.

"Having thus disposed of that part of the cutting from Sta. 499 + 30 to Sta. 504, we turn to the curve plotted from the grade point at Sta. 498 and find that, by hauling backward from 498 + 50 to 496 + 20, we can make just half the fill at Sta. 496; the total quantity hauled being 438 cu. yds. and the maximum distance 230 ft. The balance of the cutting from Sta. 498 + 50 to Sta. 499 + 30, amounting to 780 cu. yds., must be wasted.

"It will be readily seen from a study of this method that an engineer can tell in advance where to direct the contractors to borrow and where to waste, and can determine the most advantageous method of hauling out his cuts as soon as he gets his work cross-sectioned and his quantities calculated.

"Of course, if rock is struck in unexpected places and the quantities are thereby changed, it will be necessary for him to change his curves, and for this reason it is better not to ink in his quantity profile until the work is finished.

"I am indebted to R. R. Bruer, C. E., of the C. P. R., for this method of calculating overhaul." [This method is new to us and seems to have some very good points in its favor.—Ed. Eng. News.]

25. C. W. Staniford, "Calculating Overhaul for Earthwork," (Engineering News, Vol. 25, p. 377, April 18, 1891), in a communication dated March 17, 1891, gives an illustration of the application of the graphical method of treating haul to work involving large quantities, as follows:

"In your issue of Jan. 31, 1891, was published an example showing a graphic method of calculating overhaul in earthwork, by Mr. S. B. Fisher. He describes the plotting of a profile of quantity obtained from the successive algebraic addition of the quantities in the cuts and fills at each station, and this, in the main, is the same system which I have used and found an improvement on the old method. Since this issue mentioned, there have appeared several other methods and suggestions, but all the examples given (including Mr. Fisher's) are illustrated in very light work, and the haul is limited to the local consideration only of the removal of the cut direct to the nearest fill. In heavy work of a mixed classification, the most economic distribution will often necessitate the hauling or overhauling of one cut through, or around another into the same fill rather than waste the far cut and borrow. I, therefore, submit the following example and diagram, showing a heavy section in railway work taken from actual practice, where the question of haul is rather more than ordinarily complicated."

Then follows a description, with table and diagram, differing from Mr. Fisher's illustration only in the magnitude of the quantities.

26. G. H. Frost, "Engineer's Field Book," (being a reprint of C. S. Cross' "Engineer's Field Book," 1857, with numerous additions of articles on engineering subjects which have appeared in Engineering News from time to time), (Engineering News Pub. Co., N. Y., 1891), pp. 118-122, contains reprint of the paper by S. B. Fisher, describing the graphical method of treating overhaul. (Ref. No. 20.)

27. R. G. Brown, "The Calculation of Average Haul." in a paper read before the Iowa Society of Engineers and Surveyors, 1891 (Fourth Annual Report, Iowa Soc. Eng. and Surv., 1891, pp. 21-25), gives the following detailed description of the method in general use on railroad work in the West:

"One element of the cost of earthwork in railroad construction is the haul of the material. As the material is commonly taken from the excavations on the line and hauled to and deposited in the embankment, the distance which the material is hauled continually varies. The average haul is therefore a space through which, if the sum of all the number of cubic yards were moved, would be equal to the average of all the variable distances. It is calculated on the principle that a large number of yards moved a short distance is equal in the labor required to move a smaller quantity a longer distance; for instance, that the labor required to move 1,000 yds. 100 ft. is equal to that of moving 100 yds. 1,000 ft. The average haul in this case for the two combined would be 181.8 ft.; that is, that the labor required to move the whole amount, 1,100 yds., 181.8 ft., is the same as that required to move 1,000 yds. 100 ft., plus 100 yds. 1,000 ft.

"In the measurement of the number of cubic yards, in excavation and embankment, the work is divided into prismoids by cross-sections at regular stations and frequently at intermediate distances. In making an exact computation of the distance through which each prismoid is moved, its center of gravity must be found and the distance of that center from the center of gravity of the prismoid into which it is deposited. If, then, the number of cubic yards in each prismoid be multiplied by the distance it is hauled, and the sum of all the products be divided by the sum of the cubic yards, the result will be the average haul of the whole. The difficulty of practically applying this method is in finding the center of gravity of the prismoid of deposit. If the number of yards in the prismoid of excavation were always equal to the corresponding one of the embankment, there would be no trouble, for the centers of both would be the ones required, but they never are exactly equal; consequently, the surplus, if any, of the material must be carried into the next prismoid of embankment or, if not sufficient, borrowed from the next excavation, so bringing confusion all around. A much more accurate result can be more easily obtained by computing the average haul of the excavation to its terminating point, and that of the embankment from its initial point. For example, suppose it were required to calculate the entire haul of a portion of a line where the embankment was made from material taken from excavation: In the first place, the haul of the excavation would be computed as though it were all deposited at the grade point, that is, the point where the excavation ended and embankment commenced; in the second place, that of the embankment from the same point; the sum of both would be the average haul of the whole.

"In almost all contracts for earthwork there is specified a certain limit of free haul, within which all material moved is paid for in the general price per cubic yard, but when the material must be carried beyond this limit the extra distance is paid for at a certain price per 100 ft. extra. Hence, in making the computation of the overhaul which the contractor must be paid, the limit of free haul must be taken in the account. The length of the free haul varies on different roads, but is always specified in the contract. The limits of free haul are found from the profile and field notes, by finding a limit each way from the grade point, where the material taken from the excavation will just make the embankment, and the distance between these limits will be just equal to the free haul specified in the contract. After the limits are found and the distances on the line noted, the haul of the excavation to the limit can be calculated, and that of the embankment from its limit; the sum of the two will be the overhaul for which the contractor is entitled to receive pay.

"Taking it for granted that an exact computation is to be made, the first step is finding the center of gravity of each prismoid. If the areas of the cross-sections at each end are the same, the center of gravity will coincide with the midsection; but if they are unlike, as is usually the case, the center will be toward the greater area. As simple and accurate a formula for finding the distance of the center of gravity of a prismoid from its midsection as can probably be given is the following:

"Multiply the difference of the end areas of a prismoid by its length, and divide by six times the sum of the end areas; the result will be the distance of the center of gravity from the midsection.

"Example.—Length, 100 ft.; end areas, 500 and 200 sq. ft.

$$\frac{100 \times 300}{700 \times 6} = \frac{30{,}000}{4{,}200} = 7.1 \text{ ft.}$$

"Distance from the smaller end, 57.1 ft.

"This formula is derived from the principles of mechanics, and cannot well be demonstrated here.

"In calculating average haul, it is best to adopt some system of keeping the notes and adhere to it whenever such a computation is to be made. As good a system as any is to use a blank level book ruled into a number of columns. In the first column enter from the field notes the station and plus distances of every cross-section; in the second, the area of the cross-sections; in the third, the number of cubic yards in the prismoid, set opposite the greater station number; in the fourth, the station and plus distance of the center of gravity of each prismoid; in the fifth, the length of haul of the prismoid to or from the limit of free haul; in the sixth, the product of the length of haul by the cubic yards in each prismoid. After all these are found, take the sum of all the products and divide by the sum of all the cubic yards; the result will be the average haul of the whole. Pursue this method with both excavation and embankment separately, and the sum of the two will be the overhaul for which the contractor must be paid. The following is an example of overhaul calculation, excavation computed to grade point:

CALCULATION OF AVERAGE HAUL.

Station	End Areas	Cubic Yards	Center of Gravity	Length of Haul	Products
438	704.0	....	....	....	....
439	478.6	2,190.0	438+46.8	433.2	948,708.0
440	350.0	1,534.4	439+47.4	332.6	510,341.4
+60	350.0	777.8	440+30	250.0	194,450.0
441	181.7	393.8	440+77.9	202.1	79,587.0
442	123.7	265.5	441+46.8	133.2	75,324.6
+80	00.0	229.1	442+26.7	53.3	12.211.0
		5690.6			1,820,622.0

$$\text{Average haul, } \frac{1,820,622}{5,690} = 320 \text{ ft.}$$

"A great part of the labor of making these calculations is computing the centers of gravity. A close approximation can be made by using the midsection instead of the true center of gravity, which the engineer, if he is in a hurry, as he generally is, will frequently adopt. The difference, whatever it is, is usually against the contractor, as the end areas commonly increase from the limit of haul and the center of gravity at a greater distance than the midsection. However, unless there is great difference between the end areas, the distance between the two is not great. In the first prismoid, in the example given, the difference between the end areas is 225.4 sq. ft., but the distance of the center of gravity from the midsection is only 3.2 ft. The average haul, in the example given, computed from the midsections, is 317 ft., a difference of only 3 ft."

28. C. F. Allen, "Railroad Curves and Earthwork," (author's private edition, 1894, (pp. 194-211), Spon & Chamberlain, N. Y., 1899, (pp. 174-189), gives a comprehensive discussion of earthwork haul and of the mass diagram. The following extract, reproduced by permission, from pp. 174-175 of the 1899 edition, indicates the basis of the author's discussion:

"When material from excavation is hauled to be placed in embankment, it is customary to pay to the contractor a certain sum for every cubic yard hauled. Oftentimes it is provided that no payment shall be made for material hauled less than a specified distance. In the East a common limit of 'free haul' is 1,000 ft. Often in the West 100 ft. is the limit of 'free haul.'

"A common custom is to make the unit for payment of haul 1 yard hauled 100 ft.; the price paid will often be from 1 to 2 cts. per cubic yard hauled 100 ft.

"The price paid for 'haul' is small, and therefore the standard of precision in calculation need not be quite as fine as in the calculation of quantities of earthwork. The total 'haul' will be the product of (1) the total amount of excavation hauled and (2) the average length of haul.

"The average length of haul is the distance between the center of gravity of the material as found in excavation and the center of gravity as deposited. It would not, in general, be simple to find the center of gravity of the entire mass of excavation hauled, and the most convenient way is to take each section of earthwork by itself. The 'haul' for each section is the product of the (1) number of cubic yards in that section and (2) distance between the center of gravity in excavation and the center of gravity as deposited.

"When excavation is placed in embankment, there may be some difficulty in determining just where any given section of excavation will be placed and where its center of gravity will be in embankment.

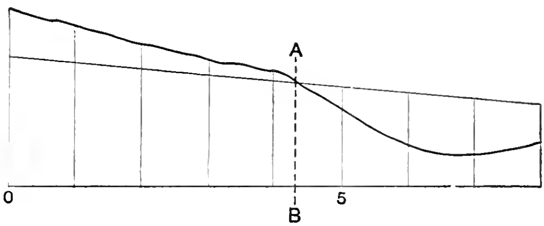


FIG. 8.

"In hauling excavation in embankment, there is some plane, as indicated by AB (Fig. 8), *to* which all excavation must be hauled on its way to be placed in embankment, and (another way of putting it) *from* which all material placed in embankment must be hauled on its way from excavation. We may figure the total haul as the sum of (1) total 'haul' of excavation *to* AB and (2) total 'haul' of embankment *from* AB.

"The total 'haul' of excavation *to* AB and the total 'haul' of embankment *from* AB will most conveniently be calculated as the sum of the hauls of the several sections of earthwork. For each section the haul is the product of (1) the solidity S of that section and (2) distance from center of gravity of that section to the plane AB.

"*When* the two end areas are equal, the center of gravity will be midway between the two end planes. When the two end areas are not equal in value, the center of gravity of the section will be at a certain distance from the midsection, as shown by the formula,

$$x = \frac{l^2}{12} \cdot \frac{A_1 - A_0}{S}$$

in which x = distance center of gravity from midsection."

Then follows the derivation of the foregoing formula and a discussion of its application (four pages); and a full chapter (ten pages) is devoted to the mass diagram.

29. C. F. Allen, "A Graphical Method of Studying Questions of Haul of Earthwork—the Mass Diagram," (Railroad Gazette, Vol. 27, pp. 326, 327, May 24, 1895), presents a complete discussion of the graphical method of treating haul problems, similar to the German method. This presentation of the subject is the same as that which appears in "Railroad Curves and Earthwork," (Ref. No. 28).

30. J. C. Nagle, "Field Manual for Railroad Engineers," (Wiley, N. Y., 1897, pp. 136, 137), first describes the method involving the extreme or "out to out" free haul limit, like Searles and Godwin (Ref. Nos. 8 and 19), and refers to two other methods, as follows:

"It will serve in most cases to find a point that divided the mass into two equal parts, and treat this as the center of gravity; such a point may be readily found by trial. Sometimes it is specified that the overhaul must be found by finding the distance of the center of gravity of the *whole* mass moved from the center of gravity of the *same* mass after depositing in embankment, and deducting from this the length of free haul, the remainder being called the overhaul. This is the easier method, but requires every yard moved to be carried the entire length of free haul before any overhaul whatever is counted."

31. W. L. Webb, "Some Practical Applications of the Mass Curve in Earthwork Computations," in paper read Nov. 20, 1897, before the Engineers' Club of Philadelphia (Proc. Eng. Club. Phila., Vol. 14, pp. 249-264), fully describes the practical application of the "mass diagram," forming the basis of the presentation of this subject by the same author in his "Railroad Construction," reproduced below (Ref. No 33).

32. F. Tscherton, "Railway Construction," ("Der Eisenbahnbau," Weisbaden, 1899, pp. 182-197), gives a very complete presentation of the graphical method of treating haul, distribution of materials, etc., as practiced by German engineers at the present time. The diagram illustrating the process (plate 3, entitled "Längenprofil and Massennivellement,") is very similar to that given in Culmann's work (Ref. No. 4).

33. W. L. Webb, "Railroad Construction," (Wiley, N. Y., 1899, 1893, pp. 116-124), presents one of the most complete discussions of the properties and uses of the mass diagram which has yet appeared. The same is here reproduced in full, by permission:

"NATURE OF SUBJECT. As will be shown later when analyzing the cost of earthwork, the most variable item of cost is that depending on the distance hauled. As it is manifestly impracticable to calculate the exact distance to which every individual cartload of earth has been moved, it becomes necessary to devise a means which will give at least an equivalent of the haulage of all the earth moved. Evidently the *average* haul for any mass of earth moved is equal to the distance from the center of gravity of the excavation to the center of gravity of the embankment formed by the excavated material. As a rough approximation the center of gravity of a cut (or fill) may sometimes be considered to coincide with the center of gravity of that part of the profile representing it, but the error is frequently very large. The center of gravity may be determined by various methods, but the method of the 'mass diagram' accomplishes the same ultimate purpose (the determination of the haul) with all-sufficient accuracy, and also furnishes other valuable information.

"MASS DIAGRAM. In Fig. 9 let $A^1B^1\ldots\ldots G^1$ represent a profile and grade line drawn to the usual scales. Assume A^1 to be a point past which no earthwork will be hauled. Such a point is determined by natural conditions, as, for example, a river crossing or one end of a long, level stretch along which no grading is to be done except the formation of a low embankment from the material excavated from ample drainage ditches on each side. Above the profile draw an indefinite horizontal line (ACn in Fig. 9), which may be called the 'zero line.' Above every station point in the profile draw an ordinate (above or below the zero

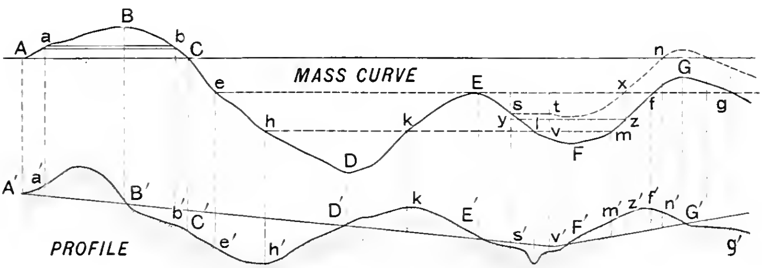


FIG. 9—MASS DIAGRAM.

line) which will represent the algebraic sum of the cubic yards of cut and fill (calling cut + and fill —) from the point A^1 to the point considered. The computations of these ordinates should first be made in tabular form, as shown below. In doing this, shrinkage must be allowed for by considering how much embankment would actually be made by so many cubic yards of excavation of such material. For example, it will be found that 1,000 cu. yds. of sand or gravel, measured in place, will make about 920 cu. yds. of embankment; therefore, all cuttings in sand or gravel should be discounted in about this proportion. Excavations in rock should be increased in the proper ratio. In short, all excavations should be valued according to the amount of *settled* embankment that could be made from them. Place in the first column a list of the stations; in the second column, the number of cubic yards of cut or fill between each station and the preceding station; in the third and fourth columns, the kind of material and the proper shrinkage factor; in the fifth column, a repetition of the quantities in cubic yards, except that the excavations are diminished (or increased, in the case of rock) to the number of cubic yards of settled embankment which may be made from them. In the sixth column place the *algebraic sum* of the quantities in the fifth column (calling cuts + and fills —) from the starting-point to the station considered. These algebraic sums at each station will be the ordinates, drawn to some scale, of the mass curve. The scale to be used will depend somewhat on whether the work is heavy or light, but for ordinary cases a scale of 5,000 cu. yds. per inch may be used. Drawing these ordinates to scale, a curve AB....G may be obtained by joining the extremities of the ordinates.

TABLE I.

Sta. (1)	Yards { Cut + / Fill — (2)	Material. (3)	Shrinkage Factor. (4)	Yards. Reduced for Shrinkage. (5)	Ordinate in Mass Curve. (6)
46+70	....	....	....	....	0
47	+ 195	Clayey soil	— 10 %	+ 175	+ 175
48	+ 1792	" "	— 10 %	+ 1613	+ 1788
+60	+ 614	" "	— 10 %	+ 553	+ 2341
49	— 143	....	....	— 143	+ 2198
50	— 906	....	....	— 906	+ 1292
51	— 1985	....	....	— 1985	— 693
52	— 1721	....	....	— 1721	— 2414
+30	— 112	....	....	— 112	— 2526
53	+ 177	Hard rock	+ 60 %	+ 283	— 2243
+70	+ 180	" "	+ 60 %	+ 289	— 1954
54	— 52	....	....	— 52	— 2006
+42	— 71	....	....	— 71	— 2077
55	+ 276	Clayey soil	— 10 %	+ 249	— 1828
56	+ 1242	" "	— 10 %	+ 1118	— 710
57	+ 1302	" "	— 10 %	+ 1172	+ 462

"PROPERTIES OF THE MASS CURVE. (1) The curve will be rising while over cuts, and falling while over fills.

"(2) A tangent to the curve will be horizontal (as at B, D, E, F and G), when passing from cut to fill or from fill to cut.

"(3) When the curve is *below* the 'zero line' it shows that material must be drawn *backward* (to the left); and *vice versa,* when the curve is *above* the zero line it shows that material must be drawn *forward* (to the right).

"(4) When the curve crosses the zero line (as at A and C) it shows (in this instance) that the cut between A^1 and B^1 will just provide the material required for the fill between B^1 and C^1, and that no material should be hauled past C^1, or, in general, past any intersection of the mass curve and the zero line.

"(5) If any horizontal line be drawn (as ab), it indicates that the cut and fill between a^1 and b^1 will just balance.

"(6) When the center of gravity of a given volume of material is to be moved a given distance, it makes no difference (at least theoretically) how far each individual load may be hauled or how any individual load may be disposed of. The summation of the products of each load times the distance hauled will be a constant, whatever the method, and will equal the total volume times the movement of the center of gravity. The *average haul*, which is the movement of the center of gravity, will therefore equal the summation of these products divided by the total volume. If we draw two horizontal parallel lines at an infinitesimal distance dx apart, as at ab, the small increment of cut dx at a^1 will fill the corresponding increment of fill at b^1, and this material must be hauled the distance ab. Therefore, the product of ab and dx, which is the product of distance times volume, is represented by the area of the infinitesimal rectangle at ab, and the total area ABC represents the summation of volume times distance for all the earth movement between A^1 and C^1. This summation of products divided by the total volume gives the average haul.

"(7) The horizontal line tangent at E and cutting the curve at e, f, and g, shows that the cut and fill between e^1 and E^1 will just balance, and that a *possible* method of hauling (whether desirable or not) would be to 'borrow' earth for the fill between C^1 and e^1, use the material between D^1 and E^1 for the fill between e^1 and D^1, and similarly balance cut and fill between E^1 and f^1 and also between f^1 and g^1.

"(8) Similarly the horizontal line hklm may be drawn cutting the curve, which will show another *possible* method of hauling. According to this plan, the fill between C^1 and h^1 would be made by borrowing; the cut and fill between h^1 and k^1 would balance; also that between k^1 and l^1 and between l^1 and m^1. Since the area ehDkE represents the measure of haul for the earth between e^1 and E^1, and the other areas measure the corresponding hauls similarly, it is evident that the sum of the areas ehDkE and ElFmf, which is the measure of haul of all the material between e^1 and f^1, is largely in excess of the sum of the areas hDk, kEl, and lFm, plus the somewhat uncertain measures of haul due to borrowing material for e^1 h^1 and wasting the material between m^1 and f^1. Therefore to make the measure of haul a minimum a line should be drawn which will make the sum of the areas between it and the mass curve a minimum. Of course, this is not necessarily the cheapest plan, as it implies more or less borrowing and wasting of material, which *may* cost more than the amount saved in haul. The comparison of the two methods is quite simple, however. Since the amount of fill between e^1 and h^1 is represented by the *difference* of the ordinates at e and h, and similarly for m_1 and f_1, it follows that the amount to be borrowed between e^1 and h^1 will exactly equal the amount wasted between m^1 and f^1. By the first of the above methods the haul is excessive, but is definitely known from the mass diagram, and all of the material is utilized; by the second method the haul is reduced to about one-half, but there is a known quantity in cubic yards wasted at one place and the same quantity borrowed at another. The length of haul necessary for the borrowed material would need to be ascertained; also the haul necessary to waste the other material at a place where it would be unobjectionable. Frequently this is best done by widening an embankment beyond its necessary width. The computation of the relative cost of the above methods will be discussed later.

"(9) Suppose that it were deemed best, after drawing the mass curve, to introduce a trestle between s^1 and v^1, thus saving an amount in fill equal to tv. If such had been the original design, the mass curve would have been a straight horizontal line between s and t and would continue as a curve which would be at all points a distance tv above the curve vFmzfGg. If the line Ef is to be used as a zero line, its intersection with the new curve at x will show that the material between E^1 and z^1 will just balance if the trestle is used, and that the amount of haul will be measured by the aera between the line Ex and the broken line Estx. The same computed result may be obtained without drawing the auxiliary curve txn ... by drawing the horizontal line zy at a distance xz (=tv) below Ex. The amount of the haul can then be obtained by adding the triangular area between Es and the horizontal line Ex, the rectangle between st and Ex, and the irregular area between vFz and y...z (which last is evidently equal to the area between tx and E...x). The disposal of the material at the right of z^1 would then be governed by the indications of the profile and mass diagram which would be found at the right of g^1. In fact, it is difficult to decide with the best of judgment as to the proper disposal of material without having a mass diagram extending to a considerable distance each side of that part of the road under immediate consideration.

"Area of the Mass Curve. The area may be computed most readily by means of a planimeter, which is capable with reasonable care of measuring such areas with as great accuracy as is necessary for this work. If no such instrument is obtainable, the area may be obtained by an application of 'Simpson's rule'. The ordinates will usually be spaced 100 ft. apart. Select an *even* number of such spaces, leaving, if necessary, one or more triangles or trapezoids at the ends for separate and independent computation. Let y_0, y_1, ... be the ordinates, i. e., the number of cubic yards at each station of the mass curve, or the figures of 'column six' in the table. Let the uniform distance between ordinates (=100 ft.) be called 1, i. e., one *station*. Then the units of the resulting area will be cubic yards hauled one station. Then the

$$\text{Area} = \frac{1}{3}\left[y_0 + 4\,(y_1 + y_3 + \dots y_{(n-1)}) + 2\,(y_2 + y_4 + \dots y_{(n-2)}) = y_n\right]$$

"When an ordinate occurs at a substation, the best plan is to ignore it at first and calculate the area as above. Then, if the difference involved is too great to be neglected, calculate the area of the triangle having the extremity of the ordinate at the substation as an apex, and the extremities of the ordinates at the adjacent stations as the ends of the base. This may be done by finding the ordinate at the substation that would be a proportional between the ordinates at the adjacent full stations. Subtract this from the real ordinate (or *vice versa*) and multiply the difference by $\frac{1}{2} \times 1$. An inspection will often show that the correction thus obtained would be too small to be worthy of consideration. If there is more than one substation between two full stations, the corrective area will consist of two triangles and one or more trapezoids which may be similarly computed, if necessary.

"When the zero line (Fig. 9) is shifted to eE, the drop from AC (produced) to E is known in the same units, cubic yards. This constant may be subtracted from the numbers (column 6) representing the ordinates, and will thus give, without any scaling from the diagram, the exact value of the modified ordinates.

"VALUE OF THE MASS DIAGRAM. The great value of the mass diagram lies in the readiness with which different plans for the disposal of material may be examined and compared. When the mass curve is once drawn, it will generally require only a shifting of the horizontal line to show the disposal of the material by any proposed method. The mass diagram also shows the extreme length of haul that will be required by any proposed method of disposal of material. This brings into consideration the 'limit of profitable haul.' For the present it may be said that with each method of carrying material there is some limit beyond which the expense of hauling will exceed the loss resulting from borrowing and wasting. With wheelbarrows and scrapers the limit of profitable haul is comparatively short, with carts and tram-cars it is much longer, while with locomotives and cars it may be several miles. If, in Fig. 9, eE or Ef exceeds the limit of profitable haul, it shows at once that some such line as hklm should be drawn and the material disposed of accordingly.

"CHANGING THE GRADE LINE. The formation of the mass curve and the resulting plans as to the disposal of material are based on the mutual relations of the grade line and the surface profile and the amounts of cut and fill which are thereby implied. If the grade line is altered, every cross-section is altered, the amount of cut and fill is altered, and the mass curve is also changed. At the farther limit of the actual change of the grade line the revised mass curve will have (in general) a different ordinate from the previous ordinate at that point. From that point on, the revised mass curve will be parallel to its former position, and the revised curve may be treated similarly to the case previously mentioned in which a trestle was introduced. Since it involves tedious calculations to determine accurately how much the volume of earthwork is altered by a change in grade line, especially through irregular country, the effect on the mass curve of a change in the grade line cannot therefore be readily determined except in an approximate way. Raising the grade line will evidently increase the fills and diminish the cuts, and *vice versa*. Therefore, if the mass curve indicated, for example, either an excessively long haul or the necessity for borrowing material (implying a fill) and wasting material farther on (implying a cut), it would be *possible* to diminish the fill (and hence the amount of material to be borrowed) by lowering the grade line near that place, and diminish the cut (and hence the amount of material to be wasted) by raising the grade line at or near the place farther on. Whether the advantage thus gained would compensate for the possibly injurious effect of these changes on the grade line would require patient investigation. But the method outlined shows how the mass curve might be used to indicate a possible change in grade line which might be demonstrated to be profitable.

"LIMIT OF FREE HAUL. It is sometimes specified in contracts for earthwork that *all* material shall be entitled to free haul up to some specified limit, say 500 or 1,000 ft., and that all material drawn farther than that shall be entitled to an allowance on the *excess* of distance. It is manifestly impracticable to measure the excess for each load, as much so as to measure the actual haul of each load. The mass diagram also solves this problem very readily. Let Fig. 10 represent a profile and mass dia-

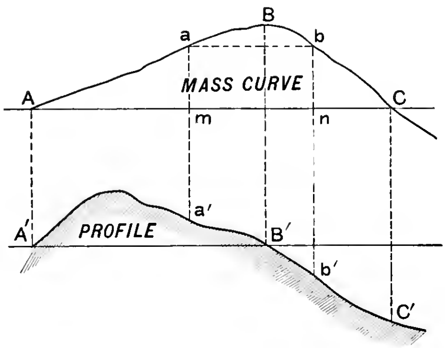


FIG. 10.

gram of about 2,000 ft. of road, and suppose that 800 ft. is taken as the limit of free haul. Find two points, a and b, in the mass curve *which are on the same horizontal line* and which are 800 ft. apart. Project these points down to a^1 and b^1. Then the cut and fill between a^1 and b^1 will just balance, and the cut between A^1 and a^1 will be needed for the fill between b^1 and C^1. In the mass curve, the area between the horizontal line ab and the curve aBb represents the haulage of the material between a^1 and b^1, which is all free. The rectangle abmn represents the haulage of the material in the cut A^1a^1 across the 800 ft. from a^1 to b^1. This is also free. The sum of the two areas Aam and bnC represents the haulage entitled to an allowance, since it is the summation of the products of cubic yards times the *excess* of distance hauled.

"If the amount of cut and fill was symmetrical about the point B^1, the mass curve would be a symmetrical curve about the vertical line through B, and the two limiting lines of free haul would be placed symmetrically about B and B^1. In general there is no such symmetry, and frequently the difference is considerable. The area aBbnm will be materially changed

Committee on Roadway.

PLATE VII., FIG. II.

"PLOTTING AND COMPUTING HAUL," Molitor and Beard's

Manual for Resident Engineers, pp. 57-61.

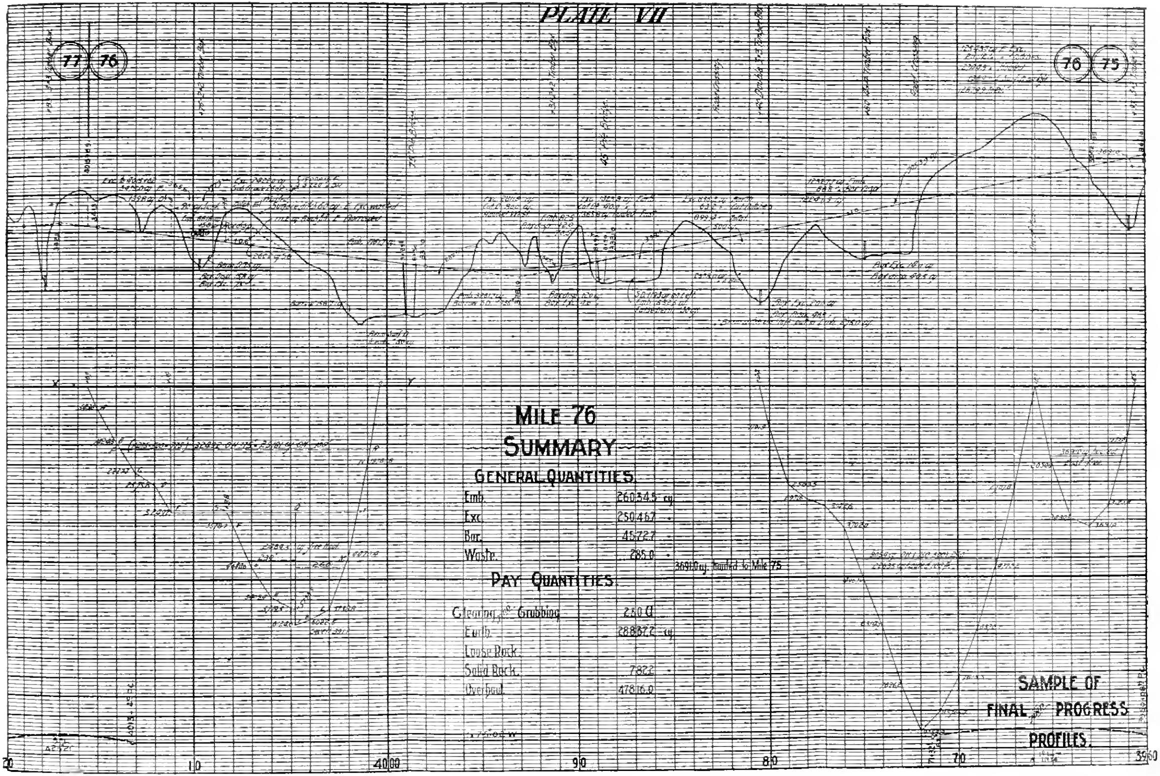


PLATE VII
77
76
75
MILE 76
SUMMARY
GENERAL QUANTITIES
Emb. 260345 cy
Exc. 250467
Bor. 45727
Waste 285.0
30910 cy. hauled to Mile 75
PAY QUANTITIES
Clearing and Grubbing 2.80 A
Earth 288372 cy
Loose Rock
Solid Rock 7822
Overhaul 47816.0
SAMPLE OF
FINAL AND PROGRESS
PROFILES.
20
10
4000
90
80
70
3960

according as the two vertical lines am and bn, always 800 ft. apart, are shifted to the right or left. It is easy to show that the area aBbnm is a *maximum* when ab is horizontal. The minimum value would be obtained either when m reached A or n reached C, depending on the exact form of the curve. Since the position for the minimum value is manifestly unfair, the best definite value obtainable is the maximum, which must be obtained as above described. Since aBbnm is made maximum, the remainder of the area, which is the allowance for overhaul, becomes a minimum. The areas Aam and bCn may be obtained as already explained. If the whole area AaBbCA has been previously computed, it may be more convenient to compute the area aBbnm and subtract it from the total area.

"Since the intersections of the mass curve and the 'zero line' mark limits past which no material is drawn, it follows that there will be no allowance for overhaul except where the distance between consecutive intersections of the zero line and mass curve exceeds the limit of free haul.

"Frequently all allowances for overhaul are disregarded; the profiles, estimates of quantities, and the required disposal of material are shown to bidding contractors, and they must then make their own allowances and bid accordingly. This method has the advantage of avoiding possible disputes as to the amount of the overhaul allowance, and is popular with railroad companies on this account. On the other hand the facility with which different plans for the disposal of material may be studied and compared by the mass-curve method facilitates the adoption of the most economical plan, and the elimination of uncertainty will frequently lead to a safe reduction of the bid, and so the method is valuable to both the railroad company and the contractor."

34. P. H. Philbrick, "Field Manual for Engineers," (Wiley, N. Y., 1901), pp. 268, 269, describes the method of extreme free limit of haul, like Searles, Godwin, and Nagle (Ref. Nos. 8, 9 and 30).

35. F. A. Molitor and E. J. Beard, "Manual for Resident Engineers," (reprint of "Standard General Instructions to Resident Engineers; Choctaw, Oklahoma & Gulf R. R., Jan., 1901), (Wiley, N. Y., 1903), pp. 57-61, describe a graphical method of treating haul and distribution problems similar to Bruckner's "Profile of Quantities," but using the "center of bulk" or yardage instead of center of gravity. Their description of the method, with folding plate illustrating the same, is reproduced by permission.

"Plotting and Computing Haul. In plotting haul consider each small horizontal space (one foot when plotting profile) 100 cu. yds., and from some base line as the 50-ft. line XY, on Plate VII., (Fig. 11), plot the 'haul curve,' ABCD, etc., in the following described manner:

The fill station 3999+ to 4004+.

In the cut east of M. P. 76 there is:

	3,475.0	cu. yds.	above the roadbed, and
	139.8	"	in cut ditches, giving
Total in cut	3,614.8	"	of which east of station
4,011 + 18...	365.6	"	was hauled in to fill station
4010, leaving....	3,249.2	"	to haul east to fill station 4000.

In the cut station 4004 + to 4008 + there is

	1,900	cu. yds.	earth,
and	522	"	solid rock,
and	260.2	"	solid rock in sub-grade.
Total in the cut	2,682.2	"	of which all west of station
4008 + 38.......	197.9	"	was hauled in to the fill station 4010,
leaving.........	2,484.3	"	to go into the fill station 4000.

"Inspection shows that the quantities placed in fill station 4010 lie within the free haul (which is 500 ft.).

"To find the haul on the quantities going into the fill at station 4000, begin at the west end of the material hauled, M. P. 76. In the 69 ft. of station 4015 to 4016, there are, including ditches, 543.6 cu. yds.; with X Y as a base line, and each horizontal space equaling 100 cu. yds., plot 'A' 543.6 cu. yds., below the base line, and from plus 69 on the base line to the point A, draw the 'haul curve.' Then between stations 14 and 15, including ditches, there are 880.7 cu. yds., which, added to 543.6 cu. yds., gives 1,424.3 cu. yds., and at station 4014, 1,424.3 cu. yds., below the base line, plot the point B, and draw the 'haul curve' A B. In this manner successively find the points C, D and E, and through these points draw the 'haul curve,' adding in all material that is hauled from each station to the fill, deducting in like manner any that may be wasted. Thus we find that at the mouth of the cut the 'haul curve' passes through the point E, or 3,249.2 cu. yds. below the base line at station 4011 + 18.

"A point on the curve one-half of this 3,249.2 cu. yds., or 1,625 cu. yds. below the base line, is the center of bulk of that portion of this cut hauled to the fill, station 4000.

"As none of this material was placed in the fill at station 4010, but went on through the cut next east and into that part of the embankment next adjoining that part of the fill made from the cut, station 4004 + to 4008 +. Draw the horizontal line E S, the point S being at the station and plus of the west end of the material in the cut, station 4008 + 38, that went into the fill, station 4000, and, of course, made the embankment next adjoining this cut. Continuing as before, adding the cubic yards in each successive station, we obtain the points F, G, H and I; through these points plot the 'haul curve,' obtaining 5,733.5 cu. yds. at I.

"By bisecting the quantities in this last cut, we obtain the center of bulk on the 'haul curve' just plotted.

"Of this last excavation plotted, there are as noted before, in the cut and sub-grade, 782.2 cu. yds. of solid rock, which, for the purpose of illustration in this example, we will consider as swelling 50 per cent. or 391.1 cu. yds.; plot this 391.1 cu. yds., vertically below the grade point, I J, giving sufficient material passing out of the mouth of the cut to make 6,124.6 cu. yds. of embankment. From this quantity deduct the embankment between the grade points and station 4, and plot the point K, in like manner (deducting all berme ditches and other quantities that have been placed in embankment, taking into account only such embankment quantities as are made with the material hauled from the cuts and of which the haul is being plotted) find the succeeding points K, L, M, N and O, and plot through them the 'haul curve.'

"Draw the horizontal line ESQT, which, of course, intersects the embankment portion of the 'haul curve' at a station to which the material from the adjoining cut made the embankment, and the vertical Q J represents the quantities in embankment and Q I the quantities in excavation; bisect the vertical for the excavation and embankment quantity separately and from the point of bisection draw horizontal lines to the respective 'haul curve,' which they will intersect at the centers of bulk. These horizontal lines carefully scaled with a 400-ft. scale give the total length of average haul, which, less 500 ft. free haul, mutiplied by the cubic yards hauled, gives the number of pay cubic yards hauled 100 ft. In this case, however, the distance between the centers of bulk is but 490 ft. or within the free haul. The material, however, hauled from the west cut was hauled more than 500 ft. and the pay haul on which is to be determined as follows: Bisect the vertical line .... at station 4011 + 18 (which represents the quantities in the west cut hauled out last), and through the point of bisection draw the horizontal line P R which will intersect the 'haul curve' at the centers of bulk of the excavation and embankment quantities. This horizontal line scaled as before, gives the total haul or 25,181 cu. yds. hauled 100 ft.

"In computing and plotting haul each cut hauled must be considered by itself, as shown in this example; in other words, the haul must be estimated separately for each cut. All haul must be paid for on the mile from which it is secured."

36. H. P. Gillette, "Earthwork and Its Cost," (Engineering News Publishing Co., 1903), pp. 211-223, Appendix B, reviews American practice in the determination of overhaul and quotes in full the articles by Russell and Fisher (Ref. Nos. 20 and 24). Gillette's discussion of the subject follows:

"In railroad excavation it has been the custom to specify a limit of haul within which the contractor received a given price per cubic yard, as 20 cts. per cu. yd., but beyond which limit he received an additional price, as 1 ct. per cu. yd. for each 100 ft. of overhaul. This limit is termed the 'free haul' limit and was usually fixed at 500 ft., or in some cases at 1,000 ft.

"Earth is ordinarily paid for at a given rate per cubic yard measured in 'cut,' or in 'borrow pit,' and is not paid for again in the 'fill' or embankment except where specific agreement is made to pay for earth measured in fill also, as is sometimes done when the haul exceeds a certain limit.

"Due to the work involved in figuring this overhaul, and due to trouble arising from disputes over interpretation of specifications relating thereto, the overhaul clause has been very generally dropped from specifications. This we believe to be a mistaken policy in most cases. There are many classes of work wherein an overhaul clause, however, is of no particular use; as (1) in heavy cuts where steam shovels and cars are used, the length of haul there making little or no difference in cost; (2) in reservoir work where hauls are ordinarily very short; (3) in street excavations where the hauls are generally very long, the contractor selling the earth for filling lots; (4) in levee or dike work where scrapers are almost entirely used for the short and nearly uniform hauls of such work; and (5) to a less degree in wagon road work where the ditches make the fills, and few long hauls occur.

"Wherever there is very slight probability of changing the profile of proposed work after the letting of the contract, the engineer can usually save himself much work by simply giving all data of yardage and haul on the profile. In such a case no overhaul clause is needed, unless it be to guide small contractors who cannot employ an engineer to estimate for them, for the profile shows all the factors needed in making a close estimate.

"In extensive railroad work, for example, it is very probable that many changes of line, and consequently of profile, will be made after work has been let and actually started. A conscientious engineer is almost certain to find betterments possible after work begins; hence he should have some clause in his specifications under which he can equitably adjust the price that the contractor should receive in case of changed alinement with resultant change of haul. No clause serves so well for this purpose as an overhaul clause.

"There is, however, one precaution which the engineer should take, that is to figure out before the letting of a contract what the total overhaul is to be and to insert it in the bidding sheet, as 40,000 cu. yds., 100-ft. overhaul; otherwise the contractor will bid excessively high (for example, 2 or 3 cts. per cu. yd. per 100 ft. of overhaul) knowing that the engineer has ordinarily no means of determining at the time of letting what this item may amount to. With an overhaul price, the engineer can evidently change the alinement and haul without overpaying or underpaying the contractor for his work, and without having claims for 'extras' filed.

"In railroad work, where the cuts are generally made to balance the fills, earth is often moved with drag or wheel-scrapers, one-horse carts, two-horse wagons, or with small dump cars on rails. Wheel-scrapers are ordinarily considered cheaper than carts up to hauls of 500 ft.; hence contractors accustomed to bidding with the purpose of using wheelers largely, felt the necessity of having some clause in specifications that would enable them to tell to what extent wagons or carts would be used on any given job. Engineers very justly met this desire by the insertion of an overhaul clause. Had they not inserted some such clause protecting the contractor, the result would have been either a refusal to bid at all on the part of reputable contractors, or an unduly high price if they did bid. It may sound strange in these days of fierce competition and often of 'cut-throat prices' to speak as if the contractors ever had a voice in the matter of specifications, yet exactly such a state of affairs has at times existed. For example, in one locality the contractors held a meeting at which they voted not to bid upon any work where the specifications did not give a double price for all earth carried past any opening in the road—that is, any place where a culvert or bridge was to be built. The specifications had to be drawn to meet this requirement.

"Unless the wording of the overhaul clause is very clear, controversies that may lead to lawsuits are apt to arise. Thus in Fig. 7 (see Russell article, Ref. No. 24) at Sta. 504, the fill passes into cut. Shall the contractor be allowed to move the cut between Stas. 503 and 504 to the fill between 504 and 505; or shall he be made to haul it the full 500 ft. of 'free haul'? There are engineers unfair enough and unwise enough to take the latter stand, acting under some such general clause in the specifications as this: 'The engineer shall have full power to direct the method and manner of doing all work, not inconsistent with limitations prescribed in these specifications.' As a matter of fact, were a law suit to follow any such unjust ruling, there can be no doubt that the court would hold that the contractor should be permitted to move the earth as is customary in such work. This being so, it could easily be shown that, ordinarily, drag-scrapers are used to move earth for the first one or two hundred feet, the ordinary method of attacking the toe of such a cut being with 'drags,' later using wheelers as the haul increases, finally using carts or cars.

"We see, therefore, that the contractor ordinarily hauls the earth just as short a distance as he possibly can before dumping it in the fill, and it is but just and right that he be permitted to do so."

A chapter on "Estimating Overhaul in Earthwork," by H. P. Gillette, very similar to the foregoing discussion, appears in E. H. McHenry's "Railway Location and Construction."

Then follow the articles describing the graphical methods of Russell (Ref. No. 24) and Fisher (Ref. No. 20).

37. C. Prelini, "Earth and Rock Excavation," (D. Van Nostrand, N. Y., 1895), pp. 33-41, states that a graphical method of dealing with

problems in haul and the distribution of earthwork materials, known as "Lalanne's Curve," was introduced in France previous to "Bruckner's Curve" in Germany. He describes the current practice of German, French and Italian engineers as follows:

"Different methods are employed for determining the distribution of the volumes of earth along the profile of the work. Italian and French engineers usually calculate it algebraically, while German and some French engineers determine it by graphical methods. The simplest manner of obtaining the distribution of masses and the mean distance of haul is that employed by Italian engineers, which is deduced in a very simple manner from the calculations of the earthwork. The information is given in the form of a table made up of ten columns as follows:

TABLE I.—ITALIAN METHOD OF TABULATION FOR COMPUTING EARTHWORK HAUL.

Sections.	Distances Between Sections.	Volumes.		Excesses.		Employment of the Earth.	Partial Volumes of Cuts.	Distance of Haul.	Product of the Volume by the Distance.
		Cuts.	Fillings.	Cuts.	Fillings.				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
						90 hauled between sections......2-3	90	77	6,930
0-1		845	285	560		310 " " " 3-4	310	114	35,340
	49					160 " " " 4-5	160	177	28,320
1-2		327	187	140		140 " " " 4-5	140	128	17,920
2-3	28	119	209		90	90 taken from sections..........0-1			
3-4	37		310		310	310 " " " 0-1			
	63					160 " " " 1-2			
4-5			540		540	140 " " " 1-2			
	19					240 " " " 5-6			
5-6		320	52	268		240 brought to sections..........4-5	240	19	4,560
	51					28 " " " 6-7	28	51	1,428
6-7		70	98		28	28 taken from sections..........5-6			
	247	1681	1681	968	968		968		94,498

"Referring to this table it will be seen that in the first section there is an excess of 560 cu. m. of cut, and between sections 1—2 an excess of 140 cu. m., while the fill exceeds the cut in the portion of the road between sections 2 and 5. The excess of cut has to be brought to the points where it is needed for fill, and consequently the 560 cu. m. will be distributed as follows: Ninety cu. m. as near as possible and consequently between sections 2 and 3, at a distance of $49 + 28 = 77$ m.; 310 m. between sections 3 and 4, at a distance of $49 + 28 + 37 = 114$ m.; 160 cu. m. between sections 4 and 5 at a distance of $114 + 63 = 177$ m. Having disposed of the 560 cu. m. excess of section 0—1, we have next to dispose of the excess of 140 cu. m. of section 1—2, and this is taken to section 4—5, as indicated by the table, which can be consulted also for information regarding the procedure for succeeding sections.

"French engineers employ a table constructed on the same principle, but more complicated in form. It contains 19 columns and considers separately transportation by wheelbarrows and carts. The following example of this French tabulation is taken from Daries' '*Cubature des Terrassements*' (Table II). The figures in columns 1 to 5 are obtained from the calculation of the volumes of earth required for the work. Those in column 6 represent the volumes moved by means of shovels, and consequently in a direction transversely to the axis of the work. In columns 7 to 10, inclusive, are given the excesses of cut and fill which have to be distributed along the axis of the work. Column 11 shows the excess volume of cut to be used as fill, column 12 the excess volume of cut to be wasted, and column 13 the volume to be taken from borrow pits. In column 14 are indicated the places to which the excess volume of the cuts is to be taken. Column 15 shows the lengths of haul; if this length is less than 90 m. the calculations are placed in columns 16 and 17, and if it is greater than 90 m. they are placed in columns 18 and 19. After the table is completed and the calculations made, if the work is correct, the following equations should result, S being the sum of the column as indicated by the small numerals.

$$S_4 = S_6 + S_{11} + S_{12}$$
$$S_5 = S_6 + S_{11} + S_{13}$$
$$S_4 + S_{13} = S_5 + S_{12}$$
$$S_{11} + S_{12} + S_{13} = S_{16} + S_{13}$$

"The distribution of the earth along the profile may be calculated graphically by the curves of Bruckner and Lalanne.

TABLE II.—FRENCH METHOD OF TABULATION FOR COMPUTING EARTHWORK HAUL.

Number of Cross-Section	Volume of Cuts on Each Section		Definite Volumes of Cuts	Volumes of Fillings on Each Section	Volumes to be Employed in the Portion Between two Sections	Excess of the Cut on Fillings		Excess of the Fillings on the Cut		Volumes of the Excess of the Cuts		Borrow Pits for the Fillings	Indication of the Place where the Excess of the Cuts should be Deposited	Distance of Hauling	Wheelbarrow		Carts and Wagons	
						On Each Cross-Section	In the Adjacent Cross-Section	On Each Cross-Section	In the Adjacent Cross-Section	To be Carried Along the Lines	To be Deposited for some other Purpose				Volumes	Products of the Volumes by the Distance	Volumes	Products of the Volumes by the Distance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
1				547				547		455			On Section 1	61	155	27.755		
2	155		455			455				92			" " 1	128			92	11,776
3	1946		1946			1946					567		On a lateral spoil bank	30	567	17.010		
..										31			On Section 10	337			31	11.458
..										138			" " 9	302			138	11.676
..										193			" " 8	281			493	138,533
..										622			" " 4	16	622	28.612		
4	91		91	716	91					1447			" " 8	181			1447	261.907
5	1604		1604			1604				157			" " 7	112			157	17.584
..										859			" " 7	87	859	71.733		
6	859		859			859												
7				1016				1016										
8				1940				1940										
9	15		15	153	15			138							2503	148.110	2361	182.934
10	73		93	107	73			34										

Mean distance of hauling with wheelbarrow $\frac{148,110}{2,503} = 59$ m

Mean distance of hauling with cart and wagon $\frac{182,934}{2,361} = 205$ m

"BRUCKNER'S CURVE. The figure known as Bruckner's curve is constructed as follows: Along a horizontal line indicating the longitudinal profile of the axis of construction are marked to scale the distances between the various cross-sections and through each point is drawn a perpendicular line. On these perpendiculars are laid off the algebraic sum of the cuts and fills, the cuts being considered as positives and the fills as negatives. When the result is positive the amount is laid off above the horizontal line, and where it is negative the amount is laid off below the horizontal line. By connecting the extremities of the succeeding ordinates by straight lines or parabolic curves, the resulting figure forms what is called Bruckner's curve (Fig. 12). This curve is constructed upon the following assumptions:

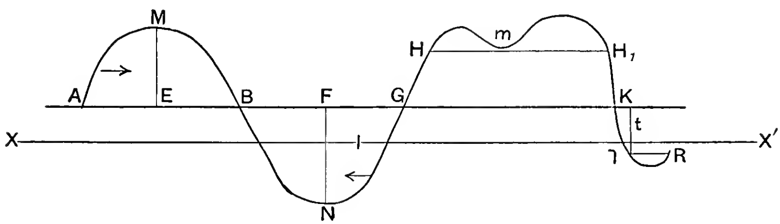


FIG. 12—BRUCKNER'S CURVE.

"(1) That each mass of cuts and fills is concentrated on its corresponding point of the longitudinal profile.

"(2) That on each cross-section only the excesses of the cuts over the fills, or vice versa, are recorded, and consequently the volume of earth transferred from cut to fill by shovel is not considered.

"Bruckner's curve possesses a number of important properties which may be summarized as follows:

"(1) The maximum and minimum of the curve correspond to the points at grade where the cut ends and the fill begins, or vice versa; thus the points M and N in the figure are points at grade.

"(2) The nature of the work is the same in the space between a maximum and a succeeding minimum, and is always cut; it is also the same between a minimum and a succeeding maximum, and is always fill. Thus in the figure the work between A and M is cut, E and F being points at grade.

"(3) The base-line detaches from the curve segments whose bases represent sections of line in which the cuts and fills are compensated. Thus the cuts equal the fills for the section of the line AB, and the common volume is represented by the line EM.

"(4) Considering any section AB in which the fills MB are made with materials taken from the cuts AM, the area of the surface AMB represents the sum of the moments of the corresponding haul (products of the volumes by the distance).

"Property No. 3 of the curve indicates a method of distributing along the axis of the construction the materials obtained from the cuts. But since this solution is possible for every line parallel to the ground-line, and each one will give a new distribution of the earth, among the infinite solutions must be selected the one which requires the minimum of transportation. In giving the line of distribution two conditions must be observed:

"(1) That the sum of the surfaces of the segment separated by this line on the curve be the minimum.

"(2) That the volume of materials taken from borrow pits or deposited on the spoil banks must not be increased.

"Several cases may occur. The curve of Bruckner ends at the ground-line, or else either above or below the ground-line. If the extreme of the curve ends at the ground-line this is the line of distribution of the masses. But if the curve of Bruckner ends above or below it, from the free end of the curve is drawn a horizontal line. Afterward are calculated the respective sums of the chords intercepted by the ground-line in the segments that increase and decrease in a plane toward the free end of the polygon; if the first sum is greater than the second, then the ground-line is the line representing the distribution of the volumes; otherwise the line is raised or lowered until the sums of the opposite segments are equal. The position of the line satisfying such a condition is the line of the distribution of the volumes; but when it is not satisfied before the free end of the curve is reached, then from this extreme is drawn a horizontal line, and this will be the line of the distribution of the masses.

"Lalanne's Curve. This is the only graphical method employed by the French engineers for calculating the distribution of the materials along the longitudinal profile of the construction as well as the mean distance of hauling. It is older than the Bruckner curve and it can be

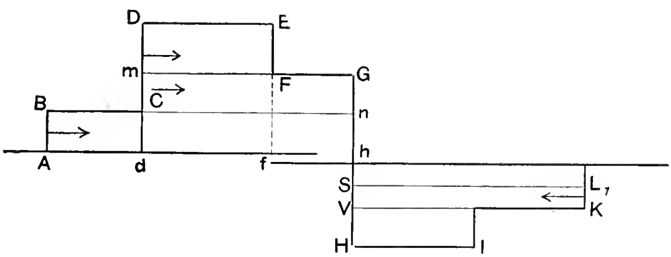


Fig. 13—Lalanne's Curve.

considered as a modification of this, notwithstanding it is simpler and is based on the same principle. Also in this case the ordinates represent the algebraic sum of the volumes of cuts and fillings, the cuts being considered as positive and the fillings as negative. The upper points of the various ordinates, instead of being connected by means of straight lines or parabolic curves, as in the Bruckner method, are connected by horizontal lines drawn parallel to the ground-line. The so-called Lalanne's curve is really composed of a series of parallelograms above or below the ground-line and it is very convenient for the location of the line of distribution and the calculation of the mean distance of hauling.

"In Fig. 13, representing Lalanne's curve as given by Daries, he says that the volume BA of the cut should be carried on the equivalent volume Nh of fillings, and the mean distance for this partial hauling is Ah. If the hauling is smaller than 90 m., barrows will be employed, otherwise the material will be transported by means of carts and wagons. Also the volume mC of cuts must fill in the equivalent volume Gn of fillings, and the partial mean distance of hauling is dh.

"When Lalanne's curve ends above the ground-line, there is an excess Ll of fillings, which is necessary to build with materials taken from borrow pits, but when the line of the curve ends on the ground-line this is the line of distribution of the volumes, and the work will then be compensated.

"The mean distance at which the materials ought to be hauled is usually calculated according to the following methods:

"(1) By the horizontal distance of the projections of the centers of gravity of the cuts and fillings.

"(2) By moments.

"(3) By Bruckner's and Lalanne's curves.

"(1) By the Projection of the Centers of Gravity. The geometrical position of the centers of gravity of the cuts and fillings can be easily deduced from the longitudinal profile and cross-sections in the following manner: On a horizontal line lay off the distances of the various cross-sections, erect perpendiculars and on these take segments representing the excess of the cut or filling in the same cross-section; the segments indicating the cuts are marked above the horizontal line, and those representing the fillings below. Unite all the points of the cuts and those of fillings, find the centers of gravity of these two figures, and the horizontal distance of their projection will represent in scale the mean distance of hauling. Only the difference between the cuts and fillings on the same sections is marked here, because the earth removed from the cut and used for filling on the same section is not removed, and consequently it is only the surplus that must be hauled away.

"The same result could be directly obtained from the graphical representation of the volumes of earthwork. By revolving the figures around the horizontal line and omitting the overlapping portions, which means to eliminate the areas of cuts and fillings compensated on the same cross-section, then the horizontal distance of the projections of the centers of gravity of the remaining areas will be the mean distance of hauling.

"The horizontal distance of the projections of the centers of gravity of the cuts and fillings, however, represents the mean distance of hauling only in case that the cuts and fillings are compensated. But when the cuts are in excess of the fillings, or vice versa, and consequently the part in excess must be deposited in the waste banks, or taken from borrow pits, the mean distance of hauling will then be given by the averages of the horizontal distance of the centers of gravity of the portions that are compensated and the horizontal distance from the projection of the centers of gravity of the excess of the cut and the spoil bank, as also for the deficiency of the fill and the borrow pit.

"(2) By Moments. The second manner of calculating the mean distance of hauling is by moments. The name is borrowed from mechanics and means in this case the quantity of volume of earthwork included within two consecutive cross-sections, multiplied by the distances to which this partial volume must be hauled. The mean distance of hauling will be obtained by the quotient of the sum of the moments of hauling, divided by the sum of the hauled volumes.

"On the application of this principle the mean distance can be correctly calculated by a very long process; but since in practical works the rapidity of a method is always preferred to great mathematical accuracy, the mean distance of the hauling is obtained from the tables already given and especially constructed in order to know the distribution of the various masses of the earth along the line of the work.

"According to the table used by the Italian engineers, the mean distance of hauling is obtained by the sum of the numbers in column 10, representing the partial products of the volumes to be removed, multiplied by the distance to which they ought to be hauled. Such a total, which in the case here considered is 94,498, must be divided by the sum of the numbers in column 8, representing the partial volumes 968. In this case the mean distance of hauling will be $\frac{94{,}498}{968} = 97$ m.

"French engineers, considering separately the hauling done by means of wheelbarrow and that done by cart and wagon, two different mean distances are obtained, the one for the barrow and the second for the cart. In both cases, however, the mean distance of hauling is given by the sum of the products of the partial volumes by their distance, divided by the sum of the partial volumes. Thus the quotient of the numbers in columns 16 and 17, 2,503 and 148,110, respectively, being 59, will represent in meters the mean distance of hauling by wheelbarrow; and the quotient of the numbers in columns 18 and 19, 2,361 and 282,934, respectively, being 205, will give the mean distance of hauling by cart and wagon.

"(3) By Bruckner and Lalanne's Curves. Both curves have been already explained at length, and consequently any further explanation will be useless. The area limited by the perimeter of the curve of Bruckner and the horizontal ground-line represents the moment of hauling of the volumes multiplied by the greatest ordinate, or the product of the volume multiplied by the mean distance; and consequently the mean distance of hauling is given by the total area divided by the greatest ordinate.

"Similarly with the Lalanne's curve. Here the heights of the parallelograms are respectively equal to the algebraic sum of the cuts and fillings, while the bases of the parallelograms represent the partial distance of hauling. In this case also the general mean distance of hauling to be used in calculations will be given by the total area divided by the greatest ordinate."

38. G. W. Kittredge, W. McNab, W. D. Taylor, H. J. Slifer, G. A. Mountain, J. G. Sullivan, C. S. Churchill, W. C. Cushing, A. S. Baldwin, G. Davis, H. McDonald, W. G. Berg, discussion on overhaul clause, "Specifications for the Formation of the Roadway," at Fourth Annual Convention, American Railway Engineering and Maintenance of Way Association, (Proceedings, Vol. 4, 1903).

Clause 53 (p. 26), as proposed by Committee on Roadway: "It is distinctly understood that the contract price per cubic yard covers any haul found necessary, and that there will be no allowance made for any so-termed 'overhaul.'"

The clause was amended (p. 34) by adding the introductory words, "unless otherwise specified."

Conclusion No. 4 (p. 32): "That profiles be made complete in regard to distribution of material, in order to obviate necessity for overhaul measurements."

The discussion on Conclusion No. 4 (pp. 66-74) follows:

The President (Mr. G. W. Kittredge, Cleveland, Cincinnati, Chicago & St. Louis):—"Conclusion No. 4 is before the Association for action."

Mr. W. McNab (Grand Trunk):—"Before this conclusion is discussed by the Association, I would like to say that it is the feeling of this Committee that it would be wise to eliminate from the specifications reference to the term 'overhaul' We have had abundant experience in the past in regard to the actual cost of the transportation of material, whether by teams or by cars, irrespective of the cost of loosening, loading and unloading. With this experience, there is no reason whatever why the profiles of a railway company cannot be got up in such shape as to show the distribution of the material desired by the company. It is not necessary to wait until getting on the ground to decide where the distribution is to be; that can be done best by a competent engineer after plotting his profile, running off his quantities and consulting his general notes. An inspection of such a profile will show the contractor very clearly what the average haul will be at any one place, and as to his methods of work—whether he is going to use drag-scrapers, wheelers, carts or wagons, steam shovels and cars operated by steam or other power—that is pretty well made up in his mind before he makes his bid. I do not think that any hardship can be inflicted upon the contractor by making use of a profile of this sort, if the proper information be put upon it. Let the information be approximate but in good shape. It will pay the railway company to have competent engineers at the work. Of course, an engineer should know primarily the requirements of his line; that is, as to how far it is going to be to its interest to use surplus material in cuts for the widening for prospective double track, or when it would be more to its advantage to waste the material. If we can eliminate this custom of overhaul from specifications, we will get rid of one of the sources of the greatest contention, annoyance and inconvenience in a grading contract. I hope there will be a good discussion on this question of overhaul."

Prof. W. D. Taylor (University of Wisconsin):—"I will make a motion that this conclusion be revised so as to put excavation on an overhaul basis.

"These specifications are drawn with the idea of doing away with any allowance for overhaul, and this idea is in line with the plan on which many construction contracts have been let; but to my mind this principle is inherently wrong. Under this system a contractor moves dirt out of a short-haul cut, which costs him, say, 12 cts. a yard, and also on the same work dirt out of a long-haul cut, but which will enable him to make so much more than a fair profit on the short-haul cut as will more than balance his loss on the long-haul cut. Now, if experience in the contract system of doing work has demonstrated any one thing to my mind clearly, it is the fact that the best incentive to get good, conscientious contract work done is to so arrange the contractor's prices that he will make a fair profit, and only a fair profit, on each unit of work done. The average contractor, who is quite a resourceful individual, will find a hundred ways how not to do that portion of the work which is a dead loss to him. He will persuade your engineer that a trestle is needed to pass the water where that fill with the long haul was intended. He will slight that work in every conceivable way till the track is about to catch him there, and in desperation the engineer orders him to borrow and waste under the full price for excavation, that is, under payment both ways. It is certain that the contractor will not do, except under great stress, that portion of the work on which he loses. The common-sense way of getting such work done to good purpose is to pay more for it when it costs more, and less when it costs less.

"Let me illustrate by two examples, which you may consider hypothetical if you wish, how this idea of 'balancing up' on contract prices works in practice. A contract was let for driving a tunnel. Though the tunnel could have been driven more economically without it, a deep shaft was sunk midway of the tunnel to hasten the work. The president of the road had given peremptory orders that the tunnel excavation price should not exceed a certain figure, since the road had never paid above that price.

It so happened that this price afforded a very large margin of profit on the excavation through the portals on this particular tunnel, but on account of the conformation, caused a loss on all excavation through the shaft. A contractor took the work at the required figure, but succeeded in extracting a big price for the shaft excavation and for the installation of the hoisting machinery, pumps, etc. Once the shaft was driven, there was almost a continual breakdown in the pneumatic pumping or hoisting plant at the shaft, and in spite of the engineer the draft forces were simply used as a reserve supply to keep the forces that worked through the portals at maximum efficiency. The excavation simply could not be taken out through the shaft at the price named, and the shaft was constructed to little purpose. The contractor simply succeeded in getting a higher price on the whole work than he was entitled to, only because the railway company was not willing to pay a reasonable profit on more costly work. Again, a road was being constructed through the suburbs of a city. A long depression was crossed on a high fill. The adjacent ground outside of the regular right-of-way afforded excellent material for borrow pits. But the landholders jumped the price of the land to a prohibitory figure as soon as they found that the railroad company wanted it. It was then arranged to make a long haul from a cut, and the cut was shown on the profile when the contract was let, at a uniform price per cubic yard, which included the haul. As soon as the work was started and the landowners saw that the railroad company was not going to allow them to hold it up, they were eager to sell their land at a reasonable figure, but the road could not profit by their change of heart because the 'no-overhaul' contract gave the contractor his turn at the hold-up business, and he was not willing to make a reasonable enough reduction in his price to save the haul, for, as usual, 'he was not making anything on the work anyway.' In nine cases out of ten a contract let on a scale of prices which will allow the contractor a reasonable profit on every unit of work will save the company money.

"I grant that there may be sections of second-track work and possibly of short extensions through well-known country, where very careful surveys have been made and the right-of-way all plotted out and surveyed beforehand, where the 'no-overhaul' contract may not be so very objectionable, for then the character of material, the regimen of the streams and the effect of the weather may be well known and the engineer can work out beforehand with some certainty the best disposition of his material, so as to show it at the time of the letting on his profiles. But I have never yet seen a heavy piece of new work in new country where the material was disposed of entirely, as shown on the profile at the time of the letting of the contract. The material always develops characteristics which require an alteration in the plans; even the state of the weather compels at times a change from the proposed disposition. In such cases it is inevitable that there will be long hauls shown on the profile which will never be made in the field, and there will be long hauls on the ground which have not been shown on the profiles. The contractor will never fail to present his 'extra' for the latter work, but I have never yet known where a reduction could successfully be made in the former case. In such cases there is no reasonable doubt but that the engineer should have flexible prices in his contract, which will enable him to pay a price affording reasonable profits on work which costs him more, and which will enable him to pay only a reasonable profit on work which costs less than was contemplated.

"I think that the absence of the overhaul clauses from so many construction contracts is due to the fact that this kind of construction work formerly fell so largely in the hands of uneducated engineers, who doubted their own ability to accurately calculate overhaul. These men know from experience that the calculation of overhaul by the old 'cut-and-dried' methods was an exceedingly tedious operation, and that any two of the old engineers could rarely get the same results from the calculation of the overhaul on a heavy excavation. But I take it that such work from now on will be largely in the hands of educated engineers, and the technical schools of the country are turning out many graduates, to whom the accurate calculation of overhaul is mere child's play. I suggest to the Association that it is advisable to revise these specifications before approving them, so as to put excavation work done by contract on an overhaul basis."

Mr. H. J. Slifer (Chicago, Rock Island & Pacific) :—"If we are educating men of this character, why should they not be able to make the profiles called for and arrange for the overhaul to be carefully platted on the profile? The average contractors to-day do not depend upon this 'cut-and-dried' method. They are hiring the best engineering talent obtainable to determine their bids. These engineers are as capable of figuring the overhaul from the profile as the man who makes the original survey, and I see no reason why we should continue the old practice of paying a contractor for something he can figure out for himself."

Mr. G. A. Mountain (Canada Atlantic) :—"I second the motion, and my reason for doing it is this: No matter how carefully the profile is made and the grades laid down on it, some changes are more or less necessary. Take a grade of 40 ft. to the mile, through a cut and fill; the extreme from the beginning of the cut to the end is, say, 2,000 ft. Now, we find it necessary, say, to reduce that to a grade of 30 ft. to the mile. You add 500 ft. on each end. The work is taken on the first basis and the contractor has to do it on the second, and it seems to me there is a case for an 'extra'—in other words, a breach of contract. An overhaul clause covers that, and I think it is a safeguard in the specifications."

Mr. J. G. Sullivan (Canadian Pacific) :—"I have had fifteen years' experience in the Northwest in construction matters, and this is the first time I have heard any objection made to the 'overhaul' clause of a contract. It is said that we should know exactly what to do beforehand. What is the objection to paying for the work after it is done, when we do know what material is removed and the distance it is hauled? Did any engineer ever see a contract where we could not change the grades or alinement? When this body of engineers is ready to vote that you cannot change the line of grades, I will be ready to vote to cut out the overhaul. I contend that we are never able to figure out exactly what we are going to do, or that we shall have surveys made which will not be changed."

Mr. Slifer:—"As a practical illustration of that, I have in mind a line of railroad 85 miles in length, where, with the exception of one cut, there was no overhaul. In the course of the work there was found additional overhaul. The matter was arranged to the satisfaction of both contractors and engineers."

Mr. C. S. Churchill (Norfolk & Western):—"I think Conclusion No. 4 could be well adopted without bringing in the feature of overhaul directly. I think the clause is a good one as it stands, in order to obviate the necessity of overhaul measurements. It is the business of the engineer to avoid this as much as possible. When we later take up the question of overhaul in detail (clause 53), I see no reason for allowing it to stand; but I think this particular conclusion should be adopted as it reads. As to the overhaul clause entering into the contract, under certain conditions, I favor a long overhaul clause, about 1,600 ft. This reduces the possibility of it to a minimum, and by having it printed in the price column of a contract it is always easy to avoid using the clause in cases where we give full information, such as in double-track work, and there is no question where the material will go; so the contractor can be told, 'here is a place where you have 2,000 ft. overhaul; we want to let this practically without any overhaul allowance, and to pay only the excavation price.' Therefore, I believe Conclusion No. 4 should be adopted, but that nevertheless there be an overhaul clause in the body of the specifications, to be used under certain conditions."

Mr. Sullivan:—"I presume if this clause is carried as it stands, the Committee will tell us how we can do it. We will certainly need a school for that."

The President:—"Prof. Taylor desires that the specifications be revised so as to put excavation on an overhaul basis. That takes out Conclusion No. 4 and substitutes this motion."

Prof. Taylor:—"I will leave it to the Committee. The question is whether or not they will put excavation on an overhaul basis."

Mr. Slifer:—"The recommendation of the Committee is that profiles be made complete in regard to distribution of material, in order to obviate the necessity for overhaul measurements. We do not say there shall be no overhaul measurements. We want the engineers to make their profiles complete and avoid overhaul."

Prof. Taylor:—"How can you make profiles complete when you cannot tell what the condition of the weather is to be? You may lay out an embankment one day, and when you come to build it you cannot do it on account of difficulties which exist and which were not noticeable before. Water may cover the ground where borrow pits were intended."

The President:—"Your amendment is that Conclusion No. 4 shall be amended, and a conclusion as written by you shall take its place. This is out of order. The amendment to the conclusion of the Committee, as given by Professor Taylor, is that the specifications be revised so as to put excavation on an overhaul basis."

Prof. Taylor:—"The Committee has drawn up specifications, not allowing excavation work on an overhaul basis. I think, and I think a majority of the members of this convention believe, it ought to be permitted to put it on an overhaul basis My motion not only includes the objection in regard to Conclusion No. 4, but requires the specifications themselves to be revised so as to put in the overhaul clause."

Mr. W. C. Cushing (Pennsylvania Lines):—"There are two classes of engineers in this convention—one class of engineers who have mostly to deal with existing lines; the other class of engineers have to deal mostly with new construction in undeveloped country. The class of engineers who deal with existing lines have done away with overhaul matters entirely. They never think of it. When there is a piece of work to be done, it is an easy matter for the contractor to go and visit the work, and with the profiles that are made it is quite feasible for him to get an accurate knowledge of exactly what is to be done, and he makes his bid accordingly. It is that condition which has also led engineers who deal with existing lines to abolish the classification of material. Material, unless it is half and half of different kinds, generally is taken under contract on the basis of the kind which is in excess, or in large majority, and these points have to be borne in mind by all of us in discussing these matters. There may be good reasons for those engineers who are constructing new lines in undeveloped country, where it is difficult for the contractor to view the work beforehand, to have an overhaul clause, and whose specifications should be such as to include that feature and make allowance for it where it is necessary. It is useless work for those engineers who do not have to deal with this condition to consider it at all. It is not unfair to the contractor. He has as good opportunity as anyone could have of judging in advance what his work is to be."

Mr. A. S. Baldwin (Illinois Central):—"I move the following as an amendment: 'That profiles be made as complete as possible, in regard to distribution of material, in order to obviate, where practicable, necessity for overhaul measurements.'"

Mr. McNab:—"Does not that expression, 'where practicable,' open the door too much for a difference in opinion, with its consequences?"

Mr. Mountain:—"I ask if any engineers doing new work know of any profiles which were made complete; in other words, that have not been changed during construction? If so, this clause is all right. If not, it is impossible to put it into use. Every engineer knows how difficult it is to put the proper gradients on profiles. The location is changed, which varies the classification, and if it does not, it varies the overhaul, and profiles cannot be made complete in regard to distribution of material."

Mr. Cushing:—"I do not believe that engineers who are engaged entirely in new construction can object to the desirability of being able to comply with what the Committee recommends, if it is possible to do so. It stands there as a desirable thing to do, where possible. It avoids work and confusion in the construction of new lines, and it is possible for such a condition to exist, where the line is passing through a rolling country, that the cuts and fills are to be made approximately equal and follow each other in regular order. I have seen a good deal of such country, where it was not a question as to how the material was to be moved—the natural thing to do was to move it into adjacent fills, and no overhaul measurement is necessary in work of that kind. That is a desirable condition of affairs, if it can be carried out. The matter of putting in an overhaul clause is entirely a special consideration, to be determined by conditions. I cannot see anything objectionable, even from the standpoint of those engineers of whom I speak, in admitting a recommendation of this kind as given in the report of the Committee."

Mr. Sullivan:—"I dislike to take up the time of the convention, but this matter of roadway construction is a subject in which I am very much interested. In answer to Mr. Cushing, I will say that these specifications are very good in a general way, and they just apply to us ignorant fellows who are out West and take up these specifications and read them very carefully. Mr. Cushing says, 'take them; they are good enough, and put in anything special you want to.' We do not do that. But you men in charge of maintenance of way, every time you write a contract, you have a special case. All your work is 'special,' and our work is general. Why not make these specifications for the men who will take them literally? These specifications will be copied by thousands of young men who are starting out as engineers on small branches, who are building roads, and they are the engineers who should be helped out. I believe Mr. Cushing will admit that he must write a special contract for everything he does—the conditions are so different. These specifications cover all work in general; not only new work."

Mr. Slifer:—"I think as a young engineer I had more experience on the subject of overhaul than any other on construction of new lines and improvement of old lines where overhaul was not allowed. It is perfectly practicable to make a profile that will avoid any question of overhaul payment."

Mr. Garrett Davis (Chicago, Rock Island & Pacific):—"You will notice in paragraph 53 that it was the intention of the Committee to cut out pay for overhaul. This is shown in the body of the specifications. I understand the Committee to mean the profile shall be made to show the overhaul, so that a flat rate shall be made to cover it. My opinion is that you will pay a little more for your work. I do not believe the contractor will bid as close where he bids a flat rate, including overhaul, as he will if the overhaul is put in separately."

The President:—"We are not discussing the question as to whether or not overhaul shall be put into specifications. We are so pressed for time that I must ask the members to confine their discussion to the question before them. Later, when we come to the discussion of the overhaul, we can find out whether it is a good thing to put in or not."

Mr. Slifer:—"If this conclusion be adopted, it will not affect the question of overhaul."

(The question was then put on Mr. Baldwin's amendment, which was lost.)

The President:—"The question will now be on the adoption of conclusion No. 4 as reported by the Committee."

(Conclusion No. 4, as reported by the Committee, was adopted.)

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis—by letter):—(Suggested substitute for clause proposed by Committee, p. 115.) "The price paid for excavation includes the cost of loosening, loading and transporting a maximum distance of seven hundred (700) ft., unloading and spreading the material. Where material is required by the engineer to be hauled more than seven hundred (700) ft., the additional price per cubic yard, measured in place, per one hundred (100) ft. haul, in one direction only, provided in the contract, shall be paid the contractor. Fractions of one hundred (100) ft. shall be counted as one hundred (100) ft. The length of overhaul shall be computed between centers of mass of excavations and embankments, measuring along the line of haul. This maximum haul applies only to the transportation of material by man and horse-power. Where it appears expedient to use other motive power for transporting material, a special agreement will be entered into as to the length of haul. This clause does not apply to tunnel excavation."

Mr. Walter G. Berg (Lehigh Valley—by letter, pp. 118-126):—"In the discussion of the report on Roadway at the convention the question of 'overhaul' received considerable attention. The Committee's recommendation was adopted, viz., to exclude overhaul payments. I consider that this sweeping decision was a mistake. We must admit that there are different governing conditions in letting work, and we should recognize same in determining this question of overhaul.

"Personally, I would congratulate any engineer who is able to let a contract without the overhaul provision, and there are conditions where this can be done with perfect equity to both parties to the contract. There are other cases, however, where one of the parties is liable to lose money unless the overhaul clause is retained.

"In grading operations in sections of the country where the railroad work is usually let to a well-known contractor and where the work has been carefully surveyed and mapped, it is perfectly feasible to expect the contractor to draw his own conclusions as to the extra cost involved in long hauls and to place upon the contractor the responsibility of conducting his operations according to his own plans relative to the method of distributing the material. Where the route is well mapped it is also feasible for the engineer to indicate on the profile the proposed distribution of the material. In such case it is not necessary to provide for overhaul payments. This is particularly the case in track-widening operations.

"Where, however, work is let on the basis of preliminary profiles, frequently even on traverse lines approximating the final location only, it is not feasible nor economical to throw on the contractor the burden of guessing at the probable haul. The railroad company will profit by inserting a properly worded overhaul clause.

"I consider, therefore, that paragraph 53 of the proposed specifications should have added to it the words 'unless otherwise distinctly specified.' These specifications should then have a supplemental clause relating to overhaul, and it should be stated that this should be considered as a special clause for use where it is desired or found necessary to have an overhaul allowance. The standard specifications indorsed by the Association would then indicate that the preferable course would be to omit overhaul, but would still offer a standard overhaul clause for use in such cases where the special conditions made it essential to arrange for overhaul.

"In the discussion at the convention one of the members emphasized that the calculation of overhaul was a very simple matter and that any engineering student while at college was taught how to calculate same. I admit that the actual determination of overhaul is based on very elementary arithmetical calculations, but I doubt whether one out of ten professors of engineering, unless he has actually had charge of heavy grading operations, would be prepared offhand to define the best method of recording all the varied movements of the actual material distribution and to explain intelligently the difference between average haul of the whole section, total haul, overhaul, free straight haul, free average haul, and whether cross-haul, or hauls to waste or from borrows should be allowed. In fact, very few engineers even know that there is a difference in dollars and cents whether the free haul is a free straight haul or a free average haul. Even the otherwise very clear substitute clause proposed by by Mr. Hunter McDonald relating to overhaul does not distinctly define this feature.

"In the issue of the Railroad Gazette of January 11th, 1884 (Ref. No. 11 in this review), I published an article on the determination of overhaul and a graphical profile method for recording the various movements of the material during the progress of the work, the method being such as to enable the engineer to plot monthly, as part of the monthly estimate, the actual material distribution and cover all the various freaks of material movements, such as working cuts in several lifts, filling embankments in sections or layers, wasting material, location and haul from borrow pits.

"In the actual determination of overhaul there are three methods, as follows:

"(1) All cuts of the section are taken into account, the average haul of each individual mass determined and the average total haul established accordingly. The free haul is deducted from the average total haul and the balance represents the overhaul applicable to the total yardage of excavation of the section. This method is called the free average haul applicable to all excavation of the section.

"(2) All cuts the material from which is disposed of within the free-haul limit are left out of consideration entirely. All other cuts from which the material, or at least some of the material, is hauled beyond the free-haul limit are taken into account, the average haul of each individual mass of same determined and the average total haul established accordingly. The free haul is deducted from the average total haul and the balance represents the overhaul applicable to the total yardage of excavation of such cuts only from which the material or some of the material is hauled beyond the free limit. This method is called the free average haul applicable, however, only to cuts with overhauls.

"(3) All cuts the material from which is disposed of within the free-haul limit are left out of consideration entirely. At all other cuts the material in the cut required to balance the material in the nearest fill or fills, is determined within the free-haul limit; in other words, a strip equal to the free-haul limit is cut out of the profile in such a way that the cut balances the fill within the length of this strip. This balanced material within the free-haul strip is not taken into account. All other material that is clearly hauled more than the free-haul limit is taken into account, the average haul of each individual mass determined and the average total haul established accordingly. The free haul is deducted from the average total haul and the balance represents the overhaul applicable to the total yardage of such parts of cuts which are hauled beyond the free limit. This method is called the free straight haul, as it eliminates consideration of absolutely all material that is hauled less than the free limit.

"The first method is the logical result of carrying out the general principles of determining overhaul as taught in most colleges. In practice it means determining the haul of all material moved, even where, as in side-hill work, the material for long stretches is simply cast sideways. It will lower the average overhaul of the section, however, as all material, even if moved only a short distance, figures in the calculation. It is not a fair method, nor one readily understood by contractors.

"The second method is probably the one most in use. It is, however, illogical. Why should material hauled less than the free limit be thrown out if in a small cut that is worked into a nearby fill, and yet other material hauled less than the free limit be considered simply because it forms a part of a large cut, the balance of which is handled beyond the free limit? The extended use of this method can be traced to the greater ease with which the overhaul can be calculated. All cuts with short hauls are simply marked off the profile and the calculation of centers of gravity made only for all other cuts in their entirety.

"The third method is the only one which is logical and corresponds to the specification clause as usually written, i. e., that all material shall be hauled up to a certain distance free. It is more laborious for the engineer, as the material at the entrance to all cuts, from which some material goes beyond the free-haul limit, has to be balanced with the fill within a distance equal to the free haul.

"The fundamental arithmetical principle of overhaul calculations is very simple, but the application of same to all the varied conditions on actual construction work is complicated by many questions. Any proposed overhaul clause in specifications must be very clearly worded accordingly.

"Is the haul to be calculated for all material on the section; is the haul to be calculated only for such cuts from which all or some of the material is hauled beyond the free limit, but the thus ascertained overhaul to be applicable to all the material in such cuts; or is the haul to be calculated only for material actually moved beyond the free-haul limit; is the distribution of material to be based on a theoretical scheme worked out on the profile or on the actual conditions; will cross-haul be allowed, i. e., when material from a small cut is necessarily hauled to a fill in the direction of a big cut and subsequently material is hauled in the opposite direction from the big cut over the fill and small cuts to another fill beyond the small cut; will overhaul be paid on borrow or waste, and in such case is the haul to be figured from stations of the center line, or from the air line, or from the actual route traveled from cut to waste bank and borrow pit to fill? If the natural method for moving the material or the preliminary scheme worked out on the profile has to be departed from in order to expedite the completion of the work, or owing to influences outside of the control of the contractor, such as bridges not being completed over which the contractor has to haul material, will the company take into account the increased cost of haul, if any, to the contractor, or will the engineer insist on following out the preliminary profile scheme?

"The above are not academic theoretical points, but questions that come up constantly in practice. They should all be well understood and defined, especially considering the importance and money value of overhaul. Most preliminary estimates disregard overhaul, and large sums have to subsequently be paid, causing estimates to overrun and casting discredit on engineers generally.

"As an illustration of the money values involved, I have taken an 8,000-ft. long section of grading work and determined the overhaul for the three methods mentioned above, on the basis of 1,000 ft. free-haul and 1 ct. overhaul rate per cu. yd. and 100 ft. overhaul. The first method gave 1,150 ft. overhaul on 101,000 cu. yds., or $11,615.00; the second method, 1,800 ft. overhaul on 73,000 cu. yds., or $13,140.00; the third method 2,600 ft. overhaul on 66,000 cu. yds., or $13,596.00. Truly, with such large payments and wide variation of results, it does not seem out of place to devote a chapter in place of a paragraph to overhaul determination in our engineering text-books. Further, we have men spending days working out carefully yardages and various quantities and yet when it comes to overhaul the office methods are usually very inaccurate and based on theoretical in place of practical premises.

"To illustrate the wide fluctuations in the material distributed as originally estimated and as actually carried out, I will quote the results of an investigation I made with the same 8,000-ft. section above referred to. The original center line profile estimate, based on center heights, showed a material distribution of excavation 103,000 cu. yds., of which 2,000 yds. were waste. The final profile after cross-sectioning, the distribution being made by the engineer familiar with the conditions—in other words, on a practical basis as far as feasible ahead of actual construction—showed excavation 108,000 cu. yds. and 10,000 borrow, or 118,000 cu. yds. to be handled. In actual construction the program had to be varied, as one bridge did not get done in time for the grading contractor to haul over same, and the results were excavation 108,000 cu. yds., borrow 41,500, or a total of 149,500 cu. yds., to be handled, of which 31,500 cu. yds. were wasted. The fluctuations in overhaul, if it had been determined, would be equally astonishing, and would vary within wide ranges according to the method adopted for ascertaining same.

"I present herewith two diagrams, A and B, Fig. 14, illustrating the difference between free straight haul and free average haul as applied to a cut and fill aggregating 4,000 ft. long and in each case 25,000 cu. yds. being handled. In both cases the free straight haul proves more favorable for the contractor. I have generally found this to be true, as stated by me in the article referred to above, published nearly 20 years ago.

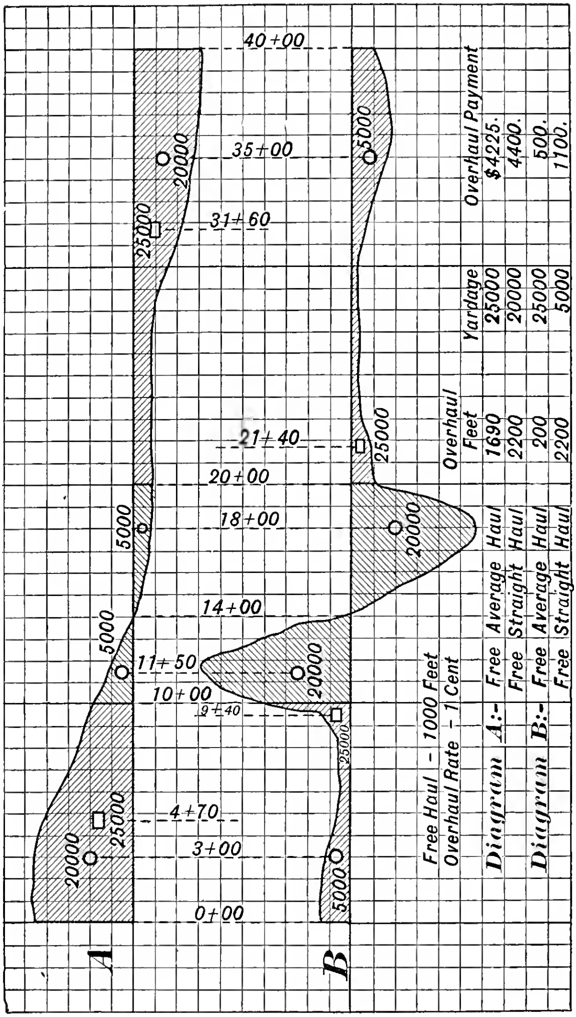
"The above figures and arguments certainly indicate the importance of a more careful study of overhaul questions, and consequently the necessity for a very carefully considered wording of the overhaul clause. It is also further apparent that a contract let on the basis of a preliminary center line profile without an overhaul clause would be largely guesswork on the part of a contractor, and the railroad company would in the end have to foot the bill.

"I consider, therefore, that the standard recommended specifications should uphold the feature that it is desirable not to have overhaul, but that there should be an alternate clause adopted for use under such conditions that render an overhaul provision absolutely necessary.

"In regard to the overhaul rate and limits, I believe in having, so to say, a sliding scale, i. e., several limits and rates. Thus, in general, the free limit should correspond to the ordinary economical limits of cart or scraper work; the next division would correspond to the economical haul limits with horses and tram cars, while the third limit would apply to engine service, with a special clause for long engine hauls. I also believe that a comparatively low free limit is better for the railroad company than a high free limit."

Mr. McNab (replying to Mr. Berg's written communication):—"An amendment to the Committee's wording of the recommendation was adopted, viz., the addition of the words 'unless otherwise specified,' and it is the purpose of the Committee to report further on when such cases may be actually necessary.

"Originally, it was the Committee's idea that so-termed 'overhaul'



		Overhaul Feet	Yardage	Overhaul Payment
Diagram A:-	Free Average Haul	1690	25000	$4225.
	Free Straight Haul	2200	20000	4400.
Diagram B:-	Free Average Haul	200	25000	500.
	Free Straight Haul	2200	5000	1100.

Fig. 14.

should be done away with in ordinary railway construction. There is no doubt but that facts, figures and plans can be so prepared as to generally obviate the necessity for a condition that too frequently exists today; and the special instances where a graduated scale for overhaul would be mutually advantageous in every degree to the contractor and the railway company appear to be very limited in number.

"Letting of work on the basis of preliminary surveys is a custom which should generally be avoided, for it is an invitation to slipshod methods on the part of the railway officers, as well as the contractor.

"A forcible argument against overhaul is given in Mr. Berg's discussion, when he quotes the small percentage of technical or practical engineers who appreciate all the conditions that exist in regard to overhaul. Yet the engineer in charge of the work may be a young man who has not had the opportunity to fully realize the exact niceties that are required, if the estimates are to be equitable allowances for work performed.

"Special cases where a graduated scale would be mutually advantageous could be covered by special figures in the judgment of the engineer, and it is the desire of the Committee that this feature be not settled before further discussion is obtained."

II. ABSTRACT OF CURRENT PRACTICE OF ASSOCIATION MEMBERS.

The Committee on Roadway, at its meeting held on December 12, requested the Secretary to issue a circular to the members of the Association, with postal card for response in brief as to practice followed or preferred in the treatment of overhaul. The following circular of inquiry, with reply card, was issued by the Secretary under date of December 27, 1905:

"The Committee on Roadway desires an expression from you as to your practice relative to paying for overhaul; your usual limit of free haul, and your method of computing overhaul.

"Please indicate on the enclosed blank which of the following methods, described by Mr. Walter G. Berg in Vol. 4 of the Proceedings for 1903, pp. 118-124, you prefer:

"(A) All cuts of the section are taken into account, the average haul of each individual mass determined and the average total haul established accordingly. The free haul is deducted from the total average haul, and the balance represents the overhaul applicable to the total yardage of excavation of the section. This method is called the free average haul applicable to all excavation of the section.

"(B) All cuts the material from which is disposed of within the free-haul limit are left out of consideration entirely. All other cuts from which the material, or at least some of the material, is hauled beyond the free-haul limit are taken into account, the average haul of each individual mass of same determined and the average total haul established accordingly. The free haul is deducted from the average total haul, and the balance represents the overhaul applicable to the total yardage of excavation of such cuts only from which the material or some of the material is hauled beyond the free limit. This method is called the free average haul, applicable, however, only to cuts with overhauls.

"(C) All cuts the material from which is disposed of within the free-haul limit are left out of consideration entirely. At all other cuts the material in the cut required to balance the material in the nearest fill or fills is determined within the free-haul limit; in other words, a strip equal to the free-haul limit is cut out of the profile in such a way that the cut balances the fill within the length of this strip. This balanced material within the free-haul strip is not taken into account. All other material that is clearly hauled more than the free-haul limit is taken into account, the average haul of each individual mass determined and the average total haul established accordingly. The free haul is deducted from the average total haul, and the balance represents the overhaul applicable to the total yardage of such parts of cuts which are hauled beyond the free limit. This method is called the free straight haul, as it eliminates consideration of absolutely all material that is hauled less than the free limit."

(Postal Card for Reply to Circular.)

NAME OF RAILWAY..

(1) What is your practice relative to paying for overhaul—Do you pay for it?..

(2) What is your usual limit of free haul?..........................

(3) Which of the following methods of computing overhaul do you use? (Note Mr. Walter G. Berg's discussion, Am. Ry. Eng. & M. W. Assn. Proceedings, Vol. 4, 1903, pp. 118-124. Draw circle around letter of paragraph describing method used.)

(A)—

(B)—

(C)—

(D)—Describe any other methods used..............................

....

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....

Replies were received from 124 different members of the Association, connected with some 75 different roads. The replies in part represented the practice of the particular roads with which the members are connected, and in part are the personal views of those sending in the cards. A tabulated digest is given in the following section, Reference "A," and the results of the canvass are stated in brief form in a note at the foot of the table.

The discussion of the circular by those responding to the inquiries is given after the tabulated digest (Reference "B"), the numerals corresponding to those used in the table "A." Unsigned replies have been omitted in "B."

An index to the names of all those whose statements or writings are quoted or referred to in this review is given on the pages preceding this report.

A. DIGEST OF REPLIES TO CIRCULAR OF INQUIRY RELATING TO PRACTICE OR PREFERENCE IN COMPUTING AND PAYING FOR OVERHAUL.

	Railway	Name and Title	See Card 1	2	3
(1)	Atl. & Birmingham	A. Bonnyman, Ch. Eng	Yes	600	B
(2)	Ala. Gt. Sou	J. C. Nelson, Div. Eng	No*		
(3)	Ann Arbor	O. D. Richards, Ch. Eng	*	500	C
(4)	A. T. & S. F.	Jas. Dun, Chf. Eng. System	*	200 / 500	B
(5)	A. T. & S. F.	W. B. Storey, Jr., Ch. Eng	Yes	500	C
(6)	A. T. & S. F.	F. M. Bisbee, Div. Eng.	Yes	500	B
(7)	A. T. & S. F. Coast Lines.		Yes	500	C*
(8)	Baltimore & Ohio	T. Fitzgerald, Gen. Mgr	No*		
(9)	Baltimore & Ohio	D. D. Carothers, Ch. Eng	No*		
(10)	Baltimore & Ohio	H. E. Hale, Eng. M W	No*		
(11)	Baltimore & Ohio	H. R. Talcott, Eng. Surveys	No*		
(12)	Baltimore & Ohio	O. Rickert, Div. Eng	No*		
(13)	Baltimore & Ohio	John Ware, Div. Eng	No*		
(14)	Baltimore & Ohio	J. B. Jenkins, Asst. Eng.	No*		
(15)	Baltimore & Ohio		No*		
(16)	B. & O. S. W.	E. Stimson, Eng. M. W.	No		
(17)	Bessemer & L. E.	H. T. Porter, Ch. Eng	No		*
(18)	Boston & Maine	H. Bissell, Ch. Eng	*		
(19)	Buff. & Susq.	H. C. Landon, Eng. M. W.	Yes	500	A
(20)	Canadian Pacific	W. A. James, Div. Eng.	Yes	500	C*
(21)	Central of Ga.	J. C. Gray, Asst. Eng	Yes*	1000	B
(22)	Cent. of N. J.	W. G. Besler, Gen. Mgr	*	200 / 1000	D
(23)	Cent. of N. J	J. O. Osgood, Ch. Eng	*	200 / 1000	D
(24)	Ches. & Ohio	H. Pierce, Eng. of Con	Yes	1000	C
(25)	C. & E. I.	W. S. Dawley, Ch. Eng	Yes*	500	C
(26)	C. & E. I.	R. McCalman, Div. Eng	Yes	500	C
(27)	C. & N. W.	C. S. Hall, Eng. Trk. Elev	Yes	1000	*
(28)	C. B. & Q.	T. E. Calvert, Ch. Eng.	Yes	500	C
(29)	C. B. & Q.	G. H. Bremner, Eng. M. W.	Yes*	500	B
(30)	C. B. & Q.	L. F. Goodale, Eng. M. W.	Yes	500	C
(31)	C. B. & Q.	A. W. Newton, Div. Eng	Yes*	500	A
(32)	C. B. & Q.	E. P. Weatherly, Res. Eng	*	500	C
(33)	Chicago Jc.		Yes	500	C
(34)	C. R. I. & P.	J. B. Berry, Ch. Eng	Yes*	500 / 1200	C
(35)	C. R. I. & P.	A. K. Shurtleff, Office Eng.	Yes*	500 / 1000	C
(36)	C. N. O. & T. P.	H. M. Waite, Supt.	Yes	500	B
(37)	C. N. O. & T. P.		Yes	500	C
(38)	C. C. C. & St. L.	O. E. Selby, Bridge Eng	No		*
(39)	Detroit & Mackinac	H. S. Waterman, Ch Eng.	*		
(40)	Duluth, M. & N.	W. A. McGonagle, 1st V. P.	Yes	1000	C
(41)	Duluth, S. S. & A	V. D. Simar, Prin. Asst. Eng.	Yes	1000	C
(42)	E. J. & E.		Yes	1000	C
(43)	El Paso & S. W.	H. J. Simmons, Gen. Man	Yes	200	A
(44)	Erie	F. L. Stuart, Ch. Eng.	No		*
(45)	Erie	C. H. Moore, Eng. Gr. Cr.	No		
(46)	Frank. & Clearfield	F. E. Bissell, 1st Asst. Eng.	Yes	1000	C
(47)	Gila Valley, G. & N.	C. C. Mallard, Supt	Yes	400	C
(48)	Grand Trunk	E. H. Fitzhugh, 3rd V. P.	No*		
(49)	Grand Trunk	F. H. McGuigan, 4th V. P.	No		
(50)	Grand Trunk Pac.	A. C. Dennis, Div. Eng	Yes	500	C
(51)	Grand Trunk Pac.	K. J. C. Zinck, Asst. Eng	Yes	500	B
(52)	Grand Trunk Pac.		Yes		C
(53)	Halifax & South W.	L. H. Wheaton, Ch. Eng	Yes	500	C
(54)	Illinois Central		No		
(55)	Illinois Central		No		
(56)	Indianapolis So.	R. S. Blinn, Asst. Eng	Yes	500	C
(57)	Kansas City Belt	G. M. Walker, Jr., Asst. Eng	No*		
(58)	K. C. M. & O.	M. P. Paret, Ch. Eng	Yes	500	B
(59)	Kansas City So.		Yes	200 / 500	C
(60)	L. S. & M. S	Samuel Rockwell, Ch. Eng	Yes	100	C
(61)	Lake Sup. & Ishp	R. C. Young, Ch. Eng	Yes	1000*	C
(62)	Lehigh Valley	W. G. Berg, Ch. Eng	No*		
(63)	L. & N.	W. H. Courtenay, Ch. Eng	Yes*	500	B
(64)	L. & N.	J. F. Burns, Roadmaster	Yes*	500	B

DIGEST OF REPLIES—CONTINUED.

	Railway	Name and Title	See Card 1	See Card 2	See Card 3
(65)	Mexican Central	Lewis Kingman, Ch. Eng	Yes*	250m (820)	D
(66)	Mexican International	Rankin Johnson, Asst. Ch. Eng	Yes*	150m (493)	D
(67)	Michigan Central		Yes	600	B
(68)	Midland Valley		Yes	500	B
(69)	Minn. & Rainy River		Yes	300	B
(70)	Minn. & St. L	H. G. Kelley, Ch. Eng	Yes	500	B
(71)	Mo., Kan. & Tex	S. B. Fisher, Ch. Eng	Yes*	300	D
(72)	Mo. Pac	H. Rohwer, Cons. Eng	Yes	200	B
(73)	N. C. & St. L	J. W. Thomas, Jr., Prest. & Gen. Man.	Yes	700	C
(74)	N. C. & St. L	Hunter McDonald, Ch. Eng	Yes	700	C
(75)	N. C. & St. L	I. O. Walker, Asst. Eng	Yes	700	C
(76)	New Orleans & N. E		No		
(77)	New Orleans Term	F. G. Jonah, Ter. Eng	Yes*	300	
(78)	N. Y. N. H & H	E H. McHenry, 4th V. P	Yes	500	C
(79)	N. Y. O. & W	C. E. Knickerbocker, Eng. M. W	Yes	1000	B
(80)	Norfolk & Southern	F. L. Nicholson, Eng. M. of W	No*	1000	B
(81)	Norfolk & Western	C. S. Churchill, Ch. Eng	No*	1600	C
(82)	No. Ill. Elect. Ry	A. M. Shaw, Ch. Eng	Yes	500	C
(83)	Ohio River & Col	Geo. C. Millett, Gen. Supt	Yes	400	C
(84)	Oregon Short Line		Yes	500	C
(85)	Pacific	C. H. Byers, Asst. Eng	Yes	1000	C
(86)	Penna. Lines W. of P.	Thos. Rodd, Ch. Eng	No*		
(87)	Penna. Lines, S. W. Sys.	W. C. Cushing, Ch. Eng. M. W	No		
(88)	Penna. Lines, N. W. Sys.	R. Trimble, Ch. Eng. M. W	No*		
(89)	Penna. Lines, N. W. Sys.	E. G. Ericson, Prin. Asst. Eng	No*		
(90)	Pennsylvania	Joseph T. Richards, Ch. Eng. M. W.	No*		
(91)	Peoria & Pekin Union			500	C
(92)	Phila. & Read	W. Hunter, Ch. Eng	No		
(93)	Phila. & Read	F. S. Stevens, Supt.	No		
(94)	Phila. & Read	J. E. Turk, Supt	No*		
(95)	St. L. & San F	J. F. Hinckley, Ch. Eng	No		C*
(96)	St. L. & San F	John V. Hanna, Asst. Eng. M. of W.	Yes	200	B
(97)	St. L & San F		Yes	200	B
(98)	San F. & N. W	H. C. Phillips, Ch. Eng	Yes	400	C
(99)	S. F. P. & P	W. A. Drake	Yes	100	C
(100)	Southern	C. H. Ackert, 4th V. P	Yes	1000	C
(101)	Southern		Yes	1000	A
(102)	Southern Pac	E. B. Cushing, Gen. Supt	Yes	400*	C
(103)	Spokane Internat	J. H. Abbott, Br. Eng	Yes		C
(104)	Spokane Internat		Yes	600	C
(105)	Texas Midland	L. W. Wells, Ch. Eng	Yes	500	C
(106)	Tidewater Deepwater	H. Fernstrom, Ch. Eng	Yes	1500	C
(107)	Trans-Continental	D. MacPherson, Asst. Ch. Eng	Yes*		
(108)	Union (Memphis)	H. G. Fleming, Prest	Yes	500	C
(109)	Union (Pittsburgh)	E. C. Brown, Eng. M. of W	No*		C
(110)	Union Pac	J. C. Beye, Res. Eng	Yes	500 1000	C
(111)	Vandalia	F. T. Hatch, Ch. Eng.	No		
(112)	Vandalia		No		
(113)	Wabash		No		
(114)	Wis. & Mich	B. C. Gowen, Ch. Eng	Yes	1000	C
(115)	Wisconsin Cent		No*		
(116)		A. L. Bowman, Con. Eng	Yes	1000	C
(117)		W. M. Camp, Editor			B
(118)		O. Chanute, Con. Eng			
(119)		John H. Fine, Cons. Eng	Yes	800	C
(120)		W. B. Hanlon, Con. Eng	*	1000	C
(121)		C. Lewis, Civil Eng			C
(122)		Robt. Moore, Con. Eng	Yes*	300	
(123)		F. W. Ranno.	No*	500	B
(124)		G. H. Scribner, Jr., Contract. Eng			C

Summary of Replies: No overhaul allowed by 37. Overhaul allowed by 73; of the latter, 4 prefer Method "A;" 21, Method "B;" 54, Method "C;" and 4 other Methods. Length of free haul: 32 prefer 500 ft.; 16, 1,000 ft.; 4, 400 ft.; 4, 300 ft.; 3, 700 ft.; 3, 600 ft.; 3, 200 ft.; 2, 100 ft.; 2, 200-500 ft.; 2, 200-1,000 ft.; 2, 500-1,000 ft.; one each, 150 meters, 250 meters, 800 ft., 1,500 ft., and 500-1,200 ft.

B. DISCUSSION OF OVERHAUL IN REPLY TO CIRCULAR.

(The figures prefixed to names correspond to those in the foregoing tabulated abstract "A.")

(1) A. Bonnyman (Atlantic & Birmingham):—"We conform to a great extent to the recommendations of the American Railway Engineering and Maintenance of Way Association. Probably the greatest change is in our overhaul clause. We have been working for several months with these specifications and have found them very satisfactory to the company and have had very little complaint from the contractors. I believe that the following would be a better overhaul clause than that in our specifications:

" 'The price paid for excavations includes the cost of loosening, loading and transporting a maximum distance between center of mass of cut and center of mass of embankment of 600 ft., unloading and spreading the material. Where the material is required by the engineer to be hauled more than 600 ft. between the center of mass of excavation and of embankment, the additional price per cubic yard, measured in place, per 100 ft. haul, in one direction only, provided in the contract, shall be paid the contractor and shall be measured along line of haul. In computing overhaul, the free haul of 600 ft. is deducted from the average total haul, and the balance represents overhaul applicable to the total yardage of excavation of such cuts only from which material or some of the material is hauled beyond the free limit. This maximum haul applies only to the transportation of material by man and horse power; where it appears expedient to use other motive power for transporting material, a special agreement will be entered into as to the length of haul. This clause does not apply to tunnel excavation.' "

(2) J. C. Nelson (Alabama Great Southern):—"Have long since cut out overhaul."

(3) O. D. Richards (Ann Arbor):—"Do not pay for overhaul if can make other arrangements."

(4) James Dun (Santa Fe System):—"I hand you herewith copy of our specifications where haul is paid for. The distance of overhaul is usually from 200 to 500 ft."

" '(Section 7) HAUL. All material from excavations which can be deposited in embankments within......hundred (.........) feet shall be paid for one way only, and without haul. When embankments are required to be made from borrow-pits, no haul shall be allowed when the outer edge of the borrow pits is less than ...... hundred (........) feet from the foot of the slope of the embankment. All material required to be taken from borrow pits, more than......hundred (........) feet from the bottom of the slope of the embankment shall be paid for as 'embankment borrowed,' and haul shall be allowed at the contract rate and for the distance hauled, measured in a direct line at right angles to center line of road, less......(.........) ft. When earth is wasted in spoil banks from excavations, on top or alongside of said excavations, rules similar to the above will apply. The distance of paid haul shall be determined by computing the distance between centers of bulk and deducting......(.........) ft. therefrom.

"'Whenever by written direction of the Chief Engineer of the Company earth from excavations is hauled any required distance into embankments, the material shall be paid for in excavation only and at the price of 'earth excavation hauled,' and the haul shall be allowed for the full distance, in a direct line from the place where the earth is taken out to the place where it is deposited, less...... (........) ft.

"'Where no written instructions are given by the Chief Engineer of the Company, the estimates of quantities and of haul of earth will be made in accordance with the latter clause of section 13 of these specifications, and the extreme haul will be such a distance that the contract price for excavation hauled, plus the haul of earth from where taken to where deposited, shall equal the price of excavation wasted plus embankment borrowed.

"'All rules relative to haul of earth will apply with equal force to haul of loose or solid rock.

"'(Section 13) ESTIMATES. On that part of the work where material from the excavation is to be put into the embankments, excavations or embankments only will be estimated, the quantity in excess being paid for. On that part of the work where material is wasted and borrowed, estimates will include both excavation and embankment, subject to the provisions of section seven (7) of these specifications.

"'Excavations may be wasted and embankments borrowed, except in cases where the Chief Engineer of the Company shall direct that excavations be hauled into embankments; but where material is hauled from excavation to embankment, it shall only be measured and estimated in the excavation.

"'In all cases the work will be estimated so as to make the least cost; that is, if necessary, earth from excavations will be estimated as having been hauled regardless of the fact that the contractor may have preferred to waste the material from the cuts and borrowed the material for the fills.'

"I also hand you herewith copy of our specifications where no haul is paid for. In place of haul there is a price paid for embankment:

"'(Section 7) HAUL. No haul will be allowed in estimates under these specifications, the price paid for embankment being understood not only to cover the expense of borrowing material for same, but also for hauling material from excavations to and into the embankments.'

"In heavy work frequently large cuts are encountered, which could not be hauled into the embankment except by track being laid and steam shovel and cars used, and the borrow and waste contract is much to be preferred for that class of work. Furthermore, it is generally the case that the location is capable of revision after the work is let and in a manner which may affect the contractor. I, therefore, am in favor of not paying any haul whatever, but pay for embankment made, however done. This gives the contractor the privilege of wasting cuts that he can waste to his advantage, but in doing so he loses the price which he would receive for the material if it were hauled into embankment, and must borrow the embankment to be paid for same."

(8) T. Fitzgerald, (9) D. D. Carothers, (10) H. E. Hale, (12) O. Rickert and (13) John Ware (Baltimore & Ohio):—"Contractors are notified that their price for excavation must include the haul necessary to transport same to points designated by the engineer in charge of the work."

(11) H. R. Talcott (Baltimore & Ohio):—"Personally, I prefer method 'A,' where haul is paid, as I consider it the most uniform."

(14) J. B. Jenkins (Baltimore & Ohio):—"Method 'C' preferred to 'A' and 'B,' but not used on B. & O. R. R.; free haul within each section; material within the section to be distributed or deposited according to instructions of the engineer. Material hauled from one section to another paid for by (1) the total amount so hauled, multiplied by (2) the distance from the center of gravity of such material in cut to the center of gravity in embankment; method similar to 'C' in principle; overhaul often entirely eliminated by form of contract."

(16) E. Stimson (Baltimore & Ohio Southwestern):—"The price per cubic yard includes all hauling and transportation of excavated materials and the depositing of same in such manner and in such places as engineer directs."

(17) H. T. Porter (Bessemer & Lake Erie):—"Formerly paid for overhaul, with 1,000 ft. free-haul limit and method 'C.' Now let all work as unclassified excavation, price to include haul, grubbing and clearing, etc. This leaves only the measurement of excavation to be disputed, which can be verified."

(18) H. Bissell (Boston & Maine):—"We have no definite rules regarding overhaul of material, as conditions are so variable that general rules are often not applicable."

(20) W. A. James (Canadian Pacific):—"Also use H. P. Gillette's method as given in McHenry's 'Railway Location and Construction,' which gives same results as 'C.'"

(21) J. C. Gray (Central of Georgia):—"Personally I do not believe in overhaul payment and necessary calculations which devolve on the construction party. I believe in an intelligent profile being furnished the contractors, so all can bid a flat price. By intelligent profile I mean one that, by figures and arrows, shows the amount of cut, waste, borrow and disposition of same within 100 ft. of exact distance of haul."

(23) J. O. Osgood (Central of New Jersey):—"The custom of this road has ordinarily been not to make any provision for overhaul, but to have this included by the contractor in his price per cubic yard. My preferred practice elsewhere has been to have a price named for excavation which included placing in embankment within a distance varying from 200 to 1,000 ft. without overhaul, the distance being deter-

mined to suit the character of the work, whether scraper or wagon work, and overhaul paid only on the material hauled more than the distance specified, but paid on the total distance hauled. This would agree closely with method 'C' of Mr. Berg's outline, excepting that I have usually preferred to have the payment for overhaul apply for the whole distance from the point of excavation to the point of depositing the material. My idea in this has been that the limit of free haul should be suited to the ordinary process available in the particular piece of work. If considerable of the work were to be done by scrapers and the rest by teams, I have used a limit of 200 ft., having in mind that within this limit scrapers would be used, and beyond it some process requiring other appliances, carts, wagons, etc. Where there was considerable of this second class of work I have thought it advisable to have a second excavation price for material to be handled beyond 200 ft., with a separate price named for haul, usually 1 ct. per cu. yd. per 100 ft., applicable to this cart or wagon work and calculated for the whole distance from point of excavation. In case of heavier work where carts would be used, the limit of free haul might be fixed at 1,000 ft. or at such distance as would call for a change in the manner of transporting the material. My idea of the principle to be followed in fixing the limit of free haul is to have the free haul cover the ordinary case and the overhaul apply only to the material which must be handled by other appliances and at different cost. My object throughout has been to make the unit prices fit any ordinary variation of conditions which might arise during construction, so that changes of grades or lines would not involve hardship or injustice on the company or contractor."

(25) W. S. Dawley (Chicago & Eastern Illinois):—"Yes and no; 500 ft. when used. The method of eliminating all material actually moved less than free-haul limit has always been used by me."

(28) T. E. Calvert (Chicago, Burlington & Quincy):—"Because of the many rules applied, there is probably no one thing connected with grading which is so frequently misunderstood by the average small contractor as the question of overhaul, and a generally applied rule, fair alike to both contracting parties, is very much to be desired. Such a rule should be based on the theory that a certain price for earth and for overhaul would each represent at least approximately a certain unit of work, regardless of the method of execution.

"Mr. Berg's statement, as outlined in method 'C,' conforms generally to my views for work, fairly well balanced between excavation and embankment. The haul clause used in this company's contract in connection with such work where earth must generally be hauled is:

"'No material will be paid for twice; that is to say, both in excavation and embankment. No allowance shall be made for hauling unless the distance shall exceed 500 ft. A cubic yard of earth hauled 100 ft. in excess of 500 ft. shall constitute a cubic yard of overhaul. In determining overhaul, the distance shall be measured from the centers of gravity of remaining cut and fill after free-haul yardage is deducted.'

"This leaves limit of haul to depend on the free haul plus the price per yard, divided by the price per cubic yard of overhaul. Haul is limited by bridge openings, but railroad reserves right at its expense to build a bridge and extend haul as though no bridge existed. Estimates are all made on basis of earth being hauled to limit, whether hauled or borrowed and wasted. This gives us for a price bid not considering that within the 500-ft. free haul and its transportation for an average of 500 ft. free. The unit of haul is definitely fixed for the price bid. On heavy steam shovel work bids can be intelligently made with earthwork price to include all haul."

(29) G. H. Brenner (Chicago, Burlington & Quincy):—"Pays for overhaul in team work, 500-ft. free-haul limit; computes overhaul by method 'B' usually, and by method 'C' occasionally."

(31) A. W. Newton (Chicago, Burlington & Quincy):—"Yes and no. Overhaul is a very great mystery to the average contractor, and the more simple the method the less liability of conflict of opinion and estimate. That is why I prefer 'A.' We make a flat price, using excavation for filling where possible."

(32) E. P. Weatherly (Chicago, Burlington & Quincy):—"No overhaul, as a rule."

(34) J. B. Berry (Chicago, Rock Island & Pacific):—"Yes, if agreed to in the contract length of free haul depends on the work, from 500 to 1,200 ft. extreme limit. Cut out the cuts and fills within the free extreme limit of haul, and only deal with the balance of average overhaul."

(35) A. K. Shurtleff (Chicago, Rock Island & Pacific):—"The Rock Island will use method 'C' wherever overhaul is paid for. Where possible to get prices favorable we may eliminate overhaul from the contract. Method 'C' is the only just method, in my opinion."

(36) H. M. Waite (Cincinnati, New Orleans & Texas Pacific):—"Use 'B' on long section of several miles. Use 'A' on short section of a mile or less.

(38) O. E. Selby (Cleveland, Cincinnati, Chicago & St. Louis):—"This road allows no overhaul. My own preference where haul is to be computed and paid for is to use free-haul limit of 500 ft. for team work and one mile for train."

(39) H. S. Waterman (Detroit & Mackinac):—"Contract work has been done on a percentage basis for the past seven years. By competent inspectors we get very good results."

(44) Francis Lee Stuart (Erie):—"If I found it necessary to use any I would use 'A' only. For the last eight years I do not now recollect more than one or two contracts under my charge with an overhaul clause in them."

(48) E. H. Fitzhugh (Grand Trunk):—"I beg to say that, of the three methods described in your letter, we consider the second—that indicated by the letter 'B'—to be the best, it being the one which we always

adopted when we had occasion to deal with overhaul, but there was usually so much trouble and dispute about the determination of the extra haul that, in our recent contracts, this question has been entirely eliminated, no allowance whatever being made on account of overhaul, and the contractors, knowing this, grade their prices accordingly. Before we eliminated the question of overhaul from our contract, our practice in estimating overhaul of earthwork was to determine the centers of gravity of the excavation to be taken out and of the fill to be made up from it. If the distance was in excess of the haul limit provided for in the specifications, an extra allowance was made on account of this excess, for the whole quantity of material taken out of the excavation and deposited in the embankment. For instance, if the limit of haul were fixed at 600 ft. and the distance apart of the centers of gravity of the excavation and of the embankment did not exceed the specified limit of 600 ft., no extra haul would be allowed, but if the centers of gravity were greater than that distance apart—say 700 ft.—then an extra haul of 100 ft. would be allowed for the total quantity taken out of the excavation and placed in embankment."

(49) F. H. McGuigan (Grand Trunk):—"Our 'General Specifications for Clearing, Earthwork, Etc.,' provides in Clause 19 that 'there shall be no allowance for extra haul of excavated material whatever may be the distance this material is drawn, whether by train or team.'"

(56) R. S. Blinn (Indianapolis Southern):—"Use same as method 'C,' except that all cuts within an economical haul limit are figured into an average haul. Several cuts may thus enter into an individual mass. For instance, where the price is 20 cts. per cu. yd. and the free haul is 500 ft., and the price for overhaul is 1 ct. per equivalent yard, I take into account all masses in cuts hauled to a balanced mass in fills within a district or section whose limits are determined by 2,500 ft. between the centers of gravity of such masses (the free-haul distances, however, being first eliminated), 2,500 ft. being an economical haul, since 2,500 ft. minus 500 ft. equals the price of borrow in this case. This is a free straight haul up to the limit where it would be more economical to borrow than to haul."

(57) George M. Walker, Jr. (Kansas City Belt):—"We have done very little grading the past 10 years. What has been done has first been cross-sectioned and the average haul between the center of gravity of cut and fill calculated, and contractors asked to bid on that individual piece of work."

(58) M. P. Paret (Kansas City, Mexico & Orient):—"Each cut and its adjoining fills are considered separately. The total haul is figured from the center of mass in excavation to the center of mass of the same material in the fill. The overhaul allowed is the total haul minus the free haul. All cuts in which the distance from the center of mass in excavation to the center of mass in the fill is less than the free haul are left out of consideration. The price paid for overhaul is 1 ct. per yard per 100 ft."

(61) R. C. Young (Lake Superior & Ishpeming):—"On prairie work I am in favor of 500 ft. free haul computed by method 'C.'"

(62) Walter G. Berg (Lehigh Valley):—"Usually no overhaul allowed. Specifications: 'No overhaul, unless otherwise provided.' Method 'C' is the correct method to correspond with the general intent of an overhaul clause, but 'B' is more often used and easier for calculations."

(63) W. H. Courtenay (Louisville & Nashville):—"I prefer method 'B.' The L. & N. practice is to consider the haul for each cut separately. Short haul from one cut is not used to offset long haul from another cut. We have an average free haul of 500 ft."

(64) J. F. Burns (Louisville & Nashville):—"Prefer 'C,' individually."

(65) Lewis Kingman (Mexican Central):—"We ask bidders to name prices including haul within 250 meters on earth. We ask for two prices; first, within 40 meters, and second, within 250 meters. All other material is subject to 250-meter haul at the price named."

(66) Rankin Johnson (Mexican International):—"Sometimes pay for overhaul; length of free haul, about 150 meters. Do not think overhaul should be paid for except in very rough country. See enclosed specifications, paragraphs 8 to 18, inclusive.

"'(8) When quantities for graduation are measured in embankment and estimated as excavated they shall be reduced by the following percentages, which are allowed for swell: For common material, .. per cent.; for loose rock, .. per cent.; for solid rock, .. per cent. This does not include drag-scraper-made embankments.

"'HAULING MATERIAL. (9) The rate per cubic meter for solid rock includes moving such material a distance not to exceed twenty-five meters from point of excavation to grade point of natural ground shown on profile, or to toe of slope of embankment, plus any necessary distance along made embankment.

"'(10) The rate per cubic meter for solid rock hauled includes moving such material between limits of twenty-five and seventy-five meters from point of excavation to grade point of natural ground shown on profile, or to toe of slope of embankment, plus any necessary distance along made embankment.

"'(11) The rate per cubic meter for loose rock includes moving such material a distance not to exceed twenty-five meters from point of excavation to grade point of natural ground shown on profile, or to toe of slope of embankment, plus any necessary distance along made embankment.

"'(12) The rate per cubic meter for loose rock hauled includes moving such material between limits of twenty-five and seventy-five meters from point of excavation to grade point of natural ground shown on profile, or to toe of slope of embankment, plus any necessary distance along made embankment.

"'(13) The rate per cubic meter for common material includes moving such material a distance not to exceed thirty meters from point of excavation to grade point of natural ground shown on profile, or to toe of slope of embankment, plus any necessary distance along made embankment.

"'(14) The rate per cubic meter for common material hauled includes moving such material between limits of thirty and three hundred meters from point of excavation to grade point of natural ground shown on profile, or to toe of slope of embankment, plus necessary distance along made embankment.

"'(15) The length of paid haul shall be determined as follows:

"'(a) Compute the quantities in excavation which shall have been moved into embankment under free-haul clauses.

"'(b) Increase these quantities by the percentages for swell as indicated in paragraph No. 8, and calculate the length along grade line of embankment which these quantities will complete.

"'(c) Compute distance along the grade line from center of gravity of the remaining excavation, which will be required to complete embankment, to center of gravity of remaining embankment. This distance will be the length of paid haul for the number of cubic meters in the remaining required excavation.

"'(16) The object of specifying the hauling of material as shown is to enable the engineer to calculate quantities governed by the specified rates before grading is completed and without possibility of disagreements.

"'(17) The haul shall not be limited by any bridge or opening across or around which a reasonable load can be moved.

"'(18) Embankments shall be commenced full width at the bottom, keeping the sides at all times as high as the center, and thus be carried up, until finished, in layers of not over one meter.'"

(71) S. B. Fisher (Missouri, Kansas & Texas):—"Bruckner's 'Profile of Quantities," described in Engineering News 'Field Book.' All material is taken into account excepting cut and fill within limit of station. Centers of gravity of consecutive stations are found.

(72) H. Rohwer (Missouri Pacific System):—"Overhaul allowed in cuts, from point of gravity (in cut) of material moved to point of gravity (in fill), where deposited. In dealing with material borrowed from pits, overhaul allowed on one-half the entire distance the team must travel, less distance described as 'free haul.' Referring to the clause of 'overhaul' to be presented to the Association, I notice it treats only of overhaul on material from cuts. Mr. Walter G. Berg in his definition of overhaul dwells likewise on this particular instance. But what about overhaul on material borrowed on the side? When a high fill is being made from material borrowed from the side, it becomes necessary that runways be constructed by the contractor, which runways constitute the limit line of travel of team. To deliver the material on the fill the team has to make the whole round. It is, therefore, not fair to measure the direct distance between the point of gravity of the borrow pit and that of the embankment as constituting the haul. It should be measured as the team travels, making the over-

haul on all material thus moved be equal to one-half the whole round minus 'free haul,' equal to the distance in feet, for which payment should be rendered."

(77) F. G. Jonah (New Orleans Terminal):—"I use the method of plotting on the profile as described in Molitor and Beard's 'Manual for Resident Engineers.'"

(80) F. L. Nicholson (Norfolk & Southern):—"Grading in this section is very light, short hauls and shovel work, and casting up from ditches. No overhaul allowed. I believe 1,000 ft. free haul to be fair. For calculation I prefer method 'B.'"

(81) C. S. Churchill (Norfolk & Western):—"We let very few contracts where overhaul is paid extra. While we have a clause in our standard contract that describes the method of computing overhaul, we do not have in the list of prices the specific term 'overhaul,' and, as stated above, very little of our work is done under the plan that we shall pay extra for overhaul. We have in the last two months awarded contracts that had an overhaul of about 1½ miles, but we pay nothing for this overhaul. Our usual limit for free haul is 1,600 ft.; that is, the description given in our haul clause. Our method of computing overhaul is that described as method 'C.'"

(83) Geo. C. Millet (Ohio River & Columbus):—"I have used what is practically method 'A' by plotting quantities on profile."

(86) Thos. Rodd (Pennsylvania Lines West of Pittsburg):—"We pay one price without classification or overhaul. Contractors determine this from close inspection of work and profile."

(88) R. Trimble (Pennsylvania Lines West of Pittsburgh):—"We pay one price without classification or overhaul."

(89) E. G. Ericson (Pennsylvania Lines West of Pittsburgh):—"Our practice is to not pay for any overhaul, and we make this clear in our specifications."

(90) Jos. T. Richards (Pennsylvania Railroad):—"Contracts for earthwork are usually awarded without any regard being paid to length of haul or without any regard to classification."

(94) J. E. Turk (Philadelphia & Reading):—"We do not allow for any extra overhaul on P. & R. Railway. Personally, I favor method 'A,' with 600 ft. overhaul."

(95) J. F. Hinckley (St. Louis & San Francisco):—"Do not pay for overhaul; pay both ways; would prefer method 'C.'"

(96) John V. Hanna (St. Louis & San Francisco):—"Our specifications call for a calculation of overhaul taking the distance between centers of gravity on a given cut or portion of a cut and a fill or portion of a fill, into which it is hauled, deducting the free haul. We would leave out of account all cuts where the distance between center of gravity of cut and center of gravity of fill would be less than the free-haul distance. Our method, I should say, is very similar to method 'B' of the circular, except that we do not calculate the average

haul. For instance, if we have a quantity of 500 yds. hauled 700 ft., we figure this as 3,500 yds. hauled 100 ft. and pay accordingly. We figure up the total of figures thus obtained and this forms the basis for vouchers. This amounts to the same thing in the end as figuring the average haul and then multiplying the total yardage hauled by the price for the average haul, but there is one less process of computation in our method."

(99) W. A. Drake (Santa Fe, Prescott & Phœnix):—"Deduct the cubic yards which balance and make 100 ft. of roadway; pay for total average distance haul on balance of excavation."

(102) E. B. Cushing (Southern Pacific):—"There is no free haul in our general specifications, as our line extends through a prairie country and through swamps in which no material is hauled. In special cases we have 400 ft. free haul and pay 2 cts. per cu. yd. per 100 ft., between 400 and 1,000 ft. being a maximum haul."

(105) L. W. Wells (Texas Midland):—"My method is to determine the center of gravity of the masses beyond points where free haul balances and the distance between center of gravity less free-haul distance is the haul paid for."

(106) H. Fernstrom (Tidewater and Deepwater):—"Steam shovel work is paid for at a fixed price, for a haul not exceeding two miles, and at another fixed price per cubic yard for haul not exceeding three miles."

(107) D. MacPherson (Transcontinental Railway):—"I send you print of a diagram and description of our method of estimating overhaul which you will see is a method described by Mr. T. S. Russell in the Engineering News, and Mr. Russell gives the credit for it to Mr. R. P. Bruer." (See "Review of Literature," where Mr. Russell's method is given in full.)

(108) H. G. Fleming (Union of Memphis):—"In our specification on contract work we use a limit of 500 ft. for free haul, and have been computing overhaul on the basis of method 'C,' as given in your letter, but it is our intention on future work to use method 'A.'"

(109) E. C. Brown (Union R. R. of Pa.):—"Prefer Mr. Berg's third method, and have used substantially the same."

(118) Octave Chanute (Consulting Engineer):—(See historical statement by Mr. Chanute concerning early American practice in introduction to "Review of Literature.")

(120) W. B. Hanlon (Consulting Engineer):—"Do not pay for overhaul as a rule."

(121) C. Lewis (Civil Engineer):—"My choice would be, on work thoroughly surveyed in advance, to give bidders full information regarding location of cuts and where material was to be used, and then make no allowance for overhaul; bids for excavations to include disposal of material as per plans and profile. On plans less thoroughly prepared would prefer method 'C.'"

(123) F. W. Ranno (Civil Engineer):—"Do not ordinarily pay for overhaul; method 'B' preferred; average haul determined according to 'B' and flat rate established on that basis. No overhaul then goes into estimates."

III. CONCLUSION.

In view of the foregoing presentation of the subject, your Committee does not deem it advisable to "present an overhaul clause for use as an optional alternate clause for clause No. 48 of Specifications for the Formation of the Roadway, defining not only the manner of payment, but also method of computing overhaul," but respectfully suggest that the question be considered by the Association.

Your Committee would respectfully report progress on "report on methods of conducting the practical work in connection with revising and improving existing lines."

Bulletin No. 66, August, 1905, included our final report on Glossary of Terms, and we would respectfully recommend that the definitions be printed in the Manual of Recommended Practice.

Respectfully submitted,

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R. C. Barnard, Superintendent, Pennsylvania Lines, Cincinnati, O., *Vice-Chairman.*
G. H. Bremner, Engineer Maintenance of Way, Chicago, Burlington & Quincy Railroad, Chicago, Ill.
J. F. Burns, Roadmaster, Louisville & Nashville Railroad, Elizabethtown, Ky.
F. R. Coates, Contracting Engineer, Chicago, Ill.
C. Dougherty, Superintendent, Illinois Central Railroad, Clinton, Ill.
W. D. Pence, Prof. of Civil Engineering, Purdue University, Lafayette, Ind.
H. Rohwer, Consulting Engineer, Missouri Pacific Railway System, St. Louis, Mo.
A. M. Shaw, Chief Engineer, Northern Illinois Electric Railway, Dixon, Ill.
A. K. Shurtleff, Assistant Engineer, Chicago, Rock Island & Pacific Railway, Chicago, Ill.
J. G. Sullivan, Assistant Chief Engineer, Isthmian Canal Commission, Culebra, Canal Zone, Panama.
H. M. Waite, Superintendent, Cincinnati, New Orleans & Texas Pacific Railroad, Somerset, Ky.
L. H. Wheaton, Chief Engineer, Halifax & Southwestern Railway, Bridgewater, N. S.
R. C. Young, Chief Engineer, Lake Superior & Ishpeming Railway, Marquette, Mich.

Committee.

DISCUSSION.

Mr. H. J. Slifer (Contracting Engineer):—Since reaching Chicago, this Committee has been accused of endeavoring to disrupt the Association by throwing the overhaul clause back into the convention for action. We plead "Not guilty." For the past three years we have been endeavoring to reach some conclusion which could be submitted to the Association and which everybody would approve, but by reading the report this year you will notice we are further from getting anything unanimous on this subject than we have ever been, and the Committee thought it wise to allow the Association to determine between the three methods, which have been named A, B and C—which of the three methods of figuring overhaul shall be considered by the Committee, after which decision the Committee will be prepared to submit an overhaul clause to suit the method agreed to. The glossary of terms can probably be passed, and the Committee would suggest that it be considered now and that the overhaul clause be brought up later.

The President:—The chair announced at the opening of the convention that in order to save time all definitions of terms would be excluded from discussion except by letter. Any exception taken to a definition should be made in writing to the chairman of the Committee. If an agreement is not reached, the matter will be brought before the Association by letter-ballot during the year.

In order to start discussion on this report, the chairman of the Committee desires the members to express their views on the three methods of overhaul, described as methods A, B and C. There is such a wide variance of practice on this question of overhaul that a full and free discussion is necessary. The Committee has outlined in methods A, B and C the three types of procedure which have been brought to their attention through correspondence with many engineers.

Mr. Slifer:—I do not suppose it is necessary to call attention to the fact that the Association is on record against the overhaul proposition as a part of our specifications. The only question now is to submit an alternate clause for such railroads as desire to pay for overhaul.

Prof. C. Frank Allen (Massachusetts Institute of Technology):—It is a somewhat interesting fact that, although the Association is on record against any overhaul clause, the returns to the circular of the Committee show that 73 roads use the overhaul clause and 37 do not. It is rather doubtful, taking the two facts into consideration, as to what the real sentiment of the Asociation is, or what it would be if the matter was submitted to the members by letter-ballot instead of to a verbal vote of those present at one of our meetings.

Prof. W. D. Pence (Purdue University):—It would depend on conditions entirely. Chiefly in the East, on the older lines, the payment of overhaul has gone into disuse. It prevails almost exclusively through the West and South.

Prof. Allen:—I ask, if Prof. Pence has the information, whether the line of cleavage is substantially that indicated by Mr. Cushing in his discussion—those roads that were widening track and carrying on work on established lines being on one side, and those who were doing a good deal of new work being on the other side?

Prof. Pence:—I think there is some distinction such as that which can be applied. I have not worked out the statistics along that line, however.

The President:—According to the summary of the replies from various engineers to whom requests for information were forwarded by the Committee, appearing on page 159 of the report, it seems that 110 replies were received; 37 allowed no overhaul, and 73 allowed overhaul. Of this latter number, four preferred method A; 21 method B; 54 method C, and 4 other methods. It shows the variance of practice and opinion on this subject, with the majority in favor of the method allowed under C.

Prof. Allen:—In view of the facts presented in this summary, and in order to bring something definitely before the Association, I would move that the Committee on Roadway be requested to bring in a specification next year in harmony with method C, as suggested in Mr. Berg's discussion.

The President:—The chairman of the Committee states that they have already prepared a clause under method C. It was not printed, but the Committee is prepared to read it to the Association while discussion is in order.

Mr. Slifer:—The clause which we have prepared is as follows:

"No payment will be made for hauling material when the length of haul does not exceed the limit of free haul which shall be ...... feet.

"The limits of free haul shall be determined by fixing on the profile two points, one on each side of the neutral grade point, one in excavation and the other in embankment, such that the distance between them equals the specified free haul limit and the included quantities of excavation and embankment balance. All haul on material beyond this free-haul limit will be estimated and paid for on the basis of the following method of computation, viz.:

"All material within this limit of free-haul will be eliminated from further consideration.

"The distance between the center of gravity of the remaining mass of excavation and center of gravity of the resulting embankment, less the limit of free haul as above described, shall be the length of overhaul.

and the compensation to be rendered therefor will be determined by multiplying the yardage in the remaining mass as above described, by the length of the overhaul. Payment for the same will be by units of one cubic yard hauled one hundred feet.

"When material is obtained from borrow pits along the embankment and runways are constructed, the haul shall be determined by the distance the team necessarily travels. The overhaul on material thus hauled shall be determined by multiplying the yardage so hauled by one-half the round distance made by the team less the free haul distance. The runways will be established by the engineer."

Prof. Allen:—I would like to withdraw my previous motion, with the consent of the second, and move that the clause read by Mr. Slifer be adopted by the Association.

The President:—The motion by Prof. Allen is that the clause on overhaul recommended by the Committee, just read by the chairman, be adopted by the Association.

Mr. Geo. H. Bremner (Chicago, Burlington & Quincy):—Do I understand that this is recommended by the Committee?

The President:—It is presented by the Committee.

Mr. Bremner:—I do not understand that the Committee recommends this. Before we vote on it I would call attention to the fact that the Committee submitted for adoption, in preference to that, method B in the conclusions on page 74. This was not adopted by the Committee nor recommended by them, but the conclusion which the Committee reached, if I remember rightly, was that in their opinion method B was preferable to method C, in the minds of a majority of the members who were present at that meeting. Method C is probably in use on more railroads in the country than method B, but the opinion of the whole Association was that overhaul, as a rule, should be eliminated wherever it was possible. If that is the case, then in establishing a method of computing overhaul, it would seem that the next step for the Association to take would be to adopt as simple a method for computing overhaul as could be devised, and we could probably not adopt a simpler method than the method B—from the center of gravity of the cut to the center of gravity of the equivalent fill. If the Association can devise some plan which will be adopted all over the country, it will certainly eliminate many difficulties both to the contractor and the engineer, and it is hardly material which method is adopted, so long as it is a method thoroughly understood by both parties, and therefore method B being somewhat simpler than method C, I would be in favor of adopting it.

Mr. Slifer:—We do not like to have the Committee divided in opinion when it comes before the Association, but its members for the last two or three years have been discussing this subject without result. At a former meeting of the Committee, at which there were only three members present, it was decided to send out plan B to the Committee for consideration and to submit it to the Association for adoption. Later, when we received replies from 134 railroads, some of us changed our mind and thought possibly plan C was the proper one to adopt. At a meeting of the Committee held this morning, at which I believe all members were present except Mr. Bremner and Mr. Barnard, we discussed the subject and concluded that method C might be the most acceptable to the Association, and we therefore drew up this alternate clause which we have presented.

The President:—The Proceedings of the Association show that we are on record against the overhaul clause, that no overhaul clause had been presented up to last year that could be adopted, and the Committee was therefore instructed to present at this meeting an alternate clause covering the question of overhaul and if the clause was adopted, to state the method of computation. The specifications for construction of roadway were adopted, in which no overhaul was permitted, and an overhaul clause was to come in as an alternate clause, with one or the other stricken out in each particular contract.

Mr. Slifer:—I think the chair is mistaken. The Association has certainly gone on record on no less than two different occasions against an overhaul class, and the specification presented last year were presented with clause 48-A and 48-B. At that time 48-A was adopted elimmating all overhaul. Two years previous to that time, the Association went on record against overhaul. We have been asked by the Association to submit this alternate clause for the use of such members as may desire to pay for overhaul.

The President:—The chair was mistaken in presenting the action of the Association last year. The chair will read precisely what was done:

"The President:—Mr. Berg's motion is that the original clause on overhaul be substituted for clauses 48-A and 48-B. The original clause reads as follows: 'Unless otherwise specified, it is distinctly understood that the contract price per cubic yard covers any haul found necessary and that there will be no allowance for any so-termed overhaul.'

"The President:—That means that 48-A and 48-B are rejected, at least for the present." The instructions to the Committee this year were to present an alternate clause on overhaul for the consideration of the Association. Is there any discussion upon Prof. Allen's motion, that this clause be adopted?

Mr. Robert Moore (Consulting Engineer):—It might be well, in view of the fact that the tendency of the letters is to differ widely from the vote of the members at the meeting, that this be referred to letter-ballot—the whole Association should be entitled to vote on so important a matter. I make that as an amendment to the motion.

(The amendment was carried.)

The President:—The vote recurs on the original motion of Prof. Allen, that the clause presented by the Committee be adopted by the Association and referred to the members for vote by letter-ballot.

(The motion was carried.)

Mr. Slifer:—It might be well to have it distinctly understood that the letter-ballot will be for or against the particular clause, and not on the question of which method shall be adopted. If you go back to the method, you will go back to the same thing we have been over for the last three years.

The President:—The motion carries with it the clause you have presented.

The chair desires to call attention of the members to the excellent compilation of the Roadway report prepared by Prof. Pence.

Prof. Allen:—I would like to ask if such matters have been submitted to letter-ballot by this Association previously?

The President:—The chair does not recall an action of that kind.

Prof. Allen:—Touching the method of procedure, I suggest that the Board of Direction make a brief summary of the arguments in favor of and against the motion. That is often done in the American Society of Civil Engineers, and it will add something to the understanding of the members who are called upon to vote on the matter. The suggestion is that the Board of Direction in its wisdom make a brief summary of what it considers the points of special interest touching this matter, for the assistance of the members who are to vote for or against the proposition.

Mr. Bremner:—I understand this eliminates method B entirely.

The President:—Simply to place before the members the exact question confronting the Association; in other words, they will not be asked to vote for or against a single paragraph on overhaul, but would have the various reasons for and against the different methods under plan C presented to them. That I understand to be your idea, Prof. Allen?

Prof. Allen:—Yes.

The President:—In continuation of what the chair was about to say, commencing on page 85, the members will find a review of literature on overhaul prepared by Prof. Pence, which is a valuable addition to the literature of this Association. It brings in many features of earthwork that are not universally known—but little known, probably—but which are extremely valuable to an engineer in the field. The method of mass curve and disposition of material is well worked out.

Mr. A. S. Baldwin (Illinois Central):—I would be glad if the Committee would consider and give us their views or have some discussion now of the advisability, instead of calling for bids under the ordinary specifications, of having the free haul computed for the various bids that are based on overhaul, and furnishing the contractor, in calling for bids, a statement of what method would be used in calculating overhaul, and then specify the amount that would be paid for overhaul. That really makes very little difference to the contractor, providing he knows what he has to bid on, and would greatly simplify the computations where a large number of bids are to be put in.

There is another feature I would like to get some information about from the Association, and that is, in specifying a price for overhaul, of naming certain limits within which a certain price would be paid, that is, having different limits for different prices. There is a great deal of convenience in the method of eliminating overhaul. It saves the engineer a great deal of trouble. At the same time it is liable to give trouble where changes come in. I have met that in a measure by stating in the specifications what percentage of changes would be allowed without extra compensation to the contractor. He bids with a certain understanding that a change in quantities from 10 to 20 per cent. as specified in the call for bids can be made by the engineer without any increase or decrease in cost. However, I believe that work could be facilitated very much if we have certain limits, say up to 500 feet, and a certain price, the object being to give the contractor a definite basis on which to work, and at the same time simplify the computation. The great amount of grade reduction work, and the large amount of low-grade line that is being constructed has changed the question of overhaul to a very considerable extent. Under an ordinary overhaul basis, on a low-grade line, you will get a great many hauls in which you will have to waste your material entirely, and at the same time the contractor, on account of the character of plant he has, could well afford to haul that material into your fill. As it is now, with the ordinary equipment, the contractor on very long hauls and steam shovel work, has merely an additional locomotive and train to put on, which makes very little addition to the actual cost. If the Committee would consider that feauture and discuss it and make some suggestions, I believe it would aid materially to simplifying roadway construction. I would be glad to hear some expression of opinion from the gentlemen present, if any have attempted such method or consider it practicable.

Mr. A. M. Shaw (Civil Engineer):—Might it not be better to classify the different lengths of hauls by the method employed in doing the work? Instead of classifying by 500 feet, 1,000 and 1,500 feet hauls, specify scraper, wagon and steam-shovel work. We might have an extreme haul, in which it would not be possible to do the work with a steam shovel. For such work the contractor should receive a higher rate of overhaul.

Mr. Baldwin:—The objection that I would see to Mr. Shaw's suggestion is that the contractor will not necessarily use the particular plant that you might specify. It may be more economical to him to use a plant that would not be the cheapest plant for a particular place, just because he happens to have that plant on hand. Contractors differ a great deal as to what is the most economical method on certain cuts. Some will say a certain piece of work is not a steam-shovel job—that it is a team job. So in considering that I have concluded that the only safe way to handle it would be to name certain limits of actual distances and leave it to the contractor to use any method he saw fit.

Mr. Slifer:—I think you will have to consider the overhaul on the basis of team haul and also on the basis of steam-shovel haul, and each should be considered separately.

Mr. Shaw:—You have, for instance, an intermediate wagon haul and other methods of work may come up. I think we should have three distances on which prices are specified.

The President:—If there are no further suggestions to the Committee, they will be relieved, with the thanks of the Association.

REPORT OF COMMITTEE NO IX.—ON SIGNS, FENCES, CROSSINGS AND CATTLE-GUARDS.

To the Members of the American Railway Engineering and Maintenance of Way Association:

The instructions given your Committee by the Board of Direction, namely, to submit specifications for fences, with marginal index; to report on galvanizing wire, and on the breaking strength of wire, and to resubmit the additional definitions published in Bulletin No. 60, have been complied with, and the Committee presents herewith the results of its labors for your consideration and approval.

*SPECIFICATIONS FOR STANDARD RIGHT-OF-WAY FENCES.

GENERAL.

1. Three classes of smooth wire fences may be used, the top wire of each to be 4 ft. 6 in. above the ground. Classes.

2. First-class fences shall consist of nine longitudinal, smooth, coiled, galvanized steel wires; the top and bottom wires shall be No. 7 gage; intermediate and stay wires shall be No. 9 gage. First-class Fence.

The spacing of the longitudinal wires shall be, commencing at the bottom: 3, 4, 5, 6, 7, 8, 9 and 9 in. The bottom wire shall be 3 in. above the ground, and the stay wires shall be spaced 12 in. apart.

3. Second-class fences shall consist of seven longitudinal, smooth, coiled, galvanized steel wires; the longitudinal wires and stay wires shall be No. 9 gage. Second-class Fence.

The spacing of the longitudinal wires shall be, commencing at the bottom, 5, 6½, 7½, 9, 10 and 10 in. The bottom wire shall be 6 in. above the ground, and the stay wires shall be spaced 22 in. apart.

4. Third-class fences shall consist of four longitudinal, smooth, coiled, galvanized steel wires; the longitudinal and stay wires shall be No. 9 gage. †Third-class Fence.

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*See amendment, page 458.

†When desirable 1x2-in. wooden stays, stood on the ground and interlaced between the longitudinal wires, may be used, spaced 6 to 8 ft. apart, in place of or in addition to the stay wires.

The longitudinal wires shall be spaced 14 in. apart; the bottom wires shall be 12 in. above the ground, and the stay wires shall be spaced 22 in. apart.

MATERIAL.

Posts. 5. Posts shall be of (to be filled in by each road) .... They shall be straight and free from rot or other defects. Split or sawn posts may be used in localities where round posts are not economically available; their dimensions shall be at least equal to those hereinafter specified for round posts.

End Posts. 6. End or gate posts and intermediate bracing panel posts shall be 9 ft. long and 8 in. in diameter at the small end, or 8x8 in. if sawn.

Intermediate Posts. 7. Intermediate posts shall be 8 ft. long and not less than 4 in. in diameter at the small end.

Braces. 8. Braces for end posts, gate posts and intermediate brace panels shall be of 4x4 in. common lumber, 12 ft. long, free from large knots, splits or rot.

Wire. 9. All woven wire fences shall be constructed of steel galvanized wire.

All longitudinal wires shall be coiled.

The elastic limit of all wire shall be at least 1,500 lbs. for No. 9 gage wire, and 2,000 lbs. for No. 7 gage wire.

The ultimate tensile strength shall be at least 1,800 lbs. for No. 9 gage wire, and 2,500 lbs. for No. 7 gage wire. It must stand without sign of fracture, winding tight around wire of the same size.

Stay Wires. 10. All stay wires shall be straight and of No. 9 gage.

Locks. 11. The locks or fastenings at the intersection of the longitudinal and stay wires shall be of such design as will prevent them from slipping either longitudinally or vertically.

Staples. 12. Staples used in posts shall be 1 in. long for hard wood, and 1½ in. long for soft wood, and be made of No. 9 galvanized steel wire.

Galvanizing. 13. *All galvanizing shall consist of an even coating of zinc, which shall withstand one-minute immersion tests in a solution of commercial sulphate of copper crystals and water, whose specific gravity shall be 1.185 and whose temperature shall be from 60 to 70 degrees Fahrenheit. After each immersion the sample shall be washed immediately in water and be wiped dry. If the zinc is removed, or a copper-colored deposit is formed after the fourth immersion, the lot of material from which the sample is taken shall be rejected.

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*See amendment, page 458.

14. The fence shall be so manufactured as not to remove the galvanizing nor impair the tensile strength of the wire. Manufacture.

ERECTION.

15. End posts shall be set vertical, at least 4 ft. in the ground, thoroughly tamped, braced and anchored. End Posts.

16. Gate posts shall be set vertical and braced in a similar manner to the end posts. Gate Posts.

17. Intermediate posts shall be set at least 3 ft. in the ground, and from 16½ to 33 ft. apart, depending upon the nature of the ground and the service required. Holes of full depth must be provided for all end and gate posts, even if blasting must be resorted to. For intermediate posts, where rock is encountered, not more than two adjacent posts shall be set on sills 6x6 in. by 4 ft. long, braced on both sides by 2x6 in. braces, 3 ft. long. Holes must be provided for all other posts. Intermediate Posts.

All posts shall be set with the large end down.

All posts shall be set in perfect line on the side on which the wire is to be strung. After the fence is erected, the top of the posts shall be sawed off with a one-fourth pitch, the high side being next to the wire and 4 in. above it.

18. All end and gate posts shall be anchored by gaining and spiking two cleats to the sides of the posts, at right angles to the line of fence, one at the bottom and the other just below the surface of the ground. The cleat near the ground surface to be put on the side of the post next the fence and the bottom cleat to be put on the opposite side. Anchoring.

Intermediate posts set in depressions of the ground shall be anchored by gaining two cleats into the side near the bottom of the post, same to be properly spiked.

19. All cleats shall be 2x6 in. by 3 ft. long, of common lumber. Cleats.

20. All end, corner and gate posts shall be braced by a piece of 4x4 in. common lumber, gained into the end corner or gate post, about 12 in. from the top, and into the next intermediate post, about 12 in. from the ground, and be securely spiked. A cable made of a double strand of No. 9 soft galvanized wire looped around the end post at the ground line and around the next intermediate post, about 12 in. below the top, shall be put on and twisted until the top of the next intermediate post is thrown back at least 2 in. Bracing.

21. Longitudinal wires shall be stretched uniformly tight, and be parallel; stays shall be straight and vertical and be uniformly spaced. Stretching.

The wires should be placed on the side of the post away from the track, except on curves, where they should be so placed that the pull of the wires is against the post.

Stapling. 22. All staples shall be set diagonally with the grain of the wood, and be driven home tight. The top wire shall be double stapled.

Splicing. 23. Approved bolt clamp splices or a wire splice made as follows may be used: In making wire splices the ends of the wires should be carried 3 in. past the splicing tool and wrapped around both wires backward toward the tool for at least five turns, and after the tool is removed the space occupied by it be closed by pulling the ends together.

GALVANIZED WIRE FENCING.

The object of this investigation is to determine the cause of the rapid oxidation or rusting of smooth galvanized wire fences erected in recent years, and, if possible, to suggest a remedy.

Fence wire is galvanized to protect it from oxidation, and galvanizing consists in coating the wire with a thin layer of zinc applied by passing the cleansed wire through a zinc bath whose temperature is about 800 degrees Fahrenheit.

The zinc coating or galvanizing on the older barb wire fences, which was galvanized after the barbs were woven in, has withstood oxidation successfully for 18 or 20 years, and there are many examples of galvanized telegraph wire that have been in service for over 30 years and which to-day retain the zinc coating so that the wires are practically as good as new.

All of the smooth galvanized wire woven fences that have been in service for more than five years have lost considerable of their galvanizing, and the exposed iron or steel is rusting. Some strands are good for their entire length, others have lost the zinc coating entirely; the majority of the wires, however, have a fair proportion of the zinc coating intact separated by short stretches having no zinc whatever, and the wire at these points is rusting. These rusted places are found on top, bottom, intermediate wires and stays in such locations as to indicate that its cause is variable thickness, quality or workmanship in the galvanizing rather than on account of the variation in exposure.

As zinc is acted upon by sulphurous acid and sulphuric acid more readily than upon steel or iron, we cannot expect galvanized wire to last longer than bare iron or steel would do when exposed continually to the fumes of switching engines or when located near smelters or other manufacturing plants where much smoke is emitted.

The telegraph companies are not having trouble with the galvanizing of iron wire recently purchased when exposed to ordinary conditions along railways, nor are they having any difficulty in securing sufficient thickness of zinc to withstand four one-minute immersions in a saturated solution of blue vitriol, such as is called for in the galvanizing specification presented by the Committee.

The thickness of the zinc coating on wire supplied to-day for the manufacture of woven wire fence is such as will usually stand only two one-minute immersions in the blue vitriol bath, so it is fair to assume that fence wire galvanizing is only about half as thick as telegraph wire galvanizing.

The reason the manufacturers make the fence wire galvanizing so thin is to prevent the scaling of the zinc when the wire is being twisted, knotted and wrapped by the fence weaving machines. The thick layer of zinc is not sufficiently elastic to withstand the work of the machines without scaling, while the very thin coating has appeared to withstand this work better and has therefore been adopted with the very unsatisfactory results above mentioned. Your Committee had several samples of fence woven of all No. 9 double galvanized wire on which the zinc coating was of sufficient thickness to withstand the four one-minute immersion tests. Upon examining this fence it was noticed that the zinc on the longitudinal wires did not suffer from the action of the weaving machines; the zinc on the stay wires, however, where they were wrapped around the longitudinal wires, scaled like dry thick paint would do.

It would appear, therefore, that the best galvanizing protection which we can secure under present methods of fence manufacture is that the longitudinal wires be double galvanized, that is, that they receive a coating that will stand the four one-minute immersions in the blue vitriol bath.

The thickness of the zinc covering for stay wires and fastenings must be regulated to suit the machines on which the various kinds of woven fence are manufactured to ensure against its scaling. This condition applies, as we believe, to all machine-made fence. There are, however, several types of field-erected fence in which both the longitudinal wires, vertical wires and fastenings can be made successfully of double galvanized wire, the cost of which is as much higher as the difference between weaving the fence by machine or having it woven in the field by hand.

One maker, in his desire to increase the life of his fence, coats it by dipping it in white zinc paint, and claims that it "will protect the life of the wire the length of time this coating stays on." The above is only a partial remedy, and if we desire to continue the use of machine-woven fence and secure proper results in the matter of galvanizing, it appears to your Committee that a better method would be to use the present thinly galvanized wire to manufacture the fence, and after it is made cleanse it and give it another coating of zinc the same as is done in the case of some kinds of poultry netting.

To galvanize fence after being manufactured was suggested to several fencemakers. The flexible joint fencemakers objected to this method on account of the soldering effect the zinc would have on the joints. Another maker advises that he has been experimenting in this direction but as yet has not made it a commercial success, the difficulty being in his inability to apply the zinc evenly and thoroughly, together with its excessive cost. One stiff stay and rigid joint manufacturer, however, offers to install the necessary plant to galvanize the fence after it is made, provided sufficient business is ensured to warrant the investment.

A most thorough investigation of this entire subject has been made by Dr. A. S. Cushman, of the United States Department of Agriculture, published in Farmers' Bulletin No. 239, which, by permission, is printed as an appendix to this report.

While Dr. Cushman's contention that the manganese content, especially if it is unevenly distributed in the steel, is at least in part the cause of the trouble, your Committee is unable either to confirm or disprove this theory, and for the present prefers to recommend good galvanizing as the remedy.

In conclusion, your Committee believes, first, that the rapid deterioration of modern woven galvanized fence wire is caused by the coating of zinc being too thin and of an uneven thickness; second, that to procure better protection to the wire and a longer lived fence it is necessary to secure an increased uniform thickness of the zinc coating on the wire, and to insure that the galvanizing is intact after the wire has gone through the fence-weaving machines it would seem to require that a second coat of zinc be applied to the fence after it is manufactured.

TENSILE STRENGTH OF FENCE WIRE.

Steel fence wire is manufactured for the trade in three grades, namely, hard wire, medium wire and soft wire. The grades are distinguished by physical tests rather than by chemical composition.

A large fence wire manufacturing company suggests that the ultimate tensile strength for the three grades be not less than the following;

	Hard.	Medium.	Soft.
No. 7	3,118 lbs.	2,530 lbs.	2,136 lbs.
No. 9	2,200 lbs.	1,800 lbs.	1,507 lbs.
No. 11	1,475 lbs.	1,295 lbs.	1,010 lbs.
No. 12	1,182 lbs.	810 lbs.	795 lbs.
No. 13	921 lbs.	756 lbs.	650 lbs.

They also state that the ranges in chemical composition are about as follows:

Carbon	.08 to .30
Sulphur	.035 to .070
Phosphorus	.02 to .065
Manganese	.30 to .70

Your Committee procured samples of fence wire from several manufacturers, and they were tested by the Pittsburg Testing Laboratory, Ltd., with the following results:

Name	Gage	Manufacturers Mark	Elastic Limit	Ultimate Strength
Brown	No. 9	No. 1	1,685	2,000
	No. 9	No 2	1,870	2,220
American Steel & Wire Co.	No. 12	Soft	....	560
	No. 11	Hard	....	1 015
	No. 9	Hard	....	1,580
	No 7	Hard	1,355	1,970
International	No. 11½	....	....	1,080
	No. 10	....	1,095	1,510
	No. 9	....	1,280	1,765
Frost	No. 10	Plain Hard	1,190	1,500
	No. 9	Plain Hard	....	1,800
	No. 9	Soft	830	1,020
	No. 11	Coiled	....	1,510
	No. 10	Coiled	1,330	1,550
	No. 9	Coiled	1,780	2,030
	No. 9	Stay Wire	....	1,450
	No. 8	Stay Wire	....	2,020
	No. 7	Stay Wire	....	2,200
Page	No. 12	....	....	1,220
	No. 11½	....	....	1,350
	No. 11	....	....	1,870
	No. 10	....	2,090	2,580
	No. 9½	....	2,110	2,630
	No. 9	....	2,550	2,920
	No. 7½	....	3,110	3,580
	No. 7	....	2,740	3,520

The best results can be obtained by using hard wire for longitudinals, on account of the increased strength, together with the spring effect of the cooling. Soft or medium wire must be used for verticals in those fences where the vertical wire is wrapped around the longitudinal ones, as well as for knots or fastenings at the intersections of the longitudinal and vertical wires. Different types of fence for the best results require different grades of wire for the verticals and fastenings,

DEFINITIONS.

Anchor Post.—A fence post fixed or fastened in position by some contrivance.

Fence Anchor.—A contrivance of wood, metal or other material designed to prevent a fence post from being raised or moved.

CONCLUSIONS.

Your Committee recommends that the following conclusions be adopted:

(1) That the specifications for standard right-of-way fences be adopted as being good practice.

(2) That hard wire, whose ultimate tensile strength for No. 9 gage is from 1,8co to 2,200 lbs., be used for longitudinal wires and that the verticals and fastenings be as near the above in ultimate tensile strength as the action of the various fence weaving or erecting machines will admit without injuring the wire.

(3) That the definitions for Anchor Post and Fence Anchor be approved.

Respectfully submitted,

W. D. Williams, Chief Engineer, Cincinnati Northern Railroad, Van Wert, O., *Chairman.*

F. P. Gutelius, Engineer Maintenance of Way, Canadian Pacific Railway, Montreal, Canada, *Vice-Chairman.*

F. E. Bissell, First Assistant Engineer, Lake Shore & Michigan Southern Railway, Cleveland, O.

S. B. Fisher, Chief Engineer, Missouri, Kansas & Texas Railway, St. Louis, Mo.

F. G. Jonah, Assistant Engineer, New Orleans Terminal Railway, New Orleans, La.

A. G. Norton, Resident Engineer, Erie Railroad, Otisville, N. Y.

H. R. Talcott, Engineer of Surveys, Baltimore & Ohio Railroad, Balti-More, Md.

W. A. Wallace, Division Engineer, Chicago, Indianapolis & Louisville Railroad, Chicago, Ill.

A. A. Wirth, Engineer Maintenance of Way, Pennsylvania Lines West, Pittsburg, Pa. *Committee.*

AMENDMENTS.

Amend title to read: "Specifications for standard right-of-way fences built with wooden posts."

Change the words "whose specific gravity," in the third line, to read, "the specific gravity of which."

*THE CORROSION OF FENCE WIRE.

APPENDIX TO REPORT ON SIGNS, FENCES, CROSSINGS AND CATTLE-GUARDS.

It is frequently asserted that wire for fencing is manufactured from the refuse of the furnaces and the junk piles, and that the metal used in forming the galvanized coating is largely adulterated with metals cheaper than zinc. The first contention shows ignorance of the fact that refuse metal of this kind could never be drawn to the form of wire, and that any manufacturer who followed such methods would speedily find his finished product upon his own junk pile; and as to the second contention it may be said that, if it is true, no indication of the fact has been discovered during the course of the investigation.

The real cause of the trouble is a metallurgical problem and requires careful and impartial consideration. This bulletin is an effort to give all the evidence obtainable up to the present time, and also a short, simple description of the modern method of iron and steel manufacture and of the processes involved in making the wire. It also contains evidence pointing to what may turn out to be the real cause of the trouble and suggestions for possible future improvement.

For some time past numerous complaints from different sources have reached the Department concerning the inferior lasting quality of the steel-wire fencing which is to be found in the market at the present time. Among the various statements of fact and explanations which have been advanced, whether supported by sufficient evidence or not, the following may be cited to show the necessity for a thorough investigation of the subject in all its bearings:

(1) That, while the older wire, purchased twenty or more years ago, is frequently found still in good condition, modern wire goes to pieces in from two to five years.

(2) That iron wire resists oxidation better, and therefore is more durable than steel wire.

(3) That the entire difficulty lies in the use of Bessemer steel, and that puddled iron is far better suited to the purpose.

(4) That heavier weight wire was used in the older product, and hence its lasting quality.

(5) That the trouble is wholly caused by the inferior weight and quality of the modern galvanized coating, and that the character of the metal itself has nothing to do with it.

(6) That in order to cheapen the product lead and other adulterants are added to the zinc spelter bath used in making the galvanized coating, and that the methods in use at present are in general inferior to the older methods.

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*Abstract from Bulletin No. 239, U. S. Department of Agriculture.

(7) That the manufacturers do not desire to make a resistant wire, but prefer a product that will require frequent renewal.

(8) That the majority of consumers prefer cheapness to any other consideration, and that if a better product can be manufactured for a higher price, there will be little or no market for it.

(9) That the whole agitation is ridiculous and unnecessary, as better wire is now being manufactured than ever before, and that the whole trouble lies in the greater amount of coal that is at present consumed, leading to an increase of corroding gases in the atmosphere.

(10) That the manufacturers are aware that all is not right and are anxious to do all in their power to improve the durability of their product.

While some of these claims may be considered extreme, they also contain much that is true and worthy of careful investigation. At all events, a very large amount of evidence can easily be obtained to show the truth of the original contention that the older iron wire is much more durable than modern steel wire.

MANUFACTURE OF IRON AND STEEL.

Before the user of steel wire can intelligently consider the problem of the corrosion and deterioration of iron and steel, it is necessary that he should be to some extent familiar with the methods of manufacture, the system of classification, and some of the effects of the ordinary impurities.

Iron as it is manufactured from its ores is never pure, nor would perfectly pure iron be suitable for the various purposes for which the metal is used. Iron is found in nature combined with oxygen in the form of an oxide, in which it occurs in great reddish-brown or bluish rock-like deposits, known as hematite and limonite. There are several oxides of iron, which differ from each other in the relative amount of oxygen which is combined with the iron. The ordinary red oxide which forms when iron rusts is essentially the same oxide that occurs in nature as hematite ore.

HOW CAST IRON IS PRODUCED.

In rusting, oxygen is added to the iron, and in smelting the ore, oxygen has to be taken away from the iron. To do this, ore is mixed with coke and limestone and heated in large furnaces, so arranged that a blast of hot air can be forced in through suitable holes near the bottom. Air consists mainly of a mixture of oxygen and nitrogen gases, and at the high temperature of the blast furnace a great many things happen. Coke is almost pure carbon, and when it burns in the furnace it not only combines with all of the oxygen of the air, but also takes away all of the oxygen which was combined with the iron in the ore, passing out of the stack in the form of gases. The metallic iron is thus set free in a liquid or molten condition, in which it falls to the bottom, or hearth, of the furnace.

Now, however, we come to an important point. Carbon is very soluble in molten iron, and as more than enough carbon to combine with the oxygen is always present, the molten metal is really a solution of carbon in iron. This simply means that the carbon goes into the iron just as sugar or salt will pass into water. At definite times the molten metal is allowed to run out of the tap hole of the furnace into a series of sand molds, which is known as the pig bed. There the iron cools more or less rapidly, but as it cools another very important thing happens—part of the dissolved carbon crystallizes out into hard crystals of solid carbon as the mass takes on the solid condition, while the rest of the carbon remains in the iron and does not crystallize out. The carbon which does not crystallize out is now believed to be in part combined with the iron and in part held in a state known scientifically as "solid solution," but by the iron metallurgist it is spoken of as "combined carbon." The crystalline carbon is far more like black diamond than it is like the soft, greasy variety of carbon known as graphite, from which lead pencils are made, and yet the iron metallurgist has come to speak of this free carbon in his metal as "graphitic."

Besides carbon, the molten iron either dissolves or combines with several other substances that are of the very greatest importance in the metallurgy of iron. These are sulphur, phosphorus, silicon, and manganese. All these so-called elements are introduced into the furnace, not necessarily on purpose, but as impurities in the ore, coke, and limestone; and while, if not properly controlled, they become very harmful, some of them, like carbon and silicon, are absolutely necessary to the proper working of the iron.

Pig iron is the crude form of iron, the raw material for the manufacture of all the finished grades of iron and steel. When simply melted up in a reheating or cupola furnace and cast into shapes, such as car wheels, a good iron may have the following analysis:

	Per cent.		Per cent.
Total carbon	3.50	Manganese	.40
Graphitic carbon	2.90	Phosphorus	.50
Combined carbon	.60	Sulphur	.08
Silicon	.70		

As is well known, cast iron cannot be forged into shapes or drawn into wire, on account of its crystalline granular structure. In order to render iron suitable for working in this way, it must be changed by some process into what is known as wrought iron or into steel.

Described briefly, the Bessemer process consists of pouring molten cast iron into a large pear-shaped vessel called a "converter," fur-

THE BESSEMER PROCESS.

nished with a number of small holes in the bottom, through which a blast of air is forced under high pressure. By this means the carbon is nearly all burned out, together with the silicon. The iron, too, is slightly burned, and after the blow is over a certain amount of manganese, in the form of lumps of an alloy or combination of manganese and iron known as ferro-manganese, is thrown into the converter before the metal is poured into the molds to cool. These cooled blocks of steel are known as "ingots." This addition of manganese is a very important point in the metallurgy of steel, and, as we shall have occasion in this paper to return to it frequently, it is necessary that the various reasons for the operation should be understood.

(1) If the molten metal were to be immediately poured after the blow, it would be found on cooling to be full of cavities, known as "blow holes," caused by the retention in the metal of gases from the air blast, and would be quite unfit for any purpose whatever. For reasons which it is not necessary to explain here, the action of even the small amount of manganese that is added is almost magical in its effect. The burned iron is again reduced or deoxidized, the mass of metal becomes more perfectly fluid, the gases escape, and the metal pours smoothly and evenly. In other words, the manganese acts as a so-called "flux."

(2) Just as small quantities of carbon dissolved in iron change and modify its properties, so small quantities of other substances produce their own effects. Manganese is supposed to decrease the danger of breaking up as the metal passes hot through the rolls in the "rod mills."

It is now apparent that manganese plays an important role in the Bessemer process, and, in fact, Bessemer steel will generally be found to contain anywhere from 0.4 to 1 per cent. of manganese.

BASIC OPEN-HEARTH PROCESS.

Phosphorus and sulphur both have a deleterious effect upon steel, reducing the ductility and making the metal brittle. In a process like the one just described, it is necessary to specify that the pig iron shall contain below a certain percentage of phosphorus. This would, of course, exclude much of the pig iron that is manufactured, as phosphorus, in some of its combinations, is almost always found in iron ore. By making the lining of the furnace out of a material that will combine with elements like phosphorus, which easily combines with oxygen to form phosphoric acid, much of this impurity may be made to combine with the furnace lining and to remove itself from the metal by entering the slag floating on top of the molten mass. Without going further into the chemistry of the subject, this is all that is meant by basic open-hearth steel, namely, that the pig iron is melted in large basin-shaped furnaces in which the carbon is burned out by the play of hot air over the surface of the molten mass, while at the same time the acid-forming impurities, such as phosphorus and silicon, are absorbed by the basic lining of the furnace, which is usually made of a rock material found in nature, consisting of carbonate of lime and magnesia, and known as "dolomite." Lime or limestone is also added to hasten this action and save the lining. With the exception that the hot air is not blown through the molten metal, the open-hearth process is much like the Bessemer. At the end of the run ferro-manganese is thrown into the liquid bath of metal to flux it. This is done sometimes in the furnace and sometimes in a ladle into which the metal is tapped. It is then run off into the ingot molds to cool in the usual way. It will be noted that the open-hearth process depends essentially, as does the Bessemer, upon refluxing with manganese.

PUDDLED IRON.

It only remains now to outline briefly the older puddling method by which wrought iron was made, which yielded most of the extremely durable wire that was found in the market many years ago. This process consists essentially of heating the iron in flat-shaped furnaces to a more or less fluid or pasty condition and then working it over and over in the presence of air by means of special tools known as "rabbles," in the hands of skilled workmen. By this means the impurities are oxidized and burnt off, and the slag or cinder which always forms is worked into the metal, so that when it comes to be rolled not only are the impurities very evenly distributed throughout the mass, but it possesses the structure of a bundle of fibers, each one of which is coated with a film of cinder, which protects it in very large measure from subsequent rusting. This cinder is composed of oxide of iron, combined with silica, which comes from the fireclay lining of the furnace, for in this process basic linings are not used.

In the minds of most metallurgists some sort of return to this older method would be the best solution of the problem of the manufacture of wire which would resist oxidation, but the trouble lies in the impossibility of competing with the price of metal manufactured by the more economical modern processes. It must be apparent to everyone that the high price of labor would not permit hand-worked metal to compete on a large scale with that produced by modern methods. It has, however, been proposed to use a form of mechanical puddling which would be capable of treating at one time charges of metal as large as those used in the Bessemer process. It is not impossible that eventually this will furnish a solution of the difficulty.

MILD AND HIGH-CARBON STEELS.

As has already been pointed out, steel is to be considered as an alloy or solution in varying proportions of carbon in iron. It may now be said that within certain limits the higher the carbon content the harder the steel. Mild steel is that in which the carbon rarely runs above 0.1 to 0.2 per cent., while in hard steel the carbon may run as high as 1 per cent. or even higher.

The following analyses may be taken as fairly typical of the various kinds of metal we have been discussing, although these figures may of course vary widely with the different degrees of hardness that the manufacturer desires to obtain:

CONSTITUENTS.	Bessemer Steel. Per Cent.	Basic* Open-Hearth Steel. Per Cent.	Swedish Puddled Iron. Per Cent.
Carbon	0.10	0.70	0.04
Manganese	.50	.50	.06
Sulphur	.08	.06	.01
Phosphorus	.102	.05	.01

* Open-hearth metal may run much lower in carbon and much higher in manganese than these figures indicate. Some samples which have been received ran as high as 1.5 per cent manganese

The presence of these various impurities complicates the difficulty in tracing the trouble to any one element. In some grades of wire it is said to be a positive advantage to have high phosphorous and silicon, but in fence-wire stock these elements are present in comparatively small quantity, while the carbon and manganese run high. It will be noticed that the amount of impurities in the Swedish iron is extremely small.

MANUFACTURE OF WIRE.

Having now described briefly the various kinds of metal used in the manufacture of wire, it will be necessary to explain the methods of wire making, or such as apply to the sort of wire that is used for fencing.

The ingots already described, after cooling in the molds, are reheated to a bright red heat, rolled down, and cut into lengths of a certain shape and size, known as "billets." Most wire-fence manufacturers buy either their wire or their billets from the steel mills, and comparatively few make their own steel. The horizontal heavy wires of a woven fence are usually made from a fairly high-carbon hard steel, in order to attain great tensile strength or resistance to breaking under strain. The vertical or tie wires must of course bend easily without breaking, and they are made from a mild or soft steel, usually Bessemer metal. All metal used for fence wire at present made in this country is classed as steel, irrespective of the percentage of carbon or whether made by the Bessemer or open-hearth process. The billets are rolled hot into No. 5 gauge wire rod. This is then pickled in sulphuric acid until clean, then soaked in hot lime-water to remove the acid, and baked for about half a day, when it is drawn cold through dies of hard steel to the required gauge, usually No. 12. The lime coating on the wire lubricates it, and prevents it from cutting out the dies. The wire is now ready for galvanizing, which consists of running it through brick tubes or ovens, which are heated by coal or gas, where the process of annealing or softening takes place. When the wire is cool enough it enters a bath of acid, which cleans it and removes any scales that may have formed during the process of annealing. This so-called "pickle" consists of diluted muriatic acid, and is a necessary treatment, as the wire would not take the zinc unless it had first been through the acid bath. The question as to whether the acid should be washed from the wire before it enters the zinc bath is important, and manufacturers seem to differ in their practice. It is by no means certain that acid included in the zinc and under it will not tend to corrode the metal rapidly. Some sort of chloride is undoubtedly necessary to make the iron take the zinc, but it is natural to suppose that the presence of actual acid should be avoided.

The wire is next run into a vessel about 16 feet long containing melted zinc. As the wire emerges from the zinc bath it is run through asbestos wipers, which wipe off nearly all of the zinc and leave a smooth coating, which amounts usually to about 1 to 1½ per cent. of the wire. The discussion of the method of galvanizing will be reserved for a separate section; it is sufficient to point out at this place that the coating of zinc furnished by this single process is very thin, and therefore presumably more perishable than a thicker coating would be. After the wire is galvanized, if a woven-wire fence is to be made, it goes to the weaving room, where the finished product is turned out. In some cases, especially in the manufacture of fine wire fencing, such as poultry mesh, the galvanizing is done after the weaving.

INVESTIGATION OF THE CAUSES OF FENCE-WIRE CORROSION.

Having now followed the processes of the manufacture of steel-wire fencing from the ore to the finished product, we are in a position to consider intelligently the information that has been obtained by means of a rather long and detailed investigation.

EXAMINATION OF SAMPLES OF WIRE.

Evidently the first thing to be done was to prove beyond all doubt that the older wire, as claimed, did outlast modern steel wire; and secondly, to determine, if possible, the reason for this. A large number of letters were received from all over the country in response to official inquiry, and all pointed in the same direction. As far as human testimony is capable of establishing a fact, there need be not the slightest question that modern steel does not serve the purpose as well as the older metal manufactured twenty or more years ago.

A great number of samples of wire were sent to the Division of Tests, and a series of analyses were made to see whether chemical analyses would throw any light upon the subject. In a paper of this kind it is not desirable to go too deeply into scientific and technical details, and therefore no tabulated results of analyses will be given. It is sufficient for our present purpose to state that it soon became noticeable that the majority of the old wires sent in which were in good condition were either free from manganese or contained only very small amounts—0.2 per cent. or under of this metal. It is true that many of the good wires ran as high as 0.5 per cent. and even higher in manganese, but the fact was nevertheless noticeable that the bad wires, with very few exceptions, contained manganese, while the good wires were frequently, if not always, free from it.

ELECTROLYLSIS AND ITS EFFECTS ON WIRE.

In order to pursue the inquiry further it will be necessary to show just how the manganese can have the bad effect that it does. Nearly everybody has probably heard at some time that steel pipes and conduits are liable to corrosion, owing to electrolysis or galvanic action. As a word this may be satisfactory, but unless the exact character of the action which it describes is understood it is a very unsatisfactory explanation. If this paper were to sum up the whole investigation by saying there is reason to believe that the cause of the rapid deterioration of steel fence wire has been traced to electrolysis induced by unequal distribution of manganese or other impurities, perhaps some readers might justly complain of being little wiser than before. It is necessary, therefore, to define as simply as possible "electrolysis," "difference of potential," and several other terms which will be used in this discussion before proceeding further.

If we wish to generate in a house small currents of electricity with which to ring an electric bell it is necessary to purchase or make a simple form of electrical cell or battery. Reduced to its simplest terms, this usually consists of a strip of zinc and a strip of some other metal immersed in a more or less dilute solution of some salt. Common table salt would do, but for special reasons some other soluble salt, like chloride of ammonia, is usually selected. If now by means of a wire or other metallic conductor the zinc strip is connected with the other metal, an electric current flows through the circuit. Whenever this is able to happen, we say that there is a difference of potential between the zinc and the other metal. In general, whenever a difference of potential is established between two points in a metallic conductor or circuit a current of electricity will flow. If in the case of the battery referred to, the current is allowed to flow through an especially constructed electro-magnet, it can be caused to ring a bell. In the same way, if the current were strong enough, it could be used to saw wood or to run a street car. In other words, electric currents, however small, represent energy and can be made to do work.

There is a great and well-known law of nature which tells us that it is impossible to get something for nothing. If work is being done in one place, something is being, so to speak, undone in another place to balance it exactly. Every person who climbs upon a street car pays a fare, which represents, at least in some degree, the cost of the coal or carbon which has to be burned (oxidized) at the power house in order to move him. Every time the bell rings in the house the zinc in the battery is corroded or oxidized or burned up to represent the work done. Whenever, through the agency of a liquid conductor like a salt solution, a current of electricity moves in a circuit, this is known as electrolysis. Whenever electrolysis goes on, some chemical reaction takes place, which, for all practial purposes, can be likened to the oxidation or burning of some metal. If a battery were to be made, as could easily be done, in which iron took the place of zinc, then iron would be oxidized instead of zinc. If two pieces of iron of different chemical analysis—that is to say, containing different amounts of impurities—are dipped into a dilute solution of salt and the ends connected, it will be found that a difference of potential exists, an electrical current will flow, and, if continued, at least one of the iron pieces will be destroyed by oxidation. With this simple explanation of electrolysis in mind, we may return to the consideration of the oxidation of iron and steel.

The tendency of iron and steel to rust or oxidize is a characteristic of the metal itself, independent of the presence of any impurities it may contain. No iron has ever been or ever could be manufactured that would not rust in moist air, unless it were protected by some sort of covering. There is, however, a very great variability in the way different irons rust. One will cover itself over with a superficial layer of oxide, which will then act as a coating, protecting the metal for many years, while another will pit so badly that the corrosion eats to the heart of the metal in a short time. Samples of wrought-iron cut nails that had been exposed to the weather for forty years were sent to the laboratory and found to be in as good condition as the day they were bought, while samples of steel wire four years old, which were originally galvanized, have been received which were pitted to the breaking point. Our problem, therefore, is not to find a kind of iron that will not rust, but to determine the causes which lead to the kind of rusting which makes wire short-lived, whether it is furnished with a protective coating or not; and, further than this, to see if there is not some way in which we may eventually be in a position to insist upon specifications for steel wire that will be reasonably resistant.

Wire that is hung in the field is in just the condition to suffer from electrolysis if the metal is not perfectly homogeneous in structure; that is to say, if the manganese and other impurities are not perfectly distributed throughout the metal. All rain water contains small amounts of salts dissolved from the dust in the air, and is therefore a conductor of electricity. Water collected during a thunder shower is particularly rich in substances that conduct electricity, as the sparking of the lightning through moist air forms small quantities of nitric acid, and acids conduct electrical currents even better than salt solutions. A moment's thought will show that under the conditions cited we have all the elements present to cause electrolysis to take place. Differences of potential will occur in the wire, local circuits will be established through the wires or through the wires and ground, and currents will flow. Just as in the case of the bell battery, these currents can only be generated at the expense of something, and in this case it is the iron if it is not the zinc of the galvanized covering. This explanation is capable of accounting for the deep pitting observed in the corrosion of many wires, this pitting being characteristic of electrolytic action. It also accounts for the much more rapid corrosion of wire near the seashore, as the rain water in such a locality contains more salt, and thus this action is hastened.

If manganese is unevenly distributed in the metal, why, it may be asked, have chemists generally failed to notice the fact in the course of large numbers of duplicate analyses that have so frequently been made? The answer to this question lies in the fact that such extremely small differences in the chemical composition as might easily escape detection in ordinary chemical analysis are still sufficiently large to account for slight differences of electrical potential. It is almost impossible to select two steel needles from the same package which, if tested against one another with sufficiently delicate electrical measuring instruments, will not show a difference, even though the chemical composition appears to be practically the same. Metallurgists claim that even when a molten bath of metal is very evenly mixed in the beginning, the cooled ingot made from this metal will show a certain amount of unevenness, owing to what is technically known as "segregation," which takes place while the ingot is cooling. A recent investigator has claimed that manganese segregates much less than some of the other impurities, notably sulphur and phosphorus. So little is definitely known about this subject as yet, however, that more experimental evidence is necessary.

Although it is probable that the effects of electrolysis in a fence wire are extremely small, it must be remembered that they are continually going on whenever the wire is wet. While it is true that puddled iron is in large measure protected from corrosion by the presence in its fibers of mill cinder, this has nothing to do with the fact that in almost all modern steel woven-wire fences some wires will be found to far outlast others, independent of the original weight of the galvanized covering which they carry. If in woven wire fence all the wires would last as well as the best ones do, there would have been no complaints, and this investigation would never have become necessary. It is just this point of unevenness of lasting quality in wires from successive heats in the same mill, which have practically the same chemical composition, that is hard to explain by any theory but that of galvanic or electrolytic action. The manufacturers have believed that the whole trouble was in the unevenness in the weight of zinc covering that was put on the wire, but experiment and observations show that this is not so. Some wires will go to pieces before others, although there is no discernible difference either in the weight or quality of the zinc covering. In one fence which has been under observation for four years one wire was in perfect condition, although it carried a light covering of zinc, while the wire next to it was badly rusted from end to end. Careful chemical analyses were made of these two wires, and, in order to check the results secured, samples were sent to one of the most eminent iron chemists in the country. This chemist reported as follows:

"We have examined these samples, finding as follows:

CONSTITUENTS.	Good Wire. Per Cent.	Bad Wire. Per Cent.
Carbon	0.17	0.17
Manganese	.45	.53
Phosphorus	.092	.096
Silicon	.070	.060
Sulphur	.059	.083

"You will note that, so far as these two samples go, there is very little difference in the wire, and practically no explanation chemically as to why one should be good and the other bad. They might almost be from consecutive heats from the same Bessemer converter; I do not think they are from the same heat. Notwithstanding this similarity of analysis of the samples which we have examined, it is more than probable that there may be quite unequal distribution of the manganese in the two samples."

It would seem that the easiest way to prove once and for all whether unequal distribution of the impurities is at the bottom of the trouble would be to make a great number of analyses of samples taken from different parts of just such wires as these. Unfortunately, however, the slight but unavoidable errors of chemical analysis are apt to be as large, if not larger, than the slight differences we are trying to detect. It is also probable that the problem is complicated by the variation of more than one element. For instance, the combination of manganese and sulphur is known to show a larger difference of potential to iron than manganese alone. It would be natural to suppose that the easiest way to correct the trouble would be to cut down, in the process of manufacture, as much as possible the impurities that are present, but the difficulties in the way of doing this will now be understood.

Leaving the subject of laboratory investigations, we may now turn to the result of observation in the field. Almost everyone who has taken the pains carefully to inspect woven-wire fence as it is exposed to the weather on the farm has observed that some of the wires go to pieces much more rapidly than others. The bottom wires lying close to the ground, which are kept wet in summer by the growth of weeds and grass and in winter by melting snow, are naturally the ones which we should expect to rust most quickly. As a matter of fact, however, they almost never do so, but, on the contrary, are far more lasting than the wires farther removed from the ground. This observation has been substantiated by a large number of competent observers. Furthermore, wires that are stapled to living trees will almost invariably be preserved to some extent in the immediate neighborhood of the point of contact. One explanation that has been offered for these undoubted facts is that a certain protection from wind and weather is furnished by the growth about the wires, but this explanation is far from satisfactory. One would not seek to preserve iron from rust or zinc from corrosion by laying these metals away in wet snow or weeds. If, however, electrolysis takes place, and if the action can be diminished by keeping the wires electrically neutral through frequent connections to the earth, or through frequent short circuits, we should then expect that wires which were kept along their whole length in constant contact with the earth would, in the long run, show greater lasting quality. Experiments are at present being made to test the effect of earthing the fence by frequent connection to the ground. It is not easy to carry on a discussion of this highly technical subject in a paper of this nature, and it must be left for future presentation elsewhere.

THE PROCESS OF GALVANIZING WIRE.

The consideration of the protective effect of covering wire with a coating of zinc has been purposely put off up to this point. Why, it may be asked, does the quality of the steel make any difference, if it is to be covered with a protective coating of zinc? The answer is simple. It is extremely unlikely that any coating is sufficiently waterproof or sufficiently elastic not to develop numerous cracks and openings through which water can act and electrolysis begin. Once begun, the electrolytic action corrodes zinc even more rapidly than it does steel. This may explain the very rapid disappearance of the galvanized covering from some wires and its great tenacity on others.

It will now be necessary to explain briefly the methods and practice of covering wire with zinc. In the first place, the word "galvanizing" as used gives a wrong impression. It is possible to dissolve zinc in an acid, and then, by means of a galvanic current, by the very principles of electrolysis, properly controlled, that we have been discussing, to deposit it as a coating upon another metal, like iron. It has been shown that this method will give the most adhesive coating of zinc upon iron that it is possible to obtain. When we think, however, of the large amount of wire fencing made and the price for which it must be sold, one might as well consider plating it with gold as to suppose that fence wire is to receive a true galvanized coating. The universal custom is to pass the wire, when manufactured for fencing, after it has been cleaned with acid, through a molten bath of zinc, and then through asbestos wipers, as has been described in an earlier part of this paper. The object of the wipers is to remove all excess of zinc and make the coating smooth.

The zinc ordinarily used for fence wire is known as "spelter." It is made of virgin ores and consists of about 99 per cent. of zinc, 0.1 per cent. of iron, 0.5 per cent. of lead, and occasionally cadmium and some other elements, depending on the location of the zinc mine. The ordinary weight of the zinc protective coating per unit weight of wire for fencing purposes is made as small as possible, and will often run as low as from 1 to 1.5 per cent. The temperature of the galvanizing bath should be kept as low as possible, to prevent excessive drossing of zinc and disintegration of the metal.

A very much better covering and perhaps a more durable wire can be made by what is known as the double galvanizing process. The double process does not, as its name implies, mean that more than one coating of zinc is put on, but only that about twice as much zinc by weight is carried by the wire. In the double process the wire is drawn much more slowly through the zinc bath and does not pass through asbestos wipers, but is smoothed by passing through a shallow bed of slightly damp charcoal powder. Telegraph wire is usually treated by this method, and is generally acknowledged to be more durable than fence wire, but it is worth noting at the same time that care is exercised in the manufacture of telegraph wire to keep the manganese low, because the presence of this element increases the electrical resistance of the wire. The difficulty experienced in rolling low-manganese steel and the slow rate of speed at which the mill must be run to draw the wire through the zinc bath in the double process adds materially to the cost of the product. It is a question that cannot be decided here, whether or not high-grade fence wire is worthy of the same care and consideration that is given to wire which brings a higher price in the market and which is intended for other purposes.

Although, as has been said in an earlier paragraph, it is not the intention to maintain that the weight of the galvanized coating has nothing to do with the lasting quality of fence wire, in view of the evidence which has been collected it is impossible to believe, as many people do believe, that insufficient galvanizing is the whole cause of the difficulty. Among the wire fences that have been under the careful observation of the writer for a long time is one woven-wire fence five years old that contains among its twelve horizontal wires, all of one roll, seven wires that are perfectly good from beginning to end, four that are partially rusted, and one that is badly rusted, without a particle of zinc remaining on it. Of the seven perfectly good wires, six are on the bottom. Now, if the theory of electrolysis is left out of the question, it would seem that the good wires had received a better coating of zinc than the bad wires. This explanation is not supported either by observation or experiment. Two wires are made in the same mill, pass through the same zinc bath, are wiped off in precisely the same way; chemical analysis shows them to have practically the same weight of zinc covering per pound of metal; and yet one wire will outlast the other 5 to 1 on the fence. It is, however, entirely possible that the perfection with which the manganese and other impurities are distributed may happen to be more perfect in one ingot than it is in another. Within certain practical and possible limits it is probably true that, other things being equal, the wire with the heavier zinc coating per unit of surface area will be the most resistant to weather conditions.

None the less, in the opinion of the writer and for the reasons outlined in the foregoing pages, the problem will not be solved until attention is directed to obtaining the proper conditions in the wire itself. Although the Department of Agriculture cannot undertake to make specifications, it is highly probable, now that the attention and interest of manufacturers has been aroused, a substantial improvement in the rust-resisting character of fence wire will follow in the future. One of the prominent manufacturing companies claims to have already solved the problem of making a better wire. If these expectations are justified, and even if such improvements remain to some extent trade secrets, there is no question but that the consumer will soon begin to get the benefit of the better quality of fencing, which will result from the persistent effort on the part of manufacturers to improve their product and distance their competitors.

DISCUSSION.

The President:—The report of the Committee on Signs, Fences, Crossings, etc., is before you. The chairman of the Committee, Mr. W. D. Williams, asks that the report be taken up in regular order, and that the specifications for standard right-of-way fences be considered clause by clause, in order that the conclusions with reference to it may be acted upon. As the Secretary reads the various clauses, any member desiring to discuss them will interrupt, and we will discuss the questions. Any clause to which no objection is made will be considered adopted, for the time being, at least.

The Secretary:—"Classes. (1) Three classes of smooth wire fences may be used, the top wire of each to be 4 ft. 6 in. above the ground.

"First-class Fence. (2) First-class fences shall consist of nine longitudinal, smooth, coiled, galvanized steel wires; the top and bottom wires shall be No. 7 gage; intermediate and stay wires shall be No. 9 gage.

"The spacing of the longitudinal wires shall be, commencing at the bottom: 3, 4, 5, 6, 7, 8, 9 and 9 in. The bottom wire shall be 3 in. above the ground, and the stay wires shall be spaced 12 in. apart.

"Second-class Fence. (3) Second-class fences shall consist of seven longitudinal, smooth, coiled, galvanized steel wires; the longitudinal wires and stay wires shall be No. 9 gage.

"The spacing of the longitudinal wires shall be, commencing at the bottom, 5, 6½, 7½, 9, 10 and 10 in. The bottom wire shall be 6 in. above the ground, and the stay wires shall be spaced 22 in. apart.

"Third-class Fence. (4) Third-class fences shall consist of four longitudinal, smooth, coiled, galvanized steel wires; the longitudinal and stay wires shall be No. 9 gage.

"When desirable 1x2-in. wooden stays, stood on the ground and interlaced between the longitudinal wires, may be used, spaced 6 to 8 ft. apart, in place of or in addition to the stay wires.

"The longitudinal wires shall be spaced 14 in. apart; the bottom wires shall be 12 in. above the ground, and the stay wires shall be spaced 22 in. apart."

The President:—"If there are no objections to the general clauses, we will proceed with "Material."

The Secretary:—"Posts. (5) Posts shall be of .... They shall be straight and free from rot or other defects. Split or sawn posts may be used in localities where round posts are not economically available; their dimensions shall be at least equal to those hereinafter specified for round posts."

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis):—Going back to paragraph 5, I wish to ask whether the Committee intends to make any provision for concrete posts. They are becoming quite common, and to say that they shall be free from rot or other defects is hardly consistent.

Mr. W. D. Williams (Cincinnati Northern):—The Committee did not have that material in mind when writing the specifications. A good many reinforced concrete posts are used. If the paragraph is all right otherwise, we can omit the word "rot."

Mr. McDonald:—You might say that wood posts shall be straight and free from rot. That would cure it.

The President:—The Committee accepts Mr. McDonald's suggestion that in paragraph 5 the word "wooden" shall precede the first word "posts." Is there any discussion as to that? The reason the chair calls attention to this is that in many portions of the Northwest the seven-foot pole is still standard and is uniformly cut and used.

The Secretary:—"End Posts. (6) End or gate posts and intermediate bracing panel posts shall be 9 ft. long and 8 in. in diameter at the small end, or 8x8 in. if sawn.

"Intermediate Posts. (7) Intermediate posts shall be 8 ft. long and not less than 4 in. in diameter at the small end.

"Braces. (8) Braces for end posts, gate posts and intermediate brace panels shall be of 4x4 in. common lumber, 12 ft. long, free from large knots, splits or rot.

"Wire. (9) All woven wire fences shall be constructed of steel galvanized wire.

"All longitudinal wires shall be coiled.

"The elastic limit of all wire shall be at least 1,500 lbs. for No. 9 gage wire, and 2,000 lbs. for No. 7 gage wire.

"The ultimate tensile strength shall be at least 1,800 lbs. for No. 9 gage wire, and 2,500 lbs. for No. 7 gage wire. It must stand without sign of fracture, winding tight around wire of the same size.

"Stay Wires. (10) All stay wires shall be straight and of No. 9 gage.

"Locks. (11) The locks or fastenings at the intersection of the longitudinal and stay wires shall be of such design as will prevent them from slipping either longitudinally or vertically.

"Staples. (12) Staples used in posts shall be 1 in. long for hard wood, and 1½ in. long for soft wood, and be made of No. 9 galvanized steel wire.

"Galvanizing. (13) All galvanizing shall consist of an even coating of zinc, which shall withstand one-minute immersion tests in a solution of commercial sulphate of copper crystals and water, whose specific gravity shall be 1.185 and whose temperature shall be from 60 to 70 degrees Fahrenheit. After each immersion the sample shall be washed immediately in water and be wiped dry. If the zinc is removed, or a copper colored deposit is formed after the fourth immersion, the lot of material from which the sample is taken shall be rejected."

Mr. L. C. Fritch (Illinois Central):—I would like to suggest to the Committee that they change the relative pronoun "whose," before the words "specific gravity," and substitute the words "of which."

The President:—The Committee accepts that. The word "whose" will be stricken out and the words "of which" inserted, so that the paragraph will then read, "All galvanizing shall consist of an even coating of zinc, which shall withstand one-minute immersion tests in a solution of commercial sulphate of copper, the specific gravity of which shall be 1.185," etc.

The Secretary:—"Manufacture. (14) The fence shall be so manufactured as not to remove the galvanizing nor impair the tensile strength of the wire."

Mr. McDonald:—On that point, it is absolutely impossible to manufacture a woven wire fence without injuring the galvanizing on stay wires. As the zinc is rigid and lacks elasticity, the bending of the wires cracks it and it flakes off.

Mr. A. L. Buck (Canadian Pacific):—I think the object of the Committee is to get before the manufacturer the fact that the galvanizing can be left intact. It is a fact that when it passes through the machine the galvanizing is fractured. Even by examining the samples closely, you will see that the twisting machine opens up the galvanizing. This is a question on which all fence men disagree. We can only overcome this by galvanizing after the fence is erected, because the steel cannot be made to fit these specifications without warping so as to fracture.

The President:—The point brought out by Mr. McDonald is rather important, and we should have further discussion on it.

Mr. McDonald:—I believe that if the companies are willing to pay for the wire that is galvanized after it is woven, they can get it, and they will get a much better quality of fence than they are getting now. I think many of the gentlemen present have observed that the stay wires rust out before the horizontal wires. The reason is that the galvanizing on the stay wires is made thin on purpose, so that it will not crack when bent; but it is made so thin it is of very little use, and if the Committee could put in an alternate clause that would admit of two kinds of wire—one the ordinary kind on the market and the other kind to be galvanized after it is woven—perhaps that would be of some benefit.

Mr. Buck:—I cannot agree with Mr. McDonald about the stay wires rusting before the horizontal wires. I find it is a fact that you can take a fence that is falling, and you will find the horizontal wires practically as good as they were the day they were put in the fence; but the matter of workmanship is a different thing, and should be done so as not to destroy the galvanizing. If the wire is galvanized according to these specifications for immersion, it will probably answer the purpose; but in order not to destroy the galvanizing after the test is made, it would be almost necessary, I believe, to galvanize it after the fence is put together. No matter what the galvanizing that has been done before, I do not believe it will stand the machine test.

The President:—The effect of paragraph 14, if strictly applied, would be to compel the use of wire galvanized after it was woven or the use of stay wires electrically welded to the longitudinal cables. That is an interesting point, and we would like some discussion upon it. Mr. Trimble, have you anything to say?

Mr. Robert Trimble (Pennsylvania Lines):—I am not very much in favor of galvanizing iron fences. The best that I have seen have lasted about two years, and I would like to get away from it as fast as possible.

The President:—Mr. Carothers, of the Baltimore & Ohio, comes from a smoky and sulphurous country. Have you anything to say on this point, Mr. Carothers?

Mr. D. D. Carothers (Baltimore & Ohio):—I have not.

Mr. McDonald:—I do not believe that any wire fence can be manufactured after the wire is galvanized. Undoubtedly it would be of advantage to be galvanized after it is woven, to produce the best results.

The President:—Does the convention desire to take any action upon paragraph 14? If there is no objection, we will pass it, and take up the items under the head, "Erection."

Mr. McDonald:—Before we leave that section, I wish to state that I made a point a short while ago that I find necessitates some other changes in one or two paragraphs. I did not understand the Secretary, and corrected the defect in paragraph 5. I move that the word "they" be stricken out and "wooden posts" be substituted, making it read, Posts shall be of .... Wooden posts shall be straight and free from rot or other defects." If that is acceptable to the Committee, I will proceed further.

The President:—Striking out the word "wooden" from the first portion?

Mr. McDonald:—No, sir; strike out the word "they" in the first line and substitute for that "wooden posts."

The President:—And allow "wooden" to remain in at the beginning of the paragraph?

Mr. McDonald:—No, sir; it was not my intention to put it in the beginning of the paragraph at all. You cannot say wooden posts shall be of concrete. In regard to paragraph 6, after the word "posts," in the first line, I move to add the words, "when made of wood," making it read, "end or gate posts and intermediate bracing panel posts when made of wood shall be 8 ft. long and 8 in. in diameter at the small end, or 8x8 in. if sawn." The reason I say that is that eight inches would hardly apply to a concrete post. In the eighth paragraph, at the beginning of the second line, insert the words, "when made of wood," so that the dimensions given there will not apply to reinforced concrete.

The President:—Does the Committee accept those additions?

Mr. Williams:—Yes, sir.

The President:—We will now proceed with the reading of the third portion of the specifications, under the heading "Erection."

The Secretary:—"End Posts. (15) End posts shall be set vertical, at least 4 ft. in the ground, thoroughly tamped, braced and anchored.

"Gate Posts. (16) Gate posts shall be set vertical and braced in a similar manner to the end posts.

"Intermediate Posts. (17) Intermediate posts shall be set at least 3 ft. in the ground, and from 16½ to 33 ft. apart, depending upon the nature of the ground and the service required. Holes of full depth must be provided for all end and gate posts, even if blasting must be resorted to. For intermediate posts, where rock is encountered, not more than two adjacent posts shall be set on sills 6x6 in. by 4 ft. long, braced on both sides by 2x6 in. braces, 3 ft. long. Holes must be provided for all other posts.

"All posts shall be set with the large end down.

"All posts shall be set in perfect line on the side on which the wire is to be strung. After the fence is erected, the top of the posts shall be sawed off with a one-fourth pitch, the high side being next to the wire and 4 in. above it.

"Anchoring. (18) All end and gate posts shall be anchored by gaining and spiking two cleats to the sides of the posts, at right angles to the line of fence, one at the bottom and the other just below the surface of the ground. The cleat near the ground surface to be put on the side of the post next the fence and the bottom cleat to be put on the opposite side.

"Intermediate posts set in depressions of the ground shall be anchored by gaining two cleats into the side near the bottom of the post, same to be properly spiked.

"Cleats. (19) All cleats shall be 2x6 in. by 3 ft. long, of common lumber.

"Bracing. (20) All end, corner and gate posts shall be braced by a piece of 4x4 in. common lumber, gained into the end corner or gate post, about 12 in. from the top, and into the next intermediate post, about 12 in. from the ground, and be securely spiked. A cable made of a double strand of No. 9 soft galvanized wire looped around the end post at the ground line and around the next intermediate post, about 12 in. below the top, shall be put on and twisted until the top of the next intermediate post is thrown back at least 2 in.

"Stretching. (21) Longitudinal wires shall be stretched uniformly tight, and be parallel; stays shall be straight and vertical and be uniformly spaced.

"The wires should be placed on the side of the post away from the track, except on curves, where they should be so placed that the pull of the wires is against the post.

"Stapling. (22) All staples shall be set diagonally with the grain of the wood, and be driven home tight. The top wire shall be double stapled.

"Splicing. (23) Approved bolt clamp splices or a wire splice made as follows may be used: In making wire splices the ends of the wires should be carried 3 in. past the splicing tool and wrapped around both wires backward toward the tool for at least five turns, and after the tool is removed the space occupied by it may be closed by pulling the ends together."

Mr. McDonald:—I find that in my endeavor to revise the clauses under "Material," I have not gone far enough, and it will not be possible to revise those under the heading of "Erection" so as to apply to reinforced concrete posts. I think, therefore, the title of this specification should be amended to read, "Specifications for standard right-of-way fences built with wooden posts," and restore the text as it stood originally. It is impossible to correct it; yet I think the matter of concrete posts has gone to such an extent that it is time we should recognize that they are built.

Mr. Williams:—That was our object, and we accept the suggestion.

The President:—If there is no objection to the suggestion offered by Mr. McDonald, the title will be altered to read, "Specifications for standard right-of-way fences built with wooden posts." Then the other additions of "wooden" and so on through the specifications will be omitted and the original text remain as read. Is there any further discussion on the general specifications before we pass on to other subjects?

Mr. Buck:—Do I understand paragraph 17 to mean every third hole shall be blasted in rock country to the depth of three feet? Is that the intention? I would like to know if the Committee would recommend blasting every third hole in rock country for posts.

Mr. Williams:—Yes, sir; that was our intention.

The President:—If there are no objections to the specifications as read, they will be considered as having been approved. This takes care of conclusion 1, where the Committee recommends "That the specifications for standard right-of-way fences be adopted as being good practice."

Mr. G. B. Woodworth (Chicago, Milwaukee & St. Paul):—These specifications refer to smooth-wire fences only. Barbed wire fences are used very extensively in the West.

The President:—The Association is on record as recommending the use of smooth wire in preference to barbed wire for railroad fences.

Mr. A. S. Baldwin (Illinois Central):—Last year the Committee made a report, under instructions, as to what it would recommend for a standard fence. The specifications given were of a very general character, and, as I recall it, the report was referred back to the Committee, with instructions to prepare specifications of what they desired to recommend as a standard fence. I think the Committee is carrying out its instructions.

Mr. Buck:—As I understand these specifications, they are applicable to any section of the country. In some portions of the country it is not permitted to erect barbed wire fences, consequently I do not see how they can be incorporated. It would be a special fence, and would have to be treated as such in erection.

The President:—If there is no further discussion, conclusion 1 will be considered as having been adopted. The Secretary will read the second conclusion.

The Secretary:—"(2) That hard wire, whose ultimate tensile strength for No. 9 gage is from 1,800 to 2,200 lbs., be used for longitudinal wires and that the verticals and fastenings be as near the above in ultimate tensile strength as the action of the various fence weaving or erecting machines will admit without injuring the wire."

The President:—Unless there is objection, conclusion 2 will stand as adopted. The Committee desires to interpolate conclusion 3, as follows: "In conclusion, your Committee believes, first, that the rapid deterioration of modern woven galvanized fence wire is caused by the coating of zinc being too thin and of an uneven thickness; second, that to procure better protection to the wire and a longer lived fence it is necessary to secure an increased uniform thickness of the zinc coating on the wire, and to insure that the galvanizing is intact after the wire has gone through the fence weaving machine it would seem to require that a second coat of zinc be applied to the fence after it is manufactured." Is there any discussion on this conclusion? If there is no objection, it will be considered as having been adopted. The next conclusion, referring to definitions, will be acted upon by correspondence. Any member desiring to criticize or alter the definitions can do so by correspondence, and letter-ballot will settle the matter before they are published. The chairman of the Committee desires to call attention to the fact that the Department of Agriculture has issued a Bulletin, known as Farmers' Bulletin No. 239, entitled, "Corrosion of Fence Wire." A copy of this bulletin has been sent to each member of the Association by mail. Has the convention any suggestions to make for the work of this Committee during the ensuing year?

Mr. Buck:—The gate question, I should think, would be a part of the fence question, and is a very important matter. That is where most of our trouble occurs. It seems to me that it would be within the province of this Committee. Any decision that this Association may make will materially lessen the chances of trouble.

The President:—Are there any suggestins to be made upon the subject of signs? The work of this Committee includes signs, fences and cattle-guards.

Mr. Baldwin:—I would like to see a report from the Committee as to the comparative economy of metal and wooden signs.

Mr. E. E. R. Tratman (Engineering News):—I would like to suggest that a very important subject would be the different kinds of metal and concrete posts, and the extent to which they are being used, with the results attained.

Mr. McDonald:—I think a question that would be of vital interest to everybody would be the construction of the best kind of a cattle-guard.

Mr. Woodworth:—My suggestion would be the best form of crossing for highway and private crossings, especially with reference to providing for the flangeway, and providing proper means of spacing plank or whatever is used next to the rail. That is where there is a good deal of trouble.

The President:—If there are no further suggestions, the Committee will be relieved, with the thanks of the Association.

REPORT OF COMMITTEE NO. X.—ON SIGNALING AND INTERLOCKING.

To the Members of the American Railway Engineering and Maintenance of Way Association:

Your Committee on Signaling and Interlocking has complied with the instructions of the Board of Direction, as published in Bulletin No 63, and submits herewith its seventh annual report, embodying:

(1) Specifications for construction of telegraph block signal and connections.

(2) Standard specifications for mechanical interlocking and material for construction work.

(3) Location of automatic signals and slotting or automatic control of interlocking signals in automatic territory.

(4) Conventional symbols for signaling and interlocking work.

(5) Definitions.

(6) Result of letter-ballot relating to the question of angle travel of semaphore arm for block and interlocking signals, and upwardly inclined arm.

The Committee held meetings June 7, August 15, October 9, 1905, and January 3, 1906. The meetings were attended by Messrs. Dunham, Short, Addison, Ellis, Knowlton, Mock, Peabody, Rudd and Stevens.

CONCLUSIONS.

Your Committee submits for adoption the following conclusions:

(1) That lock and block with track circuit control, using intermediate automatic signals for following movements and abandoning the use of orders, be employed instead of the system of using automatics for both following and opposing movements as an adjunct to the order system for single-track work.

(2) That the arrangement shown in Fig. A is good practice under certain conditions for use on single-track line as a train-order signal and spacing-block signal, and that train-order signal be located to give the best view to approaching engine and trainmen.

(3) That distant signals may be used with train-order and block signal, as shown in Fig. B, and that train-order signal be located to give the best view to approaching engine and trainmen.

(4) That the arrangement shown in Fig. C be adopted when necessary to subdivide the block, and track circuit be used in the subdivided block to control the rear signal, and that train-order signal be located to give the best view to approaching engine and trainmen.

(5) That double-track arrangement be similar to single-track arrangement, as shown in Figs. A, B and C.

(6) That the specifications for construction of telegraph block signal and connections be approved.

(7) That the standard specifications for mechanical interlocking and material for construction work, adopted by the Railway Signal Association, be endorsed as good practice.

(8) That the location of automatic signals and slotting or automatic control of interlocking signals in automatic territory, as shown in Figs. 1 to 10, be approved.

(9) That the conventional symbols submitted be approved.

(10) That the definitions submitted be approved.

Respectfully submitted,

Chas. A. Dunham, Signal Engineer, Great Northern Railway, St. Paul, Minn., *Chairman.*

W. A. D. Short, Signal Engineer, Illinois Central Railroad, Chicago, Ill., *Vice-Chairman.*

C. L. Addison, Assistant to President, Long Island Railroad, Long Island City, N. Y.

F. H. Alfred, Manager, Canadian White Company, Montreal, Canada.

G. E. Ellis, Signal Engineer, Chicago, Rock Island & Pacific Railroad, Chicago, Ill.

H. H. Knowlton, Assistant Engineer, Cleveland, Cincinnati, Chicago & St. Louis Railway, Cincinnati, O.

J. C. Mock, Signal Engineer, Michigan Central Railroad, Detroit, Mich.

J. A. Peabody, Signal Engineer, Chicago & Northwestern Railway, Chicago, Ill.

A. H. Rudd, Assistant Signal Engineer, Pennsylvania Railroad, Philadelphia, Pa.

Thos. S. Stevens, Signal Engineer, Santa Fe Railway System, Topeka, Kan.

Committee.

TELEGRAPH, AND CONTROLLED MANUAL, BLOCK SIGNALS.

The requisites of installation of a Telegraph Block System, as given in the Standard Code of the American Railway Association, are as follows:

REQUISITES OF INSTALLATION.

1. Signals of prescribed form, the indications given by not more than three positions; and, in addition, at night by light of prescribed color.

2. The apparatus so constructed that the failure of any part directly controlling a signal will cause it to give the normal indication.

3. Signals, if practicable, either over or upon the right of and adjoining the track upon which trains are governed by them. For less than three tracks, signals for trains in each direction may be on the same signal mast.

4. Semaphore arms that govern, displayed to the right of the signal mast as seen from an approaching train.

5. The normal indication of Home Block Signals—"Stop."

ADJUNCTS.

The following may be used:

(A) Distant Block Signals interlocked with Home Block Signals; normal indication—"Caution."

(B) Advance Block Signals interlocked with Distant Block Signals if used, normal indication—"Stop."

(C) Advance Block Signals interlocked with Home Block Signals; normal indication—"Stop."

(D) Repeaters or Audible Signals to indicate the position of signals to the signalman operating them.

(E) The automatic release of signals to give the normal indication.

(F) The interlocking of switches with block signals.

(G) Means of communication by bell circuit or telephone for signaling between a block station and outlying switches.

(H) Unlocking circuits between a block station and outlying switches.

(I) The interlocking of telegraph keys with block signals.

Where the semaphore is used, the governing arm is displayed to the right of the signal mast as seen from an approaching train, and the indications are given by positions:

Horizontal as the equivalent of "Stop."

Vertical as the equivalent of "Proceed."

Diagonal as the equivalent of "Proceed with Caution."

The requisites of installation of the Controlled Manual Block System, as given in the Standard Code of the American Railway Association, are as follows:

REQUISITES OF INSTALLATION.

1. Signals of prescribed form, the indications given by two (2) positions, and, in addition, at night, by lights of prescribed color.

2. The apparatus so constructed that a failure of any part directly controlling a signal will cause it to give the normal indication.

3. Signals, if practicable, either over or upon the right of and adjoining the track upon which trains are governed by them. For less than three tracks, signals for trains in the same direction may be on the same signal mast.

4. Semaphore arms that govern, displayed to the right of the signal mast, as seen from an approaching train.

5. The normal indication of Home Block Signals—"Stop."

6. The apparatus so constructed that the failure of the block signal instruments or electric circuits will prevent the display of the "clear" signal.

7. The relative position of the home signal, and track instrument, or releasing circuit, such as to make it necessary that the rear of a train shall have passed ...... feet beyond the Home Block Signal before the signal at the preceding block station can be released.

ADJUNCTS.

The following may be used:

(A) Distant Block Signals interlocked with Home Block Signals; normal indication—"Caution."

(B) Advance Block Signals interlocked with Home Block Signals and with Distant Block Signals, if used; normal indication—"Stop."

(C) Track circuits.

(D) Repeaters or audible signals to indicate the position of signals to the signalman operating them.

(E) The automatic release of signals to give the normal indication.

(F) The interlocking of switches with block signals.

(G) Means of communication by bell circuit or telephone for signaling between a block station and outlying switches.

(H) Unlocking circuits between a block station and outlying switches.

Where the semaphore is used, the governing arm is displayed to the right of the signal mast as seen from an approaching train, and the indications are given by position:

Horizontal as the equivalent of "Stop."

Vertical or diagonal as the equivalent of "Proceed."

RECOMMENDED STANDARD LOCATION OF TELEGRAPH BLOCK SIGNALS.

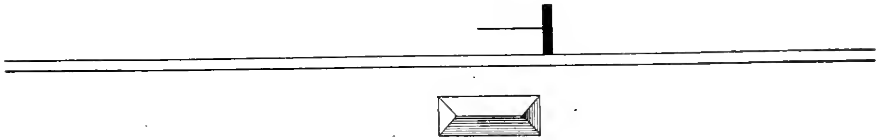


Fig. A.

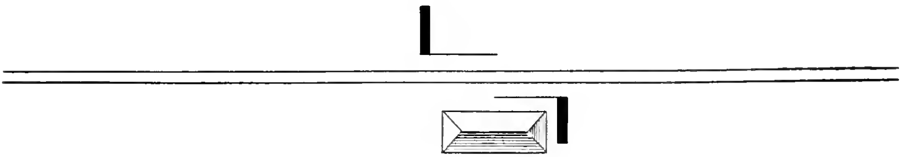


Fig. B.

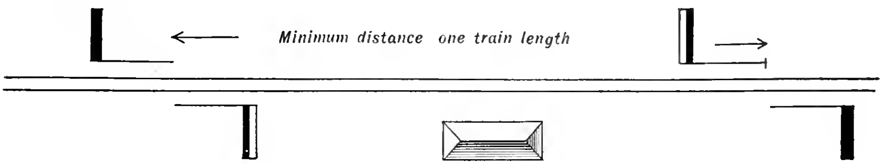


Fig. C.

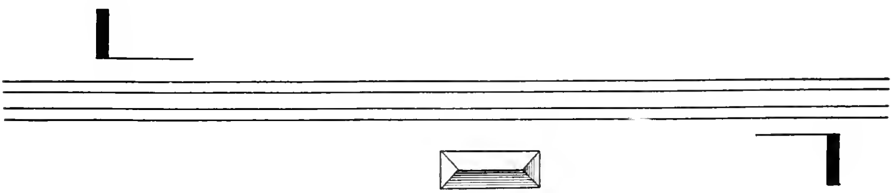


Fig. D.

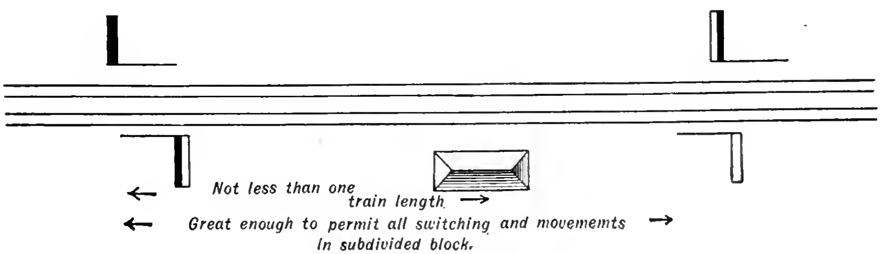


Fig. E.

SPECIFICATIONS FOR CONSTRUCTION OF TELEGRAPH BLOCK SIGNAL AND CONNECTIONS.

GENERAL.

Workmanship. 1. All material and workmanship must be of the best, and subject to the approval of the Signal Engineer.

Strength. 2. All parts must be properly proportioned for strength.

Plans. 3. All plans furnished by the Railroad Company must be considered a part of these specifications, and must not be departed from except by permission of the Signal Engineer.

MACHINE.

Lever Type. 4. Operating machine must be of the lever type and of approved design.

Locking. 5. Locking, when required for distant signals, must be of the latch or preliminary type. All wearing parts shall be of cold rolled steel, and all bolts provided with jamb nuts or cotters.

Separate Foundation. 6. The machine must be substantially placed in a suitable block station, and supported on a separate foundation, not connected with the building in any way. This foundation must be made of white oak, longleaf yellow pine, or steel.

Size of Parts. 7. There must be no difference in the size of corresponding parts for large and small machines.

Throw of Levers. 8. All the levers in a machine must have an equal uniform throw.

Position of Levers. 9. Machine levers must be numbered from left to right; generally, the levers must be placed in the machine corresponding to signal operated. Distant signal levers, when used, must be outside of home signal levers, at ends of machine.

SIGNAL CONNECTIONS.

Signal Connections. 10. Home signal connections must be made by means of pipe runs.

Pipe Material. 11. Pipe lines must be made of galvanized iron pipe, one inch (1") inside diameter, and coupled with sleeves, plugs and rivets. One end of each length of pipe must not be punched for rivet until pipe is screwed together on the ground.

12. Pipe runs must be straight, when possible, and must be placed not nearer than three feet (3′) from outside of rail. They must be laid two and three-quarters inches (2¾″) between centers, and so arranged that the shortest line will be next to the rail. Pipe lines must be supported on carriers placed not more than seven feet (7′) apart; top of pipe lines must be one and one-half inches (1½″) above base of rail, except across tracks, where they must be one inch (1″) below base of rail. **Position of Pipe Runs.**

13. Pipe carriers must be made of malleable iron, with sheaves not less than two and a quarter inches (2¼″) in least diameter **Pipe Carriers.**

14. Couplings in pipe lines must be placed not nearer than twelve inches (12″) to a pipe carrier when the lever is in the center. **Couplings.**

15. Sleeves for pipe couplings must be made of wrought-iron, and not less than two and a quarter inches (2¼″) in length. **Sleeves.**

16. Plugs for pipe couplings must be made of wrought-iron, one inch (1″) in diameter and six inches (6″) long. They must be drilled for quarter-inch (¼″) rivets, spaced four inches (4″) center to center, and one inch (1″) from each end. **Plugs.**

17. Cranks must be made of wrought-iron, and mounted in a cast or malleable iron stand. The top of the center pin must, in all cases, be supported. All crank stands must be provided with lugs, to prevent center pins from turning in stands. No more than two cranks shall be placed on the same center. **Cranks—Construction.**

18. All cranks, except those used in box or vertical stands, must have arms not less than eleven and three-quarters inches (11¾″) in length. **Crank Arms.**

19. Solid jaws must be made of wrought-iron. They must be seventeen inches (17″) long from center of pin hole to end of body; opening between sides of jaws must be straight for not less than three inches (3″) from center of pin hole. **Solid Jaws.**

20. Screw jaws must be made of malleable or wrought-iron: opening between sides of jaws must be straight for not less than five inches (5″) from center of pin hole, and thread in solid end must be at least one and a half inches (1½″) in length. Body must not be less than twelve inches (12″) long, with thread cut half its length. **Screw Jaws.**

21. Bodies of all jaws must be one and a quarter inches (1¼″) in diameter, with tang and thread for coupling to pipe. Tang must be four inches (4″) long and one inch (1″) in diameter. **Jaw Bodies.**

Bends.

22. Bends must not be made in pipe, but in cranks, jaws, or an iron rod, one and one-quarter inches (1¼") in diameter, placed in the pipe two and one-half inches (2½") between any two supports. There must be no bends made in cranks without special permission.

Compensators.

23. (See page 297, Vol. 4, Proceedings Am. Ry. Eng. & M. of W. Association.)

"Lazy Jack" Compensators must be used. They must be made of wrought-iron and mounted on cast-iron stands, but no more than one compensator shall be placed on a stand or foundation. Inside crank arms must be ten and one-eighth inches (10⅛") in length, outside to be thirteen inches (13"), from center to center of pin holes. Top of crank pins must be supported. All compensator stands must be provided with lugs to prevent center pins from turning in stands.

Pipe Adjustment.

24. Means of adjustment must be provided for each line of pipe.

Screw Jaw.

25. Lines to home signals must have a screw jaw in end of line next to function operated; lines to distant signals must have a screw jaw at each end (when pipe connections are used).

Foundations of Concrete.

26. All foundations must be made in accordance with standard plans. In general, foundations should be made of concrete.

Leadout Foundation.

27. Leadout foundation inside and immediately outside of tower must be made of twelve-inch by five-inch oak, securely bolted to rails set in tower foundation walls.

Crank Stand Fastening.

28. Four (4) three-quarters-inch (¾") bolts must be used to fasten each crank stand, or compensator stand, to its foundation.

Pipe Carrier Fastening.

29. Two (2) three and one-eighth inch by two inch (3⅛"x2") lag screws must be used for fastening each pipe carrier to its foundation.

Pins—Material.

30. All pins must be made of steel, machine turned, and provided with cotters.

Pins—Size.

31. Connecting pins for jaws, cranks, etc., must be not less than seven-eighths inch (⅞") in diameter; center pins for bell cranks must be not less than one and one-fourth inches (1¼") in diameter.

Washers.

32. Plate washers must be used under nuts and under the heads of bolts and lag screws, where they would be otherwise in contact with wood.

Highways.

33. When required, highway crossings must be boxed with four-inch (4") oak plank.

SIGNALS.

34. High signals, where practicable, must not be closer than seven feet (7′) to the outside of rail. High Signals.

35. Signal blades must be made of white ash. Signal Blade Material.

36. Signal masts must be made of iron and set on or in concrete. Signal Masts

37. Bracket posts may be either pipe or lattice construction; the bracket, or cross-arm, must be not less than twenty feet (20′) clear above top of rail. Bracket Posts.

38. All signal masts must be provided with ladders, bolted to post at top, and at bottom to a one-way pipe carrier foundation set in the ground. Ladders.

39. Short uprights or stubs seven feet (7′) long must be used to indicate each track that is not signaled from the bracket, and which intervenes between the bracket post and the farthest track signaled. The stub must be placed not less than six feet six inches (6′ 6″) from the adjacent signal mast. Stubs.

40. On signal bridges, masts for carrying signals must be placed vertically over the right-hand rail of the track governed. Bridges must be made according to standard plans, and not less than twenty-one feet (21′) in the clear from top of rail. Location of Masts on Bridges.

41. Arms must be not less than twenty-five feet (25′) above the base of rail. On bracket posts, or bridges, the arm must be not less than seven feet (7′) above top of bracket or bridge. Height of Arms.

42. Blades must be four feet six inches (4′ 6″) in length from center of casting to outer end. They must be seven inches (7″) wide at the arm grip, and ten inches (10″) wide at the outer end. Stops for the danger and safety positions must be provided in the center casting. Size of Blades.

43. Six (6) three-eighths-inch by one and one-half inch (3/8″x1½″) elevator bolts, with head one and one-fourth inches (1¼″) in diameter must be used to fasten each signal blade to casting. Blade Fastening.

44. Colored glass six and one-half inches (6½″) in diameter must be placed in signal casting. Size of Glass.

45. A lamp, made in accordance with standard drawings, must be furnished for each signal. Lamp.

46. Lamp brackets must be made in accordance with standard drawings. Lamp Brackets.

Painting. 47. All ironwork must be given one coat of good priming and two coats of finishing paint. Signal masts, and the ironwork on same, must be painted according to the standards of the Railroad Company.

Lever Painting. 48. Levers must be painted as follows:

Home signal levers, red.

Distant signal levers, green or yellow.

Spare levers, white.

Blade Painting. 49. Signal blades must be painted in accordance with standard plans.

STANDARD SPECIFICATIONS FOR MECHANICAL INTERLOCKING AND MATERIAL FOR CONSTRUCTION WORK.

(Adopted by the Railway Signal Association, October 11, 1905.)

GENERAL REQUIREMENTS.

1. The contractor shall furnish all tools, material and labor, except as may be hereinafter noted, to erect and complete the work in accordance with the intent of the plans and specifications, and anything that is obviously necessary to complete or make useful any part mentioned in specification shall be provided by the contractor, although such part is not shown by the plans.

2. The contractor will be furnished with transportation over the purchaser's own lines of railway to visit the site before making his proposal, and shall base his bid on conditions then existing, except as modified by plans or specifications furnished with request for tender.

3. The purchaser will furnish free transportation for necessary men, tools and material on its own lines of railway, going and returning.

4. The purchaser will do all track work and furnish and put in place all switches, derails, movable point frogs, together with ties for same, including those for bolt locks and crossing bars, unless the plans for any particular contract specify that the contractor shall furnish any of the above materials.

The purchaser will do all necessary draining, grading and blasting, and also provide all necessary permits for building an interlocking station.

5. The contractor shall frame all ties for switches, derails, movable point frogs, bolt locks and crossing bars, and drill all holes in rail for front feet, detector bar brackets, etc.

6. All material shall be f. o. b. cars on the purchaser's lines of railway.

7. The contractor shall clear away all refuse from the premises and leave the building in condition for occupancy.

8. All threads shall be U. S. standard, unless variations therefrom are permitted by the purchaser. All castings shall be of the best quality.

9. All parts shall be properly proportioned for strength. Material

and workmanship shall be of the best, and subject to the approval of the Signal Engineer.

10. All plans furnished by the purchaser shall be considered part of these specifications, and shall not be deviated from, except by permission from the Signal Engineer.

11. Extra sets of working drawings shall be furnished for each plant. After the completion of the plant the contractor shall furnish for each company interested "Vandyke" or similar prints of ground plan, leadout, locking and dog sheet and track circuits. Each shall be on a separate sheet and show conditions as they exist after completion of the plant.

12. In all particulars not mentioned in these specifications it is intended and understood that the best ruling practice at the time the work is performed will govern, and if any devices are furnished which have not been in general use they shall be subject to acceptance of the Signal Engineer before being placed in position.

13. In the final settlement of the contract no extra bills will be allowed unless the work shall have been ordered in writing by the proper officers of the purchasing company.

INTERLOCKING STATION.

21. The interlocking station must be built in accordance with the purchasing company's standard plans.

MACHINE.

26. Machine shall be of the preliminary latch-locking type of an approved manufacture.

27. Machine must be rigidly supported on a wood or steel frame, as selected by purchaser.

28. There must be no difference in the corresponding parts of a small and a large machine as regards size.

29. In machines of horizontal locking type, one bracket for cross-locking must be provided for each two-lever spaces, placed alternately, and in no case shall there be less than one spare bracket for each eight-lever spaces, placed near the center in each. Each spar bracket must be filled with a piece of locking steel.

30. A space for longitudinal locking bar shall be provided the entire length of the machine for each spare lever, or lever spaces in the machine. No small filling blocks shall be used; all spare spaces shall be filled with locking steel.

31. All the levers in a machine shall have an equal and uniform throw in the quadrant, and the throw in the lever tail for pipe connections shall be eight and three-quarters (8¾) in., nine and three-quarters (9¾) in., with an additional hole for increasing the throw to ten and three-quarters (10¾) in.

32. Where electric locking is used, the apparatus shall accomplish the following: The electric lock must lock the route, but shall not prevent the return of the home signal to the stop position; a release shall be provided which will require the lapse of one minute before the release is effective; the releasing mechanism shall be designed so that the operator will have to return mechanism to its normal position before he can again use the route affected.

LEADOUT.

39. Deflecting stands, cranks or rocker shaft leadout shall be furnished as specified by purchaser.

Rocker shafts shall be made from two (2) in. square, cold rolled steel with movable bearings and movable drop forged crank arms eleven and three-quarters (11¾) in. long, center to center.

40. Rocker shafts over eight (8) ft. long shall have an intermediate bearing. The bearings shall be made in four ways wherever possible, fastened with six three-eighths (⅜) in. bolts. One way bearings shall not be used, except where absolutely necessary.

41. Vertical wire leadout wheels shall be of ten (10) in. diameter. They shall be securely bolted to leadout timbers by four three-quarters (¾) in. bolts.

42. The leadout pipe shall in all cases be connected to back hole of lever. With jaw bent to fit either hole by turning the rod.

43. Wire connections to the lever tail must be made by means of stationary shackles with seven-eighths (⅞) in. pin, and four holes shall be drilled for as many different throws of connections.

Stroke of connections for switches, locks, high and dwarf signals shall be eight and three-quarters (8¾) in.; nine and three-quarters (9¾) in. and ten and three-quarters (10¾) in.; and for distant signals fourteen and three-quarters (14¾) in.; sixteen and three-quarters (16¾) in. and eighteen and three-quarters (18¾) in.

PIPE LINES.

49. Pipe lines shall be used for connections to switches, detector bars, locks and home signals, if not otherwise specified, and may be used for all signals.

The pipe shall be one (1) in. inside diameter, and weigh not less than 1.65 lbs. per ft.

50. Pipe lines shall be straight where possible, and shall not be placed less than five (5) ft. from outside rail, except where the line runs between tracks or on long ties, in which case the minimum distance shall be three (3) ft. nine (9) in. from the nearest rail, whereever conditions permit. Pipe lines shall be laid two and three-quarters (2¾) in. between centers, and shall be supported on pipe carriers placed seven (7) ft. on straight lines, and six (6) ft. centers around curves.

51. Not more than four pipes lines shall cross the track at one place, and there shall be at least three ties between the places where pipe lines cross, except where lines cross track in front of interlocking station. This may be changed to suit local conditions by permission of the Signal Engineer

52. All pipes leading across tracks shall be supported by hanging pipe carriers, fastened on top of the ties.

53. Where pipe and wire lines cross tracks which are not parallel, radial arms or deflecting bars shall be used for pipe, and chain wheels for wire. Where deflecting bars are used they shall be made with tang-ends or jaws.

54. Pipe line shall be made in lengths corrected for temperature as called for by diagrams.

COUPLINGS.

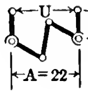
60. Sleeves for pipe couplings shall be made of wrought-iron and shall not be less than two and one-quarter (2¼) in. in length, and full section throughout.

61. Plugs for pipe couplings shall be made of wrought-iron one (1) in. in diameter, chamfered one-eighth (⅛) in., and six (6) in. in length, and drilled and countersunk for two one-quarter (¼) in. rivets, spaced four (4) in. from center to center, and one (1) in. from end.

62. Couplings in pipe lines shall not be placed nearer to pipe carrier than twelve (12) in., with lever on center.

PIPE CARRIERS.

67. Pipe carriers shall be made of best gray cast-iron malleable or pressed steel, as designated by purchaser, with sheaves or wheels not less than two and one-quarter (2¼) in. at smallest diameter, and



B = { 13″ up to 700′
16″ " " 1200′

Values of U are based on .08 of an inch as coefficient of expansion for an increase of 10° Fahr. for each 100 ft. of line, and the nearest 1-16 inch is given.

FIG. 8.—VALUES OF SPACING "U" FOR GIVEN TEMPERATURES AND LENGTHS OF LINES TO BE COMPENSATED.

TEMP F°	LENGTH OF LINES COMPENSATED IN FEET											
	100	200	300	400	500	600	700	800	900	1000	1100	1200
110°	$21\frac{1}{2}$″	21″	$20\frac{1}{2}$″	20″	$19\frac{1}{2}$″	19″	$18\frac{1}{2}$″	18″	$17\frac{1}{2}$″	17″	$16\frac{1}{2}$″	16″
90°	$21\frac{11}{16}$″	$21\frac{3}{8}$″	21″	$20\frac{11}{16}$″	$20\frac{3}{8}$″	20″	$19\frac{11}{16}$″	$19\frac{3}{8}$″	19″	$18\frac{11}{16}$″	$18\frac{1}{2}$″	$18\frac{1}{4}$″
70°	$21\frac{13}{16}$″	$21\frac{11}{16}$″	$21\frac{9}{16}$″	$21\frac{3}{8}$″	$21\frac{3}{16}$″	21″	$20\frac{7}{8}$″	$20\frac{11}{16}$″	$20\frac{1}{2}$″	$20\frac{3}{8}$″	$20\frac{1}{4}$″	$20\frac{1}{8}$″
50°				MEAN	TEMPER	ATURE	U=A=22″					
30°	$22\frac{3}{16}$″	$22\frac{5}{16}$″	$22\frac{1}{2}$″	$22\frac{5}{8}$″	$22\frac{13}{16}$″	23″	$23\frac{3}{16}$″	$23\frac{5}{16}$″	$23\frac{1}{2}$″	$23\frac{5}{8}$″	$23\frac{3}{4}$″	$23\frac{15}{16}$″
10°	$22\frac{5}{16}$″	$22\frac{5}{8}$″	23″	$23\frac{5}{16}$″	$23\frac{5}{8}$″	$23\frac{15}{16}$″	$24\frac{1}{4}$″	$24\frac{9}{16}$″	$24\frac{7}{8}$″	$25\frac{3}{16}$″	$25\frac{1}{2}$″	$25\frac{7}{8}$″
0°	$22\frac{7}{16}$″	$22\frac{13}{16}$″	$23\frac{1}{4}$″	$23\frac{5}{8}$″	$24\frac{1}{16}$″	$24\frac{7}{16}$″	$24\frac{13}{16}$″	$25\frac{1}{4}$″	$25\frac{11}{16}$″	$26\frac{1}{8}$″	$26\frac{1}{2}$″	$26\frac{13}{16}$
−10°	$22\frac{1}{2}$″	23″	$23\frac{1}{2}$″	24″	$24\frac{1}{2}$″	25″	$25\frac{1}{2}$″	26″	$26\frac{1}{2}$″	27″	$27\frac{1}{2}$″	28″

Since the mean temperature varies, it must be taken for the latitude where the work is done.

two and three-quarters (2¾) in. between centers. They shall be four and one-quarter (4¼) in. from base to center of pipe line.

Pipe carriers shall be made in half sections. Each carrier shall have a separate connection at the top. Two carriers shall not be connected with one top or bottom rod.

Where carriers are mounted on wood they shall be fastened with two one-half by two and one-half (½x2½) in. lag screws.

CRANKS.

71. Cranks shall be made of wrought-iron and mounted in a cast or malleable iron stand. The top of the center pin shall in all cases be supported. Not more than two cranks shall be placed on the same center, and in no case may two cranks be placed on the same center of foundation when the pipe line from one crank runs to switch and from other crank runs to lock on the same switch.

72. No crank less than eleven and three-quarter (11¾) in. centers may be used outside the leadout.

JAWS.

76. Solid jaws shall be made of wrought-iron. They shall be nineteen and one-half (19½) in. in length from center of pin hole to center of rivet hole. The opening between sides of jaws shall be parallel for not less than three (3) in. from center of pin hole.

77. Screw jaws shall be made of wrought or malleable iron, the openings between sides of jaws shall be parallel and not less than five (5) in. from center of pin hole. Thread on jaw end shall be not less than six (6) in. in length. Body shall be seventeen (17) in. in length from end to center of rivet hole or nineteen and one-half (19½) in. from center of pin hole to center of rivet holes. All jaws to be supplied with extra jamb nuts. Bodies of all jaws shall be one and one-quarter (1¼) in. in diameter, with tang and thread for coupling to pipe. Tang shall be four (4) in. in length and fifteen-sixteenths (15/16) in. in diameter. Special jaws made with tang-ends or bodies of one (1) in. and three-quarters (¾) in. round iron may be used for high signals, dwarf signals, torpedoes, selectors, etc., where the resistance is less than one hundred (100) lbs.; but in no case shall jaws less than one and one-quarter (1¼) in. be used in pipe line.

78. Bends shall not be made in pipe, but in jaws, or in iron rod one and one-quarter (1¼) in. in diameter, placed in the pipe line for that purpose. The total bends shall never exceed two and three-

quarters ($2\frac{3}{4}$) in. between any two supports. No bends shall be made in cranks to exceed one and one-quarter ($1\frac{1}{4}$) in.

COMPENSATORS FOR PIPE.

83. A compensator shall be provided for each pipe line over fifty (50) ft. in length and under eight hundred (800) ft. with crank arms eleven by thirteen (11x13) in. centers. From eight hundred (800) to twelve hundred (1,200) ft. in length crank arms shall be eleven by sixteen (11x16) in. centers. Pipe lines over twelve hundred (1,200) ft. in length shall be provided with an additional compensator.

Compensators shall be built of one sixty (60) degree and one one hundred and twenty (120) degree angle crank and connecting link, mounted in iron or malleable base, having top of center pins supported, same being made twenty-two (22) in. centers.

LOCKS.

88. Facing locks shall be used on all switches. Lock castings shall be placed on outside of tracks and bolted to tie through the gage plate one-half by six ($\frac{1}{2}$x6) in. placed on top of tie and securely fastened thereto.

89. Plungers shall be one (1) in. in diameter and twenty (20) in. in length from center of pin hole to end, and have a stroke of eight (8) in. Plungers shall stand not more than one (1) in. clear of lock bar when switch is unlocked. The end shall be square and not chamfered or pointed.

90. Lock rods for facing point locks shall be run direct without side bend or goose-neck from front rods into lock casting. Holes in lock bar shall not be more than one and one-sixteenth ($1\frac{1}{16}$) in. in diameter, and shall not be countersunk.

91. All facing point switches, derails, movable point frogs on high speed routes shall be bolt locked with signals governing such route.

In all cases where switch and lock movements are used, bolt locks shall also be used. Distant signals are not to be bolt locked.

92. The switch bar on all bolt locks shall have an independent connection.

93. The signal bar on bolt lock shall be made of mild steel and be a part of the line and not lugged or looped in. The switch and signal bar shall be one and three-quarters ($1\frac{3}{4}$) in. deep and five-eighths ($\frac{5}{8}$) in. wide. The notch in the signal bar shall not be more

than one and one-half (1½) in. in length. When more than one signal bar is used they shall be made of different section, so that neither can enter the wrong slot in the switch bar.

DETECTOR BARS.

98. Where no substitute is provided, detector bars shall be installed for all switches, derails, movable point frogs and torpedo machines and shall work in connection with a facing point lock or switch and lock movement; also at crossings when required to insure clearance. If on curve the bar shall be placed alongside the outer rail.

Detector bars shall give fifty (50) ft. continuous protection.

99. Detector bars shall be made of three-eighths by two and one-quarter (⅜x2¼) in. steel, with square ends. They shall be bolted together in not more than three places.

100. Detector bars shall be placed on outside of rails, and move in a plane inclined toward center of track. Top of bar shall stand one-quarter (¼) in. below top of rail when lock lever is at end of stroke. Bar shall rise not less than one and one-quarter (1¼) in. above rail.

101. Both end supports shall be placed six (6) in. and twenty-four (24) in., respectively from each end, the remaining supports to be placed not over four (4) ft. apart over remaining length of bar. The driving piece shall be placed midway between the supports and as near the center of the bar as practicable, driving rod to be not over sixteen (16) ft. in length. Connection from pipe line to driving piece shall be as nearly parallel with the track as possible. The crank end of connection rod shall be placed so as to stand not more than eight (8) in. from outside of rail. Three holes shall be drilled in crank end operating bar, and bar rod shall be connected to the inner hole. Where rocker shafts are used they shall be made from two (2) in. square, cold rolled steel with movable bearings and crank arms interchangeable with leadout rocker shafts.

102. When bar overlaps switches, special rail braces shall be provided.

103. Each bar rod shall be equipped with a set of springs, clamps and guide, and a special low pipe carrier.

SWITCH AND LOCK MOVEMENTS.

108. Switch and lock movements shall be used for derails only, and not more than one shall be connected to a lever.

ADJUSTMENTS.

112. One D. P. adjusting screw shall be put in each pipe line between the two foundations nearest the crank at switch and lock movement and facing point lock.

Wire lines for distant signals shall be provided with two adjusting screws to each wire—one in tower and one at base of signal pole. Adjusting screws shall be provided for in each wire compensator.

113. Pipe adjusting screws shall be made of wrought-iron, with right and left-hand thread, and be capable of giving an adjustment of not less than six (6) in.

114. Wire adjusting screws shall be made of wrought-iron not less than one-half (½) in. in diameter, with right and left-hand thread, and shall be capable of giving an adjustment of not less than twelve (12) in

115. Switches, derails, movable frogs shall be provided with a special adjustment riveted to the head rod.

116. Derails shall be open not less than three and one-half (3½) in. Lifting derails shall be open not less than five (5) in.

117. Switches and movable point frogs shall be open not less than four (4) in.

118. Where bolt locks are used, screw jaws shall be placed in the signal line on each side of the bolt lock.

SIGNALS.

125. The height of dwarf signal pole shall be such that the signal arm should not stand more than one and one-half (1½) ft. above top of rail.

126. Semaphore arms on the same high pole shall be placed six (6) ft. from center to center.

127. High signal arms should be made of well-seasoned, clear white ash, or other material equally good. Dwarf signal arms should be made flexible.

128. All high arm castings shall be capable of holding three glasses six and one-half (6½) in. in diameter and one-quarter (¼) in. in thickness. The back light shall be two (2) in. in diameter. Dwarf signal castings shall be capable of holding two glasses eight and three-eighths (8⅜) in. in diameter and furnished with back glasses two (2) in. in diameter when required.

129. Up and down rods for signals shall be guided every six (6)

ft. and so connected to the semaphore that the arms will be pushed to the clear position.

COUNTERWEIGHTS.

134. All signals shall be provided with counterweights to cause arm to go to the horizontal position should a break occur in any connection. Where signal poles are between tracks, the counterbalance lever shall be set parallel with the tracks.

135. Counterweight lever shall incline downward at an angle of forty-five (45) degrees to center line of arm when arm is in horizontal position.

WIRE.

140. Signal wires shall be unannealed galvanized steel No. 9 B. W. G. gage (.150"). The wires shall be cylindrical, free from scales, inequalities, flaws, splits and other imperfections and defects. Each coil shall be one whole wire, without welded joints or splices, and shall be at least five (5) ft. in diameter.

WIRE CONNECTIONS.

143. Where signals are wire connected, both front and back wires shall be used, and the back wire shall have one and one-half (1½) in. more stroke than the front wire. A counterbalance lever shall be used for each arm.

144. Wire lines shall be placed not less than six (6) ft. from outside of rail, except where carried on foundations. They shall be carried on pulleys placed not more than twenty-one (21) ft. from center to center. Wire carriers shall be placed on stakes, except where they can conveniently be placed on pipe carrier foundations. When wire carriers are placed on foundations, a three (3) in. block shall be used to keep wire off intervening foundations.

145. Where wire lines lead around curves the carriers shall be placed at the proper angle so that the resultant force is at right angles with the wire.

146. Turns in wire lines shall be made around wheels with one-quarter (¼) in. chain.

WHEELS.

151. Chain wheels shall be ten (10) in. in diameter in all places on main wire line, except leadout wheels and wheels on dwarf and bracket poles, which may be six (6) in. in diameter. Not more than three wheels are to be arranged in the same vertical line.

WIRE CARRIERS.

158. Sheaves or wheels shall not be less than two (2) in. at smallest diameter.

WIRE EYES.

162. Wire eyes shall be oval three-quarters (¾) in. inside diameter and two and one-quarter (2¼) in. over all.

SPLIT LINKS.

165. Where split links are used the points shall be closed. They shall not be used for splicing chain on wheels. They shall be made from five-sixteenths (5/16) in. steel, three-quarters-in. by one and one-half (¾x1½) in. inside opening.

LAMPS.

168. All lamps shall be of the purchasing company's standard pattern.

FOUNDATIONS.

171. Pipe carrier foundations shall be of concrete, or malleable iron, and have top of best white oak, two and one-half by eight (2½x8) in. Lumber to be surfaced on both sides. The top shall be fastened to the foundation by two, one-half by ten (½x10) in. hook bolts.

172. All crank and wheel foundations shall be concreted three by three by three (3x3x3) ft.

173. All L. J. compensators and dwarf signal foundations shall be concrete three feet in depth, two and one-half feet in width and four ft. in length (3x2½x4).

174. All cranks, compensators and wheels shall be fastened to an iron pier set in concrete, arranged with slot to hold three-quarters (¾) in. bolts. Plank to hold dwarf signals and deflecting bars to be fastened in a similar manner.

175. Iron bracket poles shall be concreted four ft. in width, four ft. in length and five ft. in depth (4x4x5).

176. Wood top shall be used only on pipe carrier and dwarf signal foundations. Top of dwarf signal foundations to be four by twelve (4x12) in., best white oak.

177. All foundations shall be concreted in such a manner that bolts can be taken out of plank and apparatus at any time without injuring and disturbing foundations.

178. Crank and wheel foundations shall be set so that center line of foundation will bisect angle made by connection.

179. All stakes shall be not less than three by four by four (3x4x4) ft. with seven (7) in. point.

CONCRETE.

186. All sand shall be clean, sharp bank sand, free from loam and vegetable matter.

187. Broken stone or gravel screenings used shall be not larger than will pass through two (2) in. ring.

188. Artificial Portland cement shall be used, of best quality.

189. The stone and gravel used shall be perfectly clean and shall be wet before mixing with mortar. Mortar and stone or gravel shall be thoroughly mixed and used immediately after mixing. The mixture should be thoroughly wet and damped as much as possible. For mortar to be used in freezing weather add one pound of salt to each four gallons of water used in mixing; but contractors must take all risks in mixing concrete in freezing weather.

190. All foundations shall stand at least ten (10) days after concrete work is done before being connected to apparatus.

PINS.

195. All pins shall be made of steel, machine turned, and provided with cotters, and either have a square head or be provided with a groove turned into the pin one-quarter (¼) in. deep and one-quarter (¼) in. wide, three-eighths (⅜) in. from top, so a bar can be used to lift the pin. The head shall have a flat surface on two sides opposite to each other to allow application of a wrench.

196. Connecting pins for cranks, compensators, levers, selectors, signals, bolt locks, switches, etc., shall be seven-eighths (⅞) in. in diameter, and have a square head. Center pins for cranks, compensators and switch and lock movements shall be one and one-quarter (1¼) in. in diameter. All center pins for cranks, compensators and switch and lock movements must be supported at top.

BOLTS AND SCREWS.

200. All bolts shall have U. S. standard threads and standard square heads and nuts.

201. All lag screws shall be standard, with square heads.

202. Two one and one-half (1½) in. No. 14 drive screws shall be used to fasten each wire carrier to its foundation.

203. Six three-eighths by one-half (⅜x½) in. elevator bolts, with head one and one-quarter (1¼) in. in diameter, shall be used to fasten each high signal arm to casting.

204. Two one-quarter by one (¼x1) in. bolts shall be used to fasten each low signal arm to casting. A single plate washer one-eighth by three-quarters (⅛x¾) in. shall be used under bolt heads.

205. Plate washers shall be used under bolt heads, nuts and heads of lag screws where they would otherwise come in contact with wood.

PAINTING.

210. The machine shall be painted one priming coat and finished with one coat of black, to and including the latch shoe. The levers shall be painted three coats, as follows:

All, except home and distant signal levers, black.

Distant signal levers, lawn green, or lemon yellow.

Home signal levers, vermillion.

211. When a lever is used for more than one purpose, it shall be painted to correspond with the colors used on separate levers for same purposes.

212. The unfinished part of latch handle inside shall be painted same color as lever.

213. All painted parts of machine above the floor shall have one coat of varnish.

214. The finished parts of the machine shall not be painted.

215. Signal arms shall be painted one coat of priming and two finishing coats.

216. Signal poles shall be painted one coat of graphite for first coat and two coats white and black for finishing coat. Under no circumstances must signal poles or any other iron work be painted or dipped in tar or asphaltum.

217. All iron work, except detector bars, tie plates and iron foundations, shall be painted two coats of graphite paint.

218. All chain and other iron work, not machine finished, shall be dipped in graphite paint before being shipped.

219. The ends of all pipe shall be dipped one (1) ft. in graphite paint before being shipped.

220. All boxing shall be painted one coat of metallic oxide paint.

BOXING.

225. Boxing, when it is required, shall be made of good pine lumber, surfaced on one side. Planks two by eight (2x8) in. shall be used for the sides and tops, and, if necessary, one (1) in. rough stuff for bottom. Boxing will be required at road crossings and streets and over leadouts, switch and lock movements and selectors. All pipe and wire lines shall be boxed for six (6) ft. from rail where they cross tracks. When required, highway crossings shall be boxed with four (4) in. oak for top and sides. Where wires cross highway they must run in three-eighths (3/8) in. galvanized pipe, provided with a stuffing box in each end, pipe to be filled with black oil.

AUTOMATIC BLOCK SIGNALS.

Your Committee submits diagrams showing the most approved method of locating automatic signals and slotting or automatic control of interlocking signals in automatic territory. In addition to this, the most desirable conventions for automatic signal work and also for interlocking signals. These conventions have been adopted as far as they go, by the Railway Signal Association. Your Committee has added some additional conventions for automatic work, and would recommend that these conventions be adopted, as they are the general conventions for work of this type.

Fig. 1 shows approved method of double-track junction at crossing illustrating the method of installing the automatic signals and slotting the interlocking signals on a plan of this type.

Fig. 2 shows the recommended method of location of automatic signals on single track. The Committee recommends the use of intermediate automatic signals and controlled manual block signals at stations automatically locked by track circuit; the intermediate automatic block signals being intended for the spacing of trains running in the same direction; the automatic locking of control manual machines at stations being intended to take care of trains in the opposing direction. The plan of signals as shown in Fig. 2 can be adopted either in conjunction with the control manual automatically locked system or on single track as an adjunct to the telegraph block system for spacing of trains and at the same time take care of opposing movements in emergency.

Fig. 3 shows double-track interlocking with crossovers and approved method of location of automatic signals and the semi-automatic control on interlocking signals.

Fig. 4 shows the most approved plan of signaling at crossovers for a four-track road, illustrating the automatic and semi-automatic features of control.

Fig. 5-A shows the approved plan of location of automatic signals to be adopted when the distance between blocks is more than 6,000 feet. In this instance, as in all double and four-track installations, where the

grades vary in opposing directions, the two tracks are signaled independent of one another.

Fig. 5-B shows the two-arm signal plan to be adopted when distance between blocks is less than 6,000 feet.

Fig. 6 is a plan recommended by the Committee for a four-track railroad location of automatic signals when gradient in opposite direction will not allow the signals to coincide and the two running tracks are signaled independent of the running tracks in opposing direction.

Fig. 7 is a four-track arrangement recommended by the Committee to be used in all cases when gradient will allow signals to coincide.

Fig. 8 is a plan recommended for eight-track arrangement of automatic signals, it being assumed that the gradient is equal in both directions.

Fig. 9 shows plan of automatic three-position upwardly inclined signals on double track recommended for consideration by the Committee. Economy of signals and perfect indications are clearly demonstrated by this figure.

Fig. 10 shows the application of three-position upwardly inclined signals on four-track interlocking. The Committee wishes particularly to call attention to the fact that the home signal, track No. 1, shows caution indication for the semi-automatic signal in advance.

VARIOUS TYPES AND LOCATIONS FOR INTERLOCKING AND AUTOMATIC ELECTRIC SIGNALS.

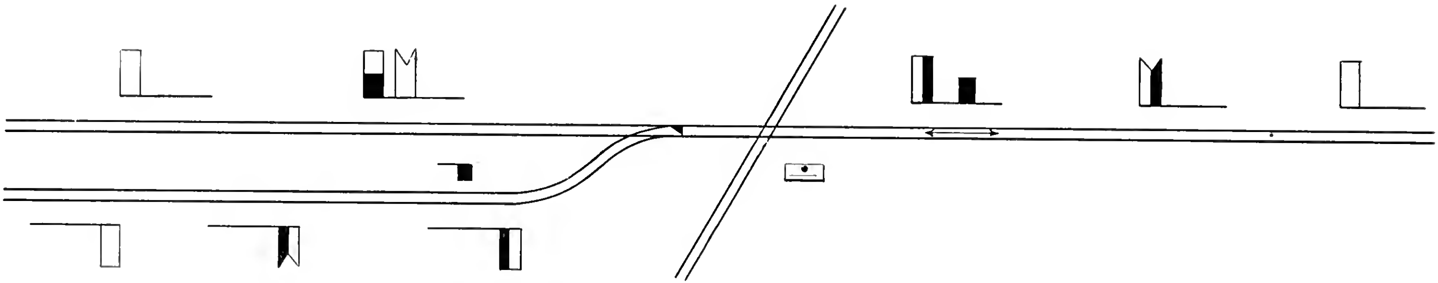


Fig. 1—Double-Track Converging to Single Track. Interlocking Signals Slotted and Automatic Signals.

VARIOUS TYPES AND LOCATIONS FOR INTERLOCKING AND AUTOMATIC ELECTRIC SIGNALS.

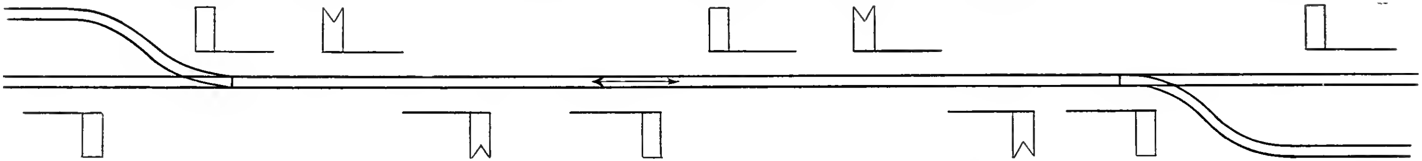


FIG. 2—APPROVED METHOD. LOCATION AUTOMATIC SIGNALS ON SINGLE TRACK. FOR APPLICATION OF EITHER THE LOCK AND BLOCK SYSTEM OR THE STRAIGHT AUTOMATIC IN CONJUNCTION WITH THE TELEGRAPH BLOCK SYSTEM.

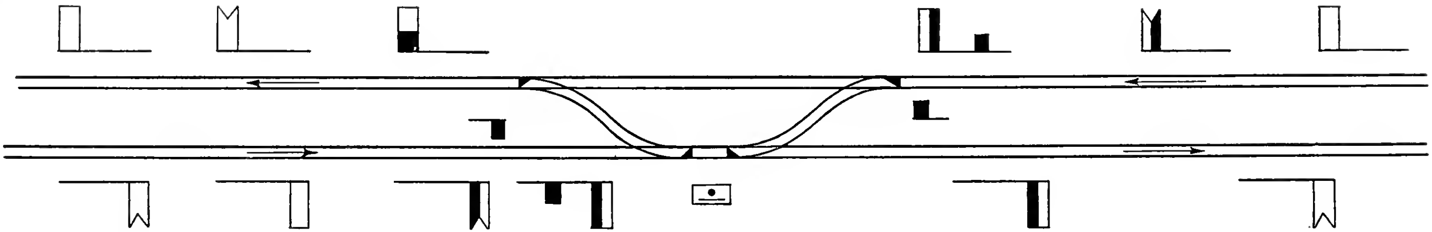


FIG. 3—DOUBLE-TRACK INTERLOCKING AT CROSSOVERS. INTERLOCKING SIGNALS SLOTTED AND AUTOMATIC SIGNALS TAKEN IN CONJUNCTION.

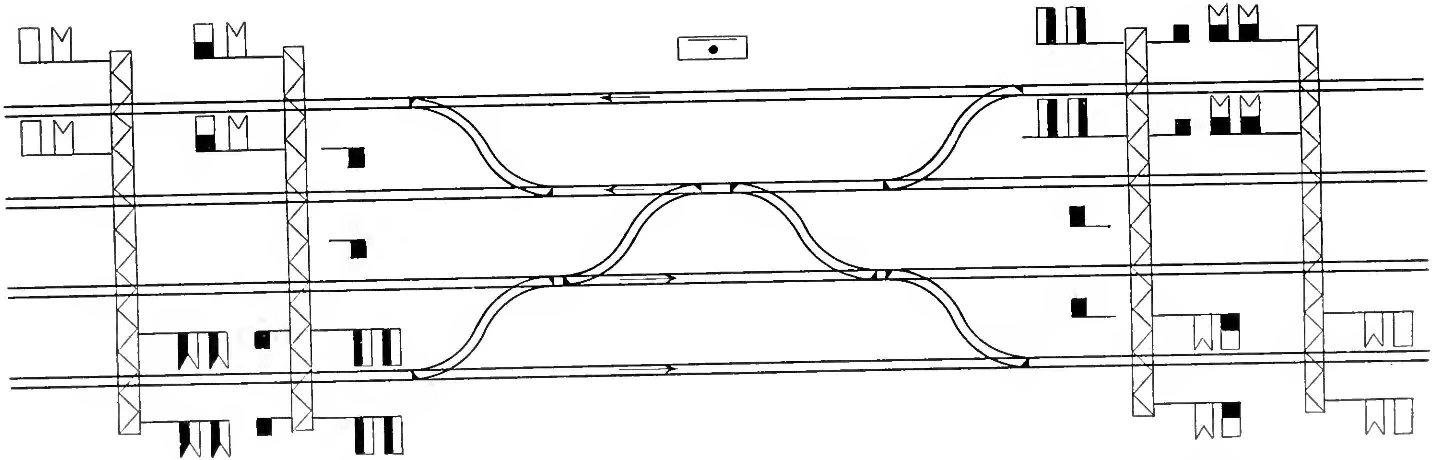


Fig. 4—Four-Track Interlocking. Approved Arrangement of Crossovers and Slotting of Interlocking Signals in Conjunction with Automatic Signals.

VARIOUS TYPES AND LOCATIONS FOR INTERLOCKING AND AUTOMATIC ELECTRIC SIGNALS.

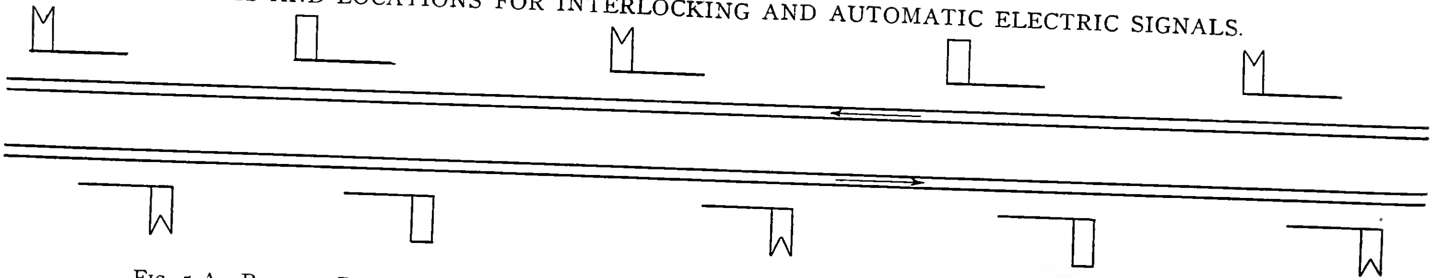


FIG. 5-A—PLAN TO BE ADOPTED WHEN DISTANCE BETWEEN BLOCKS IS MORE THAN 6,000 FEET. EACH TRACK TO BE SIGNALLED INDEPENDENT OF THE OTHER.

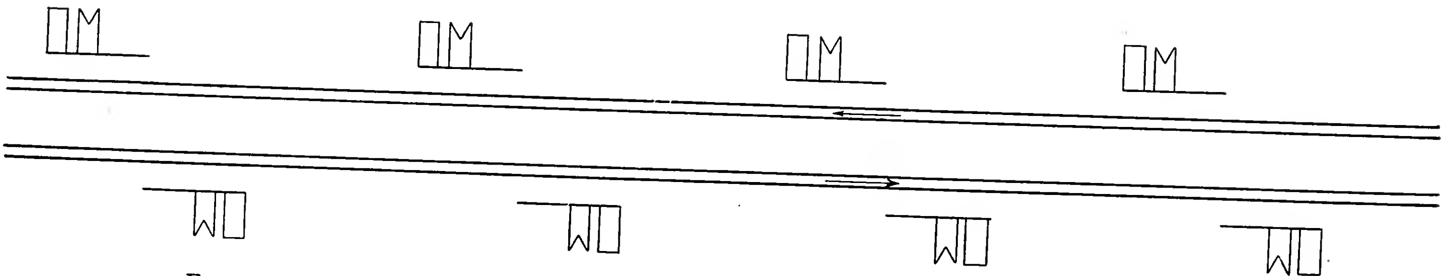


FIG. 5-B—PLAN TO BE ADOPTED WHEN DISTANCE BETWEEN BLOCKS IS LESS THAN 6,000 FEET.

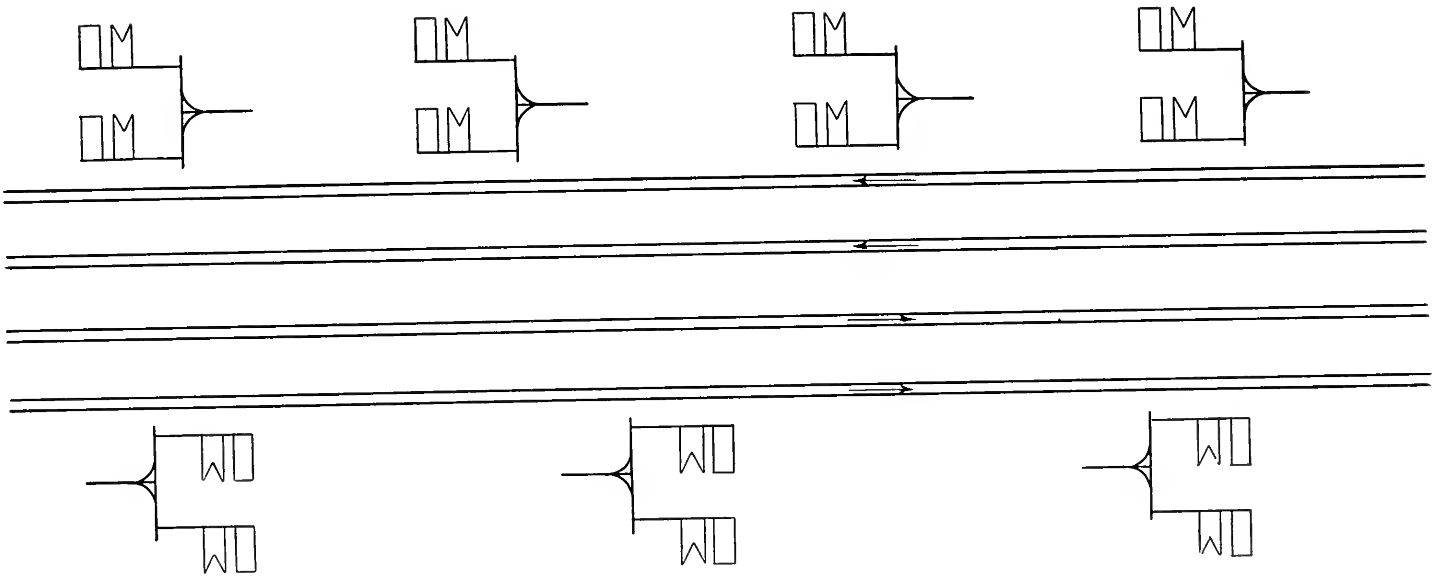


Fig. 6—Four-Track Arrangement of Automatic Signals When Grades in the Opposite Directions Will Not Allow Signals to Coincide.

VARIOUS TYPES AND LOCATIONS FOR INTERLOCKING AND AUTOMATIC ELECTRIC SIGNALS.

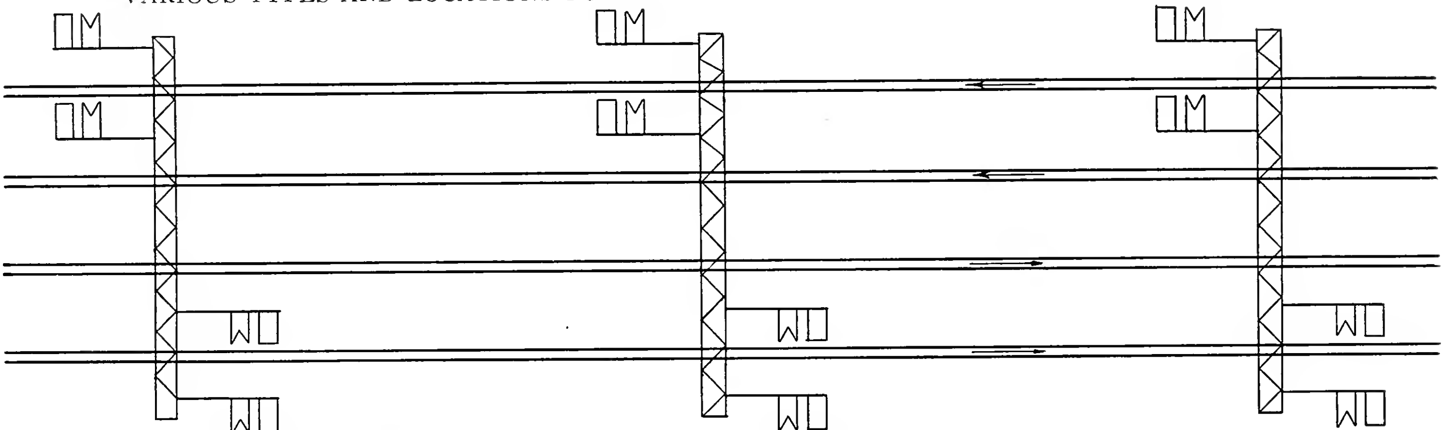


FIG. 7—FOUR-TRACK ARRANGEMENT OF AUTOMATIC SIGNALS WHEN GRADES WILL ALLOW SIGNALS TO COINCIDE.

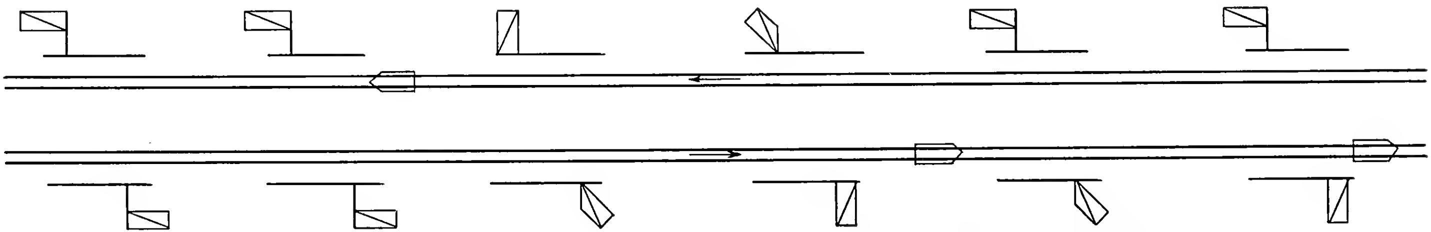


FIG. 9—THREE-POSITION UPWARDLY INCLINED SIGNALS, RECOMMENDED BY COMMITTEE.

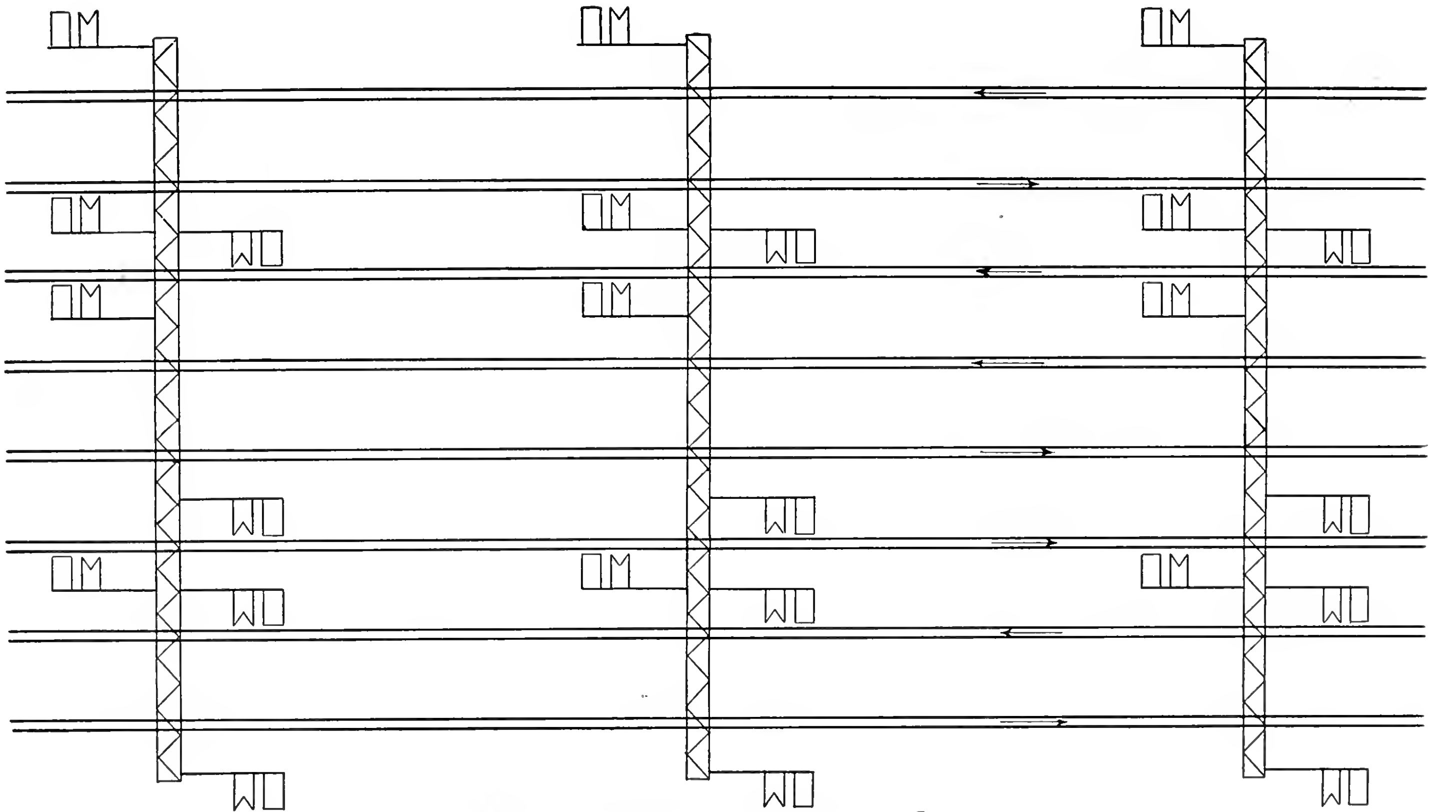


Fig. 8—Eight-Track Arrangement of Automatic Signals.

VARIOUS TYPES AND LOCATIONS FOR INTERLOCKING AND AUTOMATIC ELECTRIC SIGNALS.

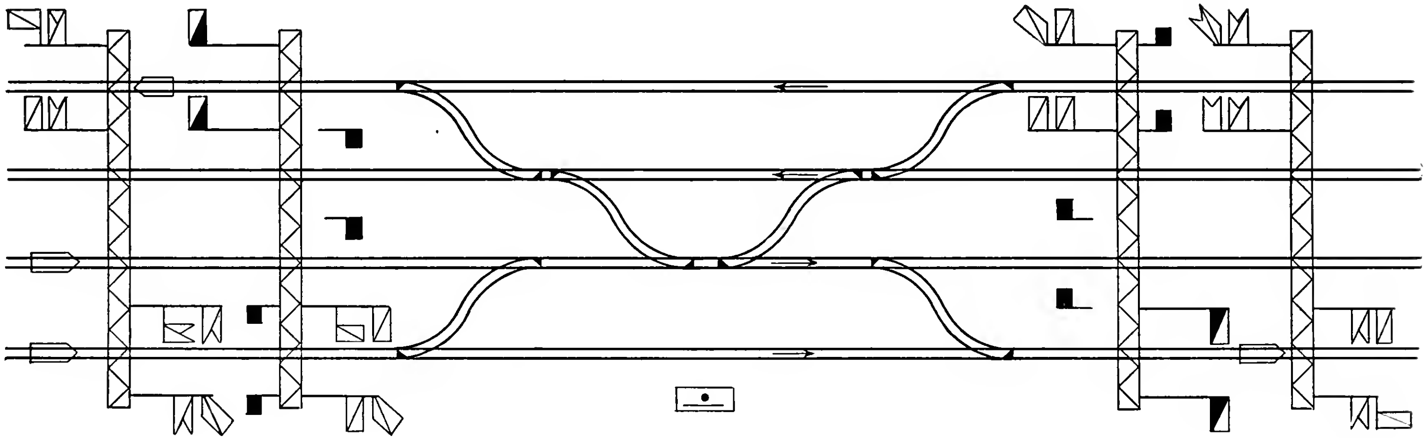


FIG. 10—APPLICATION OF THREE-POSITION UPWARDLY INCLINED INDICATIONS AT A FOUR-TRACK INTERLOCKING. APPROVED ARRANGEMENT OF CROSSOVERS AND SLOTTING OF INTERLOCKING SIGNALS IN CONJUNCTION WITH AUTOMATIC SIGNALS. SAME AS FIG. 4. TWO-POSITION SIGNALS.

CONVENTIONS.


Two-Position Mechanical Interlocking Home Signal.


Two-Position Mechanical Interlocking Distant Signal.


Two-Position Mechanical Interlocking Dwarf Signal.


Three- Position Mechanical Interlocking Home Signal.


Three-Position Mechanical Interlocking Distant Signal.


Two-Position Semi-Automatic Interlocking Home Signal.


Two-Position Semi-Automatic Interlocking Distant Signal.


Three-Position Semi-Automatic Interlocking Home Signal.

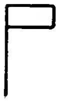

Three-Position Semi-Automatic Interlocking Distant Signal.


Two-Position Slotted Interlocking Home Signal.

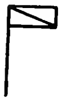

Two-Position Slotted Interlocking Distant Signal.

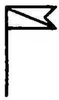

Three-Position Slotted Interlocking Home Signal.


Three-Position Slotted Interlocking Distant Signal.


Two-Position Automatic Home Signal.


Two-Position Automatic Distant Signal.


Three-Position Automatic Home Signal.


Three-Position Automatic Distant Signal.

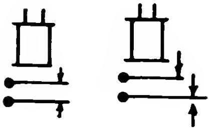

Ground Route Signal.


Suspended Dwarf Signal.

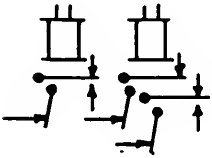

Pot Signal.

Circuit Controller on Lever, Mechanical Interlocker, normally open.

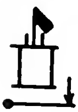
Circuit Controller on Lever, Mechanical Interlocker, normally closed.



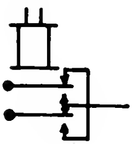
Direct Current Relays, common.



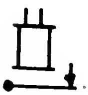
Direct Current Relays, polarized.



Direct Current Relays, Semaphore Indicator.

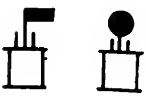


Direct Current Relays, pole changing.

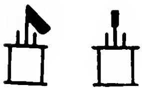


Direct Current Relays, differential.

TOWER INDICATORS.

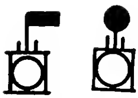


Semaphore, Disc. Stop When Energized.

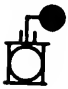


Semaphore, Disc. Proceed When Energized.

Signal Repeater. Stop or Proceed When Energized.

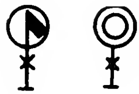


Semaphore, Disc. With Bell.

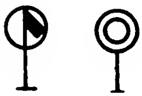


Disappearing Disc.

SWITCH INDICATORS.

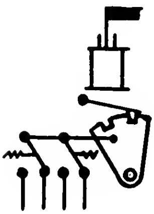


Semaphore, Disc. With Switchbox.

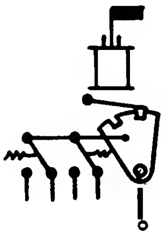


Semaphore, Disc. Without Switchbox.

ELECTRIC LOCK AND INDICATING CIRCUIT CONTROLLER.



For Mechanical Interlocker, Operated from Quadrant of Lock.



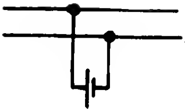
Hand Operated.

BATTERY HOUSES.

Above Surface.

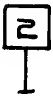
Below Surface.

Half Above Surface.



Track Battery.

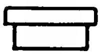
Battery Chute, Relay Box and Post. Left figure indicates Capacity of Chute; Right figure capacity of Relay Box.



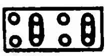
Relay Box and Post. Figure indicates capacity.

Battery Chute. Figure indicates capacity.

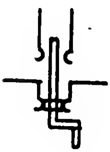
Electric Lock.



Battery Cupboard.



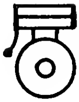
Switch Box.



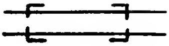
Spring Screw Release.

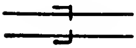
Switch Bell.

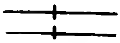
Switch Box Location.

 Crossing Bell.

 Relay Box. Figure indicates capacity.

 Short Track Circuit.

 Circuit on Right Only, Insulated Joints.

 Circuits Right and Left.

 Signal Circuit Breaker (Closed).

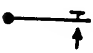
 Signal Circuit Breaker (Open).

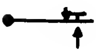
 Circuit Switch.

 Floor Push.

SPRING HAND KEYS.

 Normally Closed.

 Normally Open.

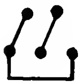
 Normally Open or Closed.

Bell.

Wires Cross.

Wires Join.

Lightning Arrester.



Pole Changing Switch.

Ground.

DEFINITIONS.

Definitions from Standard Code of The American Railway Association.

Block.—A length of track of defined limits, the use of which by trains is controlled by block signals.

Block Station.—A place from which block signals are operated.

Block Signal.—A fixed signal controlling the use of a block

Home Block Signal.—A fixed signal at the entrance of a block, to control trains in entering and using said block.

Distant Block Signal.—A fixed signal used in connection with a home block signal or a home and advance block signal to regulate the approach thereto.

Advance Block Signal.—A fixed signal used in connection with a home block signal to divide the block in advance.

Block System.—A series of consecutive blocks.

Telegraph Block System.—A block system in which the signals are operated manually, upon information by telegraph.

Controlled Manual Block System.—A block system in which the signals are operated manually, and so constructed as to require the co-operation of the signalman at each end of the block, respectively, to display a clear signal.

Automatic Block System.—A block system, in which the signals are operated by electric, pneumatic, or other agency, actuated by train or by certain conditions affecting the use of a block.

Mast.—The upright to which the signals are directly attached.

Absolute Block System.—One in which only one train at a time is permitted to occupy the block. (Southern Pacific.)

Arm Casting.—That part of the arm supported by the signal mast, which, by rotation on its axis of support, gives the night signal indications.

Arm Sweep.—The segment of a circle defining the *limits* of movement of the arm.

ARM.—The movable arm pivoted to the signal mast, and by the position of which the indications are given.

BLADE.—That part of the arm which, by its form and position, gives the day signal indications.

BRACKET POST.—An arrangement of main post with cross-beam, upon which is placed one or two masts for carrying the signal arms, the arrangement of masts determining which track or tracks the signals govern.

CHAIN WHEEL. A device used for changing the direction of a wire line.

COMPENSATOR.—A device placed in a pipe or wire line for automatically maintaining a constant length of line under changes of temperature.

CRANK.—A device used for changing the direction of a pipe line.

CRANK STAND.—The frame in which cranks are supported.

CROSS LOCKING.—A variable shaped block or bar running crosswise of the interlocking machine, actuated by the movements of the locking dog, and by means of which connection is effected between the levers.

DETECTOR BAR.—A bar placed at a switch alongside of and normally below the top of rail, operated in connection with a facing point lock, derailing device or crossing switch, or so that its operation, and consequently that of the lock, will be prevented by the presence of any of the wheels of the train.

ELECTRIC SLOT.—An appliance for automatically disengaging the signal arm connection from its actuating lever, returning signal arm to "stop."

FOUNDATION.—A fixed support, usually set in the ground, for carriers, cranks, compensators, wheels, signals and other like devices.

INTERLOCKING FUNCTION.—Any signal, switch, movable point frog, derail, lock, crossing bar or other device of an interlocking plant operated separately or in combination.

INTERLOCKING MACHINE.—The primary operating or controlling mechanism of an interlocking plant, placed in the interlocking station, and in which the interlocking feature is effected.

INTERLOCKING PLANT. An arrangement of switch, lock and signal appliances so interconnected or interlocked that one movement must succeed another in a predetermined order.

INTERLOCKING SIGNALS.—The fixed signals of an interlocking plant.

INTERLOCKING STATION.—A place from which an interlocking plant is operated.

JAW.—A device attached to pipe line for connecting same with machine, crank, compensator, or any other device designed for pipe operation.

LEADOUT.—The combination of cranks, wheels, rocking shafts, pipes and wire, etc., inside and outside of interlocking station by which connections are made between machine and pipe runs.

LEVER.—That part of an interlocking machine whose movement effects the operation of its function.

LOCKING.—The combination of locking dogs and cross-locking or locking dogs and tappets by means of which interconnection is effected between the levers and the order of movement determined.

LOCKING BAR.—A bar running lengthwise in the interlocking machine to which the locking dogs are attached.

LOCKING DOG.—A variously shaped block attached to locking bar and through which the interlocking is accomplished.

PERMISSIVE BLOCK SYSTEM.—One in which two or more trains may occupy a block at once.

PIPE CARRIER.—A frame with roller support for the pipe line.

PIPE RUN.—The assemblage of the pipe lines of an interlocking plant, with their carriers and foundations, in a common course.

ROCKING SHAFT.—A rotating shaft with arms, used for changing the line of motion from one plane to another, perpendicular to the axis of the shaft; also used at slip switches for operating several detector bars and locks.

ROUTE.—A course or way taken by a train in passing from one point to another, especially a customary or predetermined course, or any one of several possible combinations of turnouts or crossovers by which a train may travel between two places.

SEMAPHORE SIGNAL.—A device consisting of a movable arm attached to a mast, the indications being given by the position of the arm.

SCREW JAW.—A threaded jaw used for the purpose of adjustment.

SPECTACLE.—See "Arm Casting."

TAPPET.—a. (In machine with vertical locking.) A bar operated directly or indirectly by the lever or lever latch, which actuates or drives the locking bars and is locked by them.

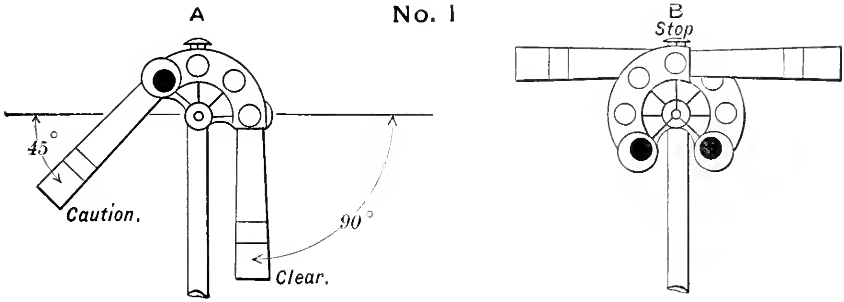
b. (In Saxby & Farmer machine.) A pivot or swing dog attached to the locking bar, and actuated or locked by the cross-locking.

WIRE CARRIER.—A frame with roller support for the wire line.

WIRE RUN.—The assemblage of the wire lines of an interlocking plant, with their carriers and foundations, in a common course.

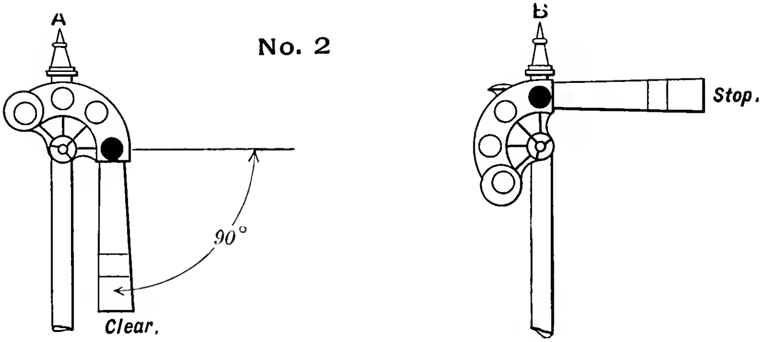
RESULT OF LETTER-BALLOT RELATING TO THE QUESTION OF ANGLE TRAVEL OF SEMAPHORE ARM FOR BLOCK AND INTERLOCKING SIGNALS.

No. 1



Railroad.	Name and Title.
Baltimore & Ohio	D. D. Carothers, Ch. Eng.
Baltimore & Ohio	L. G. Curtis, Div. Eng.
Baltimore & Ohio	O. Rickert, Div. Eng.
Baltimore & Ohio	H. R. Talcott, Eng. of Surveys.
Baltimore & Ohio Southwestern	Earl Stimson, Eng. M. of Way.
Bessemer & Lake Erie	H. T. Porter, Ch. Eng.
Boston & Maine	J. P. Snow, Bridge Eng.
Buffalo & Susquehanna	H. C. Landon, Eng. M. of Way.
Canadian Pacific	W. A. James, Div. Eng.
Central of Georgia	Henry M. Steele, Ch. Eng.
Chicago & Eastern Illinois	R. McCalman, Div. Eng.
Chicago & Western Indiana	E. H. Lee, Chief Eng.
Chicago, Indianapolis & Louisville	A. S. Kent, Div. Eng.
Cleveland, Cincinnati, Chicago & St. Louis	Paul Hamilton, Eng. M. of Way.
Cincinnati Northern	W. D. Williams, Ch. Eng.
Duluth, Missabe & Northern	W. A. McGonagle, Vice-Prest.
Duluth, South Shore & Atlantic. Mineral Range	V. D. Simar, Acting Ch. Eng.
Elgin, Joliet & Eastern	A. Montzheimer, Ch. Eng.
El Paso & Southwestern	J. L. Campbell, Eng. M. of Way.
Great Northern	J. R. W. Davis, Eng. M. of Way.
Halifax & Southwestern	L. H. Wheaton, Ch. Eng.
Kansas City, Mexico & Orient	E. Dickinson, Gen. Mgr.
Kansas City Southern	A. F. Rust, Res. Eng.
Mexican Southern	W. L. Morkill, Gen. Mgr.
Midland Valley	F. A. Molitor, Ch. Eng.
Minneapolis & St. Louis. Iowa Central	H. G. Kelley, Ch. Eng.
Nashville, Chattanooga & St. Louis	J. W. Thomas, Prest.-Gen. Mgr.
Nashville, Chattanooga & St. Louis	Hunter McDonald, Ch. Eng.
Nashville, Chattanooga & St. Louis	G. D. Hicks, Supt.
Nashville, Chattanooga & St. Louis	I. O. Walker, Asst. Eng.
Norfolk & Western	Chas. S. Churchill, Ch. Eng.
Ohio River & Columbus	Geo. C. Millet, Gen. Supt.
St. Louis & San Francisco	J. F. Hinckley, Ch. Eng.
St. Louis & San Francisco	C. D. Purdon, Eng. M. of Way.
St. Louis & San Francisco	J. V. Hanna, Asst. Eng. M. of W.
Southern Railway	C. P. Adams, Supt. Tel.
Spokane International	J. H. Abbott, Bridge Eng.
Union Railroad	E. C. Brown, Eng. M. of Way.
Wabash	F. A. Delano, Prest.
A. Q. Campbell	Prest. Hogansville Quarry Co.
W. B. Hanlon	Civil and Mining Engineer.
C. Lewis	Civil Engineer.

Total for No. 1—42.



Railroad.	Name and Title.
Atlantic & Birmingham	Alex. Bonnyman, Ch. Eng.
Baltimore & Ohio	John R. Leighty, Div. Eng.
Bessemer & Lake Erie	E. J. Randall, Prin. Asst. Eng.
Chicago & Alton	C. S. Ells, Asst. Eng.
Chicago, Burlington & Quincy	L. F. Goodale, Eng. M. of Way.
Chicago Junction	J. B. Cox, Ch. Eng.
Chicago, Rock Island & Pacific	J. B. Berry, Ch. Eng.
Chicago, Rock Island & Pacific	G. E. Ellis, Signal Eng.
Cleveland, Cincinnati, Chicago & St. Louis	O. E. Selby, Bridge Eng.
Erie	A. G. Norton, Res. Eng.
Grand Trunk Pacific	H. A. Woods, Asst. Ch. Eng.
Kansas City Belt	Geo. M. Walker, Jr., Asst. Eng.
Kansas City, Mexico & Orient	M. P. Paret, Ch. Eng.
Lehigh Valley	Walter G. Berg, Ch. Eng.
Lehigh Valley	E. B. Ashby, Eng. M. of Way.
Lehigh Valley	F. E. Schall, Bridge Eng.
Mexican Central	E. S. Banks, Supt.
Minneapolis & Rainy River	A. L. Davis, Ch. Eng.
New York, New Haven & Hartford	E. H. McHenry, Vice-Prest.
Philadelphia & Reading	F. S. Stevens, Supt.
Philadelphia & Reading	J. E. Turk, Supt.
Philadelphia & Reading	C. H. Ewing, Eng. M. of Way.
Southern	B. C. Milner, Supt.
Texas Midland	L. W. Wells, Ch. Eng.
Wabash	J. E. Taussig, Ter. Supt.
Wisconsin & Michigan	B. C. Gowen, Ch. Eng.

Total for No. 2—26.

No. 3

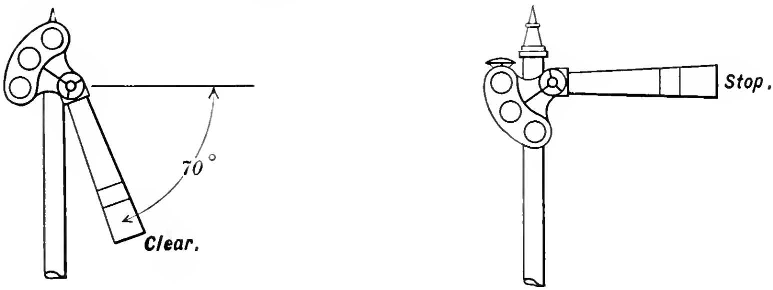
A B

Railroad.	Name and Title.
Detroit & Mackinac	H. S. Waterman, Ch. Eng.

Total for No. 3—1.

No. 4

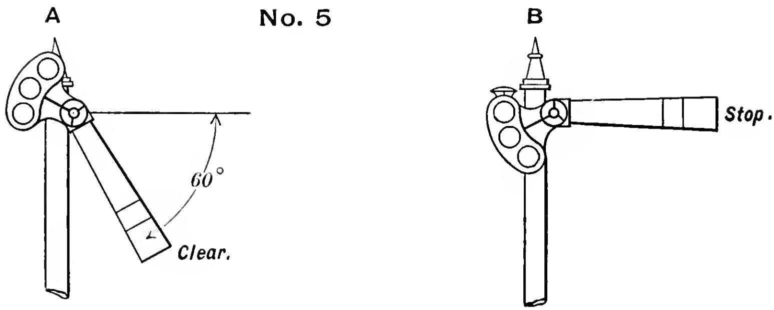
A B



Railroad.	Name and Title.
Canadian Pacific	A. L. Buck, Asst. Eng.
Central of Georgia	J. C. Gray, Asst. Eng.
Missouri Pacific	H. Rohwer, Consulting Eng.
Missouri Pacific	B. H. Mann, Signal Eng.
New York Central & Hudson River	H. S. Balliet, Eng. M. of Way.
New York, New Haven & Hartford	W. H. Moore, Bridge Eng.
Norfolk & Southern	F. L. Nicholson, Eng. M. of Way.
San Francisco & Northwestern	H. C. Phillips, Ch. Eng.
	F. W. Ranno, Civil Engineer.

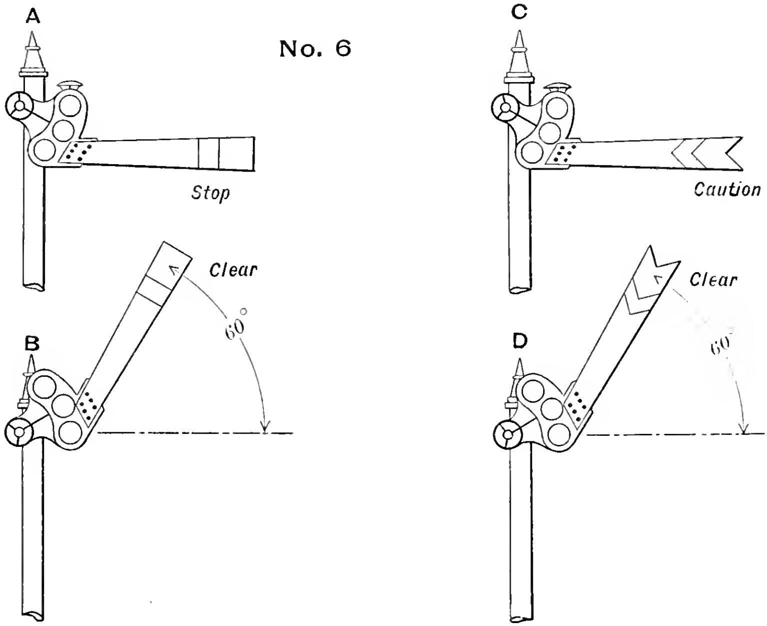
Total for No. 4—9.

No. 5



Railroad.	Name and Title.
Alabama Great Southern	J. C. Nelson, Div. Eng
Baltimore & Ohio	John Ware, Div. Eng.
Chicago & Alton	W. B. Causey, Eng. M. of Way.
Chesapeake & Ohio	H. Pierce, Eng. of Construction.
Colorado & Southern	H. W. Cowan, Ch. Eng.
New York, Ontario & Western	C. E. Knickerbocker, Eng. M. W.
Oregon Short Line	William Ashton, Ch. Eng.
Peoria & Pekin Union	C. Millard, Prest.
Santa Fe, Prescott & Phœnix	W. A. Drake, Gen. Supt.
Southern Pacific (Pacific System)	J. H. Wallace, Eng. M. of Way.
A. L. Bowman	Consulting Eng.
W. M. Camp	Editor Railway Review.
Jno. H. Fine	Consulting Eng.

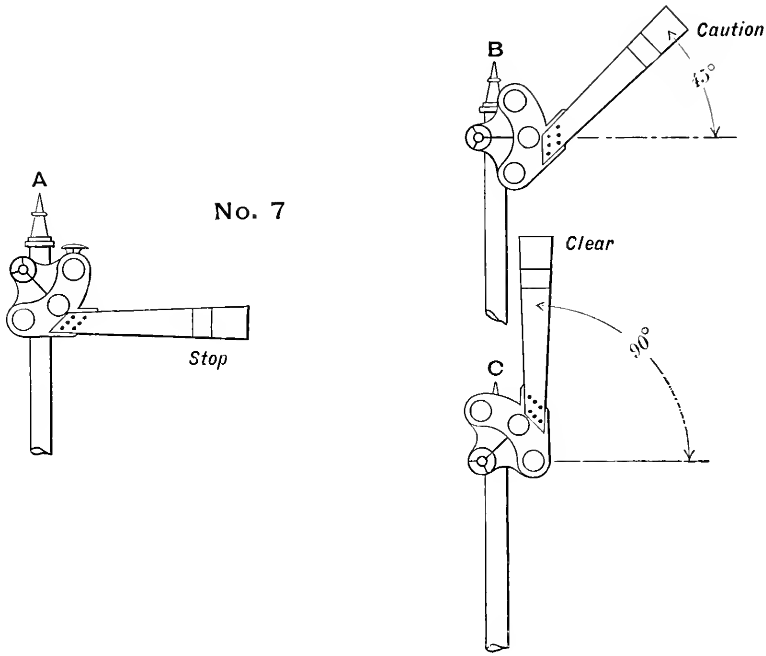
Total for No. 5—13.



Railroad.	Name and Title.
Atchison, Topeka & Santa Fe................	James Dun, Chief Eng. System.
Atchison, Topeka & Santa Fe................	E. O. Faulkner, Mgr. T. & T.Dpt.
Atchison, Topeka & Santa Fe................	A. F. Robinson, Bridge Eng.
Atchison, Topeka & Santa Fe................	Thomas S. Stevens, Signal Eng.
Pacific	C. H. Byers, Asst. Eng.

Total for No. 6—5.

No. 7



Railroad.	Name and Title.
Baltimore & Ohio	H. E. Hale, Eng. M. of Way.
Baltimore & Ohio	J. B. Jenkins, Asst. Eng.
Cleveland, Cincinnati, Chicago & St. Louis	Geo. W. Kittredge, Chief Eng.
Cleveland, Cincinnati, Chicago & St. Louis	L. S. Rose, Eng. M. of Way.
Cleveland, Cincinnati, Chicago & St. Louis	H. H. Knowlton, Asst. Eng.
Chicago & Northwestern	F. H. Bainbridge, Asst. Ch. Eng.
Chicago & Northwestern	J. A. Peabody, Signal Eng.
Chicago, Milwaukee & St. Paul	C. F. Loweth, Eng., Supt. B. & B.
Chicago, Milwaukee & St. Paul	L. R. Clausen, Signal Eng.
Chicago, Rock Island & Pacific	J. G. Bloom, Eng. M. of Way.
Erie	Francis Lee Stuart, Ch. Eng.
Franklin & Clearfield	F. E. Bissell, First As. Eng.
Grand Trunk	K. J. C. Zinck, Asst. Eng.
Great Northern	Charles A. Dunham, Signal Eng.
Gila Valley, Globe & Northern	C. C. Mallard, Supt.
Illinois Central	L. C. Fritch, Asst. to Gen. Mgr.
Illinois Central	W. A. D. Short, Signal Eng.
Louisville & Nashville	J. F. Burns, Roadmaster.
Michigan Central	J. C. Mock, Electrical Eng.
Pennsylvania R. R.	J. T. Richards, Ch. Eng. M. W.
Pennsylvania R. R.	W. S. Thompson, Asst. Eng.
Pennsylvania R. R.	A. H. Rudd, Asst. Signal Eng.
Pennsylvanla Lines West	Thos. Rodd, Ch. Eng.
Pennsylvania Lines West	W. C. Cushing, Ch. Eng. M. W.
Pennsylvania Lines West	R. Trimble, Ch. Eng. M. W.
Pennsylvania Lines West	E. G. Ericson, Principal As. Eng.
Pittsburg & Lake Erie	J. A. Atwood, Ch. Eng.
Pittsburg & Lake Erie	A. R. Raymer, Asst. Ch. Eng.
Pittsburg & Lake Erie	Edwin F. Wendt, Asst. Eng.
Vandalia	Maurice Coburn, Eng. M. of W.
H. G. Prout	Gen. Mgr. Union S. & S. Co.
G. H. Scribner, Jr	Contracting Eng.

Total for No. 7—32.

RESULT OF LETTER-BALLOT ON THE QUESTION OF UPWARDLY INCLINED ARM.

Railroad.	Name and Title.	For.	Against.
Alabama Great Southern	J. C. Nelson, Div. Eng		x
Atlantic & Birmingham	Alex. Bonnyman, Ch. Eng	x	
Atchison, Topeka & Santa Fe	James Dun, Ch. Eng	x	
Atchison, Topeka & Santa Fe	E. O. Faulkner, Mn. Tim. Dept.	x	
Atchison, Topeka & Santa Fe	A. F. Robinson, Pr. Eng	x	
Atchison, Topeka & Santa Fe	Thos. S. Stevens, Sig. Eng	x	
Baltimore & Ohio	D. D. Carothers, Ch. Eng		x
Baltimore & Ohio	H. E. Hale, Eng. M. W	x	
Baltimore & Ohio	L. G. Curtis, Div. Eng	x	
Baltimore & Ohio	O. Rickert, Div. Eng	x	
Baltimore & Ohio	John Ware, Div. Eng	x	
Baltimore & Ohio	J. R. Leighty, Div. Eng		x
Baltimore & Ohio	H. R. Talcott, Eng. Sur	x	
Baltimore & Ohio	J. B. Jenkins, Asst. Eng	x	
Bal. & Ohio Southwestern	Earl Stimson, Eng. M. W	x	
Bessemer & Lake Erie	H. T. Porter, Ch. Eng		x
Bessemer & Lake Erie	E. J. Randall, Prin. Asst. Eng.		x
Boston & Maine	J. P. Snow, Br. Eng		x
Buffalo & Susquehanna	H. C. Landon, Eng. M. W		x
Canadian Pacific	W. A. James, Div. Eng		x
Canadian Pacific	A. L. Buck, Asst. Eng	x	
Central of Georgia	H. M. Steele, Ch. Eng		x
Central of Georgia	J. C. Gray, Asst. Eng		x
Chesapeake & Ohio	H. Pierce, Eng. Con		x
Chicago & Alton	W. B. Causey, Eng. M. W		x
Chicago & Alton	C. S. Ells, Asst. Eng		x
Chicago & Eastern Illinois	R. McCalman, Div. Eng		x
Chicago & N. W	F.H. Bainbridge, Asst. Ch. Eng.	x	
Chicago & N. W	J. A. Peabody, Sig. Eng	x	
Chicago & Western Indiana	E. H. Lee, Ch. Eng	x	
Chicago, Indiana & Louisville	A. S. Kent, Div. Eng		x
Chicago, Burlington & Quincy	L. F. Goodale, Eng. M. M		x
Chicago Junction	J. B. Cox, Ch. Eng		x
Chicago, Mil. & St. Paul	C. F. Loweth, Eng. Br. & B	x	
Chicago, Mil. & St. Paul	L. R. Clausen, Sig. Eng	x	
Chicago, Rock Island & Pacific	J. B. Berry, Ch. Eng	x	
Chicago, Rock Island & Pacific	J. G. Bloom, Eng. M. W	x	
Chicago, Rock Island & Pacific	G. E. Ellis, Sig. Eng		x
Clev., Cin., Chicago & St. L	G. W. Kittredge, Ch. Eng	x	
Clev., Cin., Chicago & St. L	L. S. Rose, Eng. M. W	x	
Clev., Cin., Chicago & St. L	Paul Hamilton, Eng. M. W		x
Clev., Cin., Chicago & St. L	H. H. Knowlton, Asst. Eng	x	
Clev., Cin., Chicago & St. L	O. E. Selby, Bridge Eng		x
Cincinnati Northern	W. D. Williams, Ch. Eng		x
Colorado & Southern	H. W. Cowan, Ch. Eng		x
Detroit & Mackinac	H. S. Waterman, Ch. Eng		x
Duluth, Miss. & Northern	W. A. McGonagle, Vice-Prest.		x
Duluth S. S. & Atlantic	V. D. Simar, Act. Ch. Eng		x
Elgin, Joliet & Eastern	A. Montzheimer, Ch. Eng		x
El Paso & S. W	J. L. Campbell, Eng M. W		x
Erie	F. L. Stuart, Ch. Eng	x	
Erie	A. G. Norton, Res. Eng		x
Great Northern	J. R. W. Davis, Eng. M. W	x	
Great Northern	C. A. Dunham, Sig. Eng	x	
Grand Trunk Pacific	H. A. Woods, Asst. Ch. Eng		x
Franklin & Clearfield	F. E. Bissell, First Asst. Eng.	x	
Gila Valley, G. & Nor	C. C. Mallard, Supt	x	
Halifax & S. W	L. H. Wheaton, Ch. Eng	x	
Illinois Central	L. C. Fritch, Asst. to G. Man.	x	
Illinois Central	W. A. D. Short, Sig. Eng	x	
Kansas City Belt	G. M. Walker, Jr., Asst. Eng		x
Kansas City, Mex. & O	E. Dickinson, Gen. Man		x
Kansas City, Mex. & O	M. P. Paret, Ch. Eng		x
Kansas City Southern	A. F. Rust, Res. Eng		x
Lehigh Valley	Walter G. Berg, Ch. Eng		x
Lehigh Valley	E. B. Ashby, E. M. W		x
Lehigh Valley	F. E. Schall, Br. Eng		x
Louisville & Nashville	J. F. Burns, R. M	x	
Mexican Southern	W. L. Morkill, Gen. Man	x	
Mexican Central	E. S. Banks, Supt		x
Michigan Central	J. C. Mock, Elec. Eng	x	
Midland Valley	F. A. Molitor, Ch. Eng		x
Minn. & R. R	A. L. Davis, Ch. Eng		x

LETTER-BALLOT ON UPWARDLY INCLINED ARM—(CONTINUED.)

Railroad.	Name and Title.	For.	Against.
Minn. & St. Louis	H. G. Kelley, Ch. Eng.		x
Missouri Pacific	H. Rohwer, Con. Eng.		x
Missouri Pacific	B. H. Mann, Sig. Eng.	x	
Nash., Chatta. & St. Louis	J. W. Thomas, Pres. & G. M.		x
Nash., Chatta. & St. Louis	Hunter McDonald, Ch. Eng.		x
Nash., Chatta. & St. Louis	G. D. Hicks, Supt.		x
Nash., Chatta. & St. Louis	I. O. Walker, Asst. Eng.		x
N. Y. C. & H. R.	H. S. Balliet, E. M. W.	x	
N. Y., N. H. & H.	E. H. McHenry, V.-P.		x
N. Y., N. H. & H.	W. H. Moore, Br. Eng.		x
N. Y., O. & W.	C. E. Knickerbocker, E. M. W.		x
Norfolk & Southern	F. L. Nicholson, E. M. W.		x
Norfolk & Western	C. S. Churchill, Ch. Eng.		x
Ohio River & Columbus	G. C. Millett, Gen. Supt.		x
Oregon Short Line	Wm. Ashton, Ch. Eng.		x
Pacific	*E. J. Pearson, Ch. Eng.		
Pacific	C. H. Byers, Asst. Eng.	x	
Pennsylvania	J. T. Richards, Ch. Eng.	x	
Pennsylvania	W. S. Thompson, Asst. Eng.	x	
Pennsylvania	A. H. Rudd, Asst. Sig. Eng.	x	
Penna. Lines	Thos. Rodd, Ch. Eng.	x	
Penna. Lines	W. C. Cushing, Ch. E. M. W.	x	
Penna. Lines	R. Trimble, Ch. E. M. W.	x	
Penna. Lines	E. G. Ericson, Prin. Asst. Eng.	x	
Peoria & Pekin Union	C. Millard, Prest.		x
Philadelphia & Reading	J. E. Turk, Supt.		x
Philadelphia & Reading	C. H. Ewing, E. M. W.		
Philadelphia & Reading	F. S. Stevens, Supt.		x
Pittsburg & Lake Erie	J. A. Atwood, Ch. Eng.	x	
Pittsburg & Lake Erie	A. R. Raymer, Asst. Ch. Eng.	x	
Pittsburg & Lake Erie	Edwin F. Wendt, Asst. Eng.	x	
St. Louis & San Francisco	J. F. Hinckley, Ch. Eng.		x
St. Louis & San Francisco	C. D. Purdon, E. M. W.	x	
St. Louis & San Francisco	John V. Hanna, Asst. E. M. W.	x	
San Francisco & N. W.	H. C. Phillips, Ch. Eng.		x
Santa Fe, Prescott & Phœnix	W. A. Drake, Gen. Supt.		x
Southern	B. C. Milner, Supt.		x
Spokane International	J. H. Abbott, Bridge Eng.		x
Southern Pacific	J. H. Wallace, E. M. W.		x
Texas Midland	L. W. Wells, Ch. Eng.		x
Union Railroad of Pittsburg	E. C. Brown, E. M. W.		x
Vandalia	Maurice Coburn, E. M. W.	x	
Wabash	F. A. Delano, Prest.		x
Wabash	J. E. Taussig, Supt. Ter.		x
Wisconsin & Michigan	B. C. Gowen, Ch. Eng.		x
A. L. Bowman, Consulting Engineer			x
W. M. Camp, Editor Railway Review		x	
A. Q. Campbell, Prest. Hogansville Quarry Co.			x
John H. Fine, Consulting Engineer			x
W. B. Hanlon, Civil and Mining Engineer			x
C. Lewis, Civil Engineer			x
H. G. Prout, Gen. Man. Union Switch & Signal Co.		x	
F. W. Ranno, Civil Engineer			x
G. H. Scribner, Jr., Contracting Engineer		x	

SUMMARY.

In favor of Fig. No. 1	42
In favor of Fig. No. 2	26
In favor of Fig. No. 3	1
In favor of Fig. No. 4	9
In favor of Fig. No. 5	13
In favor of Fig. No. 6	5
In favor of Fig. No. 7	32
In favor of upwardly inclined arm	53
Against upwardly inclined arm	72

*For a modified form of No. 7.

DISCUSSION.

The President:—The chairman of the Committee asks that the convention take up for consideration, first, the specifications for the construction of telegraph block signal and connections, on page 9, of Bulletin No. 73. The Secretary will read the specifications item by item, and discussion can be had on any of them as they are read, or after he has finished reading the entire list.

The Secretary:—"Workmanship. (1) All material and workmanship must be of the best, and subject to the approval of the Signal Engineer.

"Strength. (2) All parts must be properly proportioned for strength.

"Plans. (3) All plans furnished by the Railroad Company must be considered a part of these specifications, and must not be departed from except by permission of the Signal Engineer.

"Lever Type. (4) Operating machine must be of the lever type and of approved design.

"Locking. (5) Locking, when required for distant signals, must be of the latch or preliminary type. All wearing parts shall be of cold rolled steel, and all bolts provided with jamb nuts or cotters.

"Separate Foundation. (6) The machine must be substantially placed in a suitable block station, and supported on a separate foundation, not connected with the building in any way. This foundation must be made of white oak, long-leaf yellow pine, or steel.

"Size of Parts. (7) There must be no difference in the size of corresponding parts for large and small machines.

"Throw of Levers. (8) All the levers in a machine must have an equal uniform throw.

"Position of Levers. (9) Machine levers must be numbered from left to right; generally, the levers must be placed in the machine corresponding to signal operated. Distant signal levers, when used, must be outside of home signal levers, at ends of machine.

"Signal Connections. (10) Home signal connections must be made by means of pipe runs.

"Pipe Material. (11) Pipe lines must be made of galvanized iron pipe, one inch (1") inside diameter, and coupled with sleeves, plugs and rivets. One end of each length of pipe must not be punched for rivet until pipe is screwed together on the ground.

"Position of Pipe Runs. (12) Pipe runs must be straight, when possible, and must be placed not nearer than three feet (3') from outside of rail. They must be laid two and three-quarters inches (2¾") between centers, and so arranged that the shortest line will be next to the rail. Pipe lines must be supported on carriers placed not more than seven feet (7') apart; top of pipe lines must be one and one-half inches (1½") above base of rail, except across tracks, where they must be one inch (1") below base of rail.

"Pipe Carriers. (13) Pipe carriers must be made of malleable iron, with sheaves not less than two and a quarter inches (2¼") in least diameter.

"Couplings. (14) Couplings in pipe lines must be placed not nearer than twelve inches (12") to a pipe carrier when the lever is in the center.

"Sleeves. (15) Sleeves for pipe couplings must be made of wrought-iron, and not less than two and a quarter inches (2¼") in length.

"Plugs. (16) Plugs for pipe couplings must be made of wrought-iron, one inch (1") in diameter and six inches (6") long. They must be drilled for quarter-inch (¼") rivets, spaced four inches (4") center to center, and one inch (1") from each end.

Mr. C. H. Ewing (Philadelphia & Reading):—I think, in this connection, we ought to have a little discussion on plugs. I note that one-inch rivets six inches in length are recommended. My attention has been called to this matter recently on account of the failure of a coupling, and it is a grave question in my mind as to whether or not we ought to have a longer plug and two rivets. I think we ought to have some discussion on this. Has the chairman of the Committee anything to say upon this subject?

Mr. Chas. A. Dunham (Great Northern):—The Committee is of the opinion that one plug and two rivets are sufficient. "Bearing for light surface" might be added.

The President:—Any suggestions upon the remarks of Mr. Ewing?

The Secretary:—"Cranks—Construction. (17) Cranks must be made of wrought-iron, and mounted in a cast or malleable iron stand. The top of the center pin must, in all cases, be supported. All crank stands must be provided with lugs, to prevent center pins from turning in stands. No more than two cranks shall be placed on the same center.

"Crank Arms. (18) All cranks, except those used in box or vertical stands, must have arms not less than eleven and three-quarters inches (11¾") in length.

"Solid Jaws. (19) Solid jaws must be made of wrought-iron. They must be seventeen inches (17") long from center of pin hole to end of body; opening between sides of jaws must be straight for not less than three inches (3") from center of pin hole.

"Screw Jaws. (20) Screw jaws must be made of malleable or wrought-iron; opening between sides of jaws must be straight for not less than five inches (5") from center of pin hole, and thread in solid end must be at least one and one-half inches (1½") in length. Body must not be less than twelve inches (12") long, with thread cut half its length.

"Jaw Bodies. (21) Bodies of all jaws must be one and a quarter inches (1¼") in diameter, with tang and thread for coupling to pipe. Tang must be four inches (4") long and one inch (1") in diameter.

"Bends. (22) Bends must not be made in pipe, but in cranks, jaws, or an iron rod, one and one-quarter inches (1¼") in diameter, placed in the pipe two and one-half inches (2½") between any two supports. There must be no bends made in cranks without special permission.

"Compensators. (23) (See page 297, Vol. 4, Proceedings Am. Ry. Eng. & M. of W. Association.)

"(Lazy Jack) Compensators must be used. They must be made of wrought-iron and mounted on cast-iron stands, but no more than one compensator shall be placed on a stand or foundation. Inside crank arms must be ten and one-eighth inches (10⅛") in length, outside to be thirteen inches (13") from center to center of pin holes. Top of crank pins must be supported. All compensator stands must be provided with lugs to prevent center pins from turning in stands."

The President:—The reference made to page 297, Volume 4, Proceedings of the Association, refers to the diagram which is found in the Proceedings and also in the Manual.

The Secretary:—"Pipe Adjustment. (24) Means of adjustment must be provided for each line of pipe.

"Screw Jaw. (25) Lines to home signals must have a screw jaw in end of line next to function operated; lines to distant signals must have a screw jaw at each end (when pipe connections are used).

"Foundations of Concrete. (26) All foundations must be made in accordance with standard plans. In general, foundations should be made of concrete.

"Leadout Foundations. (27) Leadout foundation inside and immediately outside of tower must be made of twelve-inch by five-inch oak, securely bolted to rails, set in tower foundation walls.

"Crank Stand Fastening. (28) Four (4) three-quarters-inch (¾") bolts must be used to fasten each crank stand, or compensator stand, to its foundation.

"Pipe Carrier Fastening. (29) Two (2) three and one-eighth inch by two inch (3⅛"x2") lag screws must be used for fastening each pipe carrier to its foundation.

"Pins—Material. (30) All pins must be made of steel, machine turned, and provided with cotters.

"Pins—Size. (31) Connecting pins for jaws, cranks, etc., must be not less than seven-eighths inch (⅞") in diameter; center pins for bell cranks must be not less than one and one-fourth inches (1¼") in diameter.

"Washers. (32) Plate washers must be used under nuts and under the heads of bolts and lag screws, where they would be otherwise in contact with wood.

"Highways. (33) When required, highway crossings must be boxed with four-inch (4") oak plank.

"High Signals. (34) High signals, where practicable, must not be closer than seven feet (7') to the outside of rail.

"Signal Blade Material. (35) Signal blades must be made of white ash.

"Signal Masts. (36) Signal masts must be made of iron and set on or in concrete.

"Bracket Posts. (37) Bracket posts may be either pipe or lattice construction; the bracket, or cross-arm, must be not less than twenty feet (20') clear above top of rail.

"Ladders. (38) All signal masts must be provided with ladders, bolted to post at top, and at bottom to a one-way pipe carrier foundation set in the ground.

"Stubs. (39) Short uprights or stubs seven feet (7') long must be used to indicate each track that is not signaled from the bracket, and which intervenes between the bracket post and the farthest track signaled. The stub must be placed not less than six feet six inches (6' 6") from the adjacent signal mast.

"Location of Masts on Bridges. (40) On signal bridges, masts for carrying signals must be placed vertically over the right-hand rail of the track governed. Bridges must be made according to standard plans, and not less than twenty-one feet (21') in the clear from top of rail.

"Height of arms. (41) Arms must be not less than twenty-five feet (25') above the base of rail. On bracket posts, or bridges, the arm must be not less than seven feet (7') above top of bracket or bridge.

"Size of Blades. (42) Blades must be four feet six inches (4' 6") in length from center of casting to outer end. They must be seven inches (7") wide at the arm grip, and ten inches (10") wide at the outer end. Stops for the danger and safety positions must be provided in the center casting."

Mr. A. R. Raymer (Pittsburg & Lake Erie):—Referring to paragraph 42, it is not evident whether the wooden blade tapers through the casting or not. "They must be 7 in. wide at the arm grip and 10 in. wide at the outer end." I want to know whether the seat in the casting tapers with the blade.

Mr. Dunham:—Ten inches at its outer end and 7 in. at the end next to the blade.

Mr. Raymer:—Is it not desirable to have the blades driven home tight and the holes cut afterward?

Mr. Dunham:—That is a detail the Committee did not take into consideration. It might be desirable, but it is not the ordinary practice.

The Secretary:—"Blade Fastening. (43) Six (6) three-eighths-inch by one and one-half (⅜"x1½") elevator bolts, with head one and one-fourth inches ($1\frac{1}{4}''$) in diameter must be used to fasten each signal blade to casting.

"Size of Glass. (44) Colored glass six and one-half inches ($6\frac{1}{2}''$) in diameter must be placed in signal casting.

"Lamp. (45) A lamp, made in accordance with standard drawings, must be furnished for each signal.

"Lamp Brackets. (46) Lamp brackets must be made in accordance with standard drawings.

"Painting. (47) All ironwork must be given one coat of good priming and two coats of finishing paint. Signal masts, and the iron-work on same, must be painted according to the standards of the Railroad Company.

"Lever Painting. (48) Levers must be painted as follows:

Home signal levers, red.
Distant signal levers, green or yellow.
Spare levers, white.

"Blade Painting. (49) Signal blades must be painted in accordance with standard plans."

The President:—The chairman of the Committee calls attention to the fact that the adoption of these specifications carries with it also the adoption of the articles on pages 6 and 7, telegraph and controlled manual block signals, as given in the Standard Code of the American Railway Association. Has any member of the Committee any suggestions or remarks to make in connection with these specifications?

Mr. Dunham:—I believe we can save a good deal of time and make better progress if we discuss the conclusions shown on page 4. Perhaps the members have all been over these specifications, and are therefore not particularly interested in having them read.

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis):—I would like to ask the Committee whether these specifications have already been adopted by the Railway Signal Association?

Mr. Dunham:—I believe the Railway Signal Association has not adopted the specifications exactly as we have them here. They have, however, adopted the specifications for interlocking, which, in a large measure, also covers the specification for controlled manual signals. I would therefore be inclined to take the ground that these specifications, generally speaking, have been approved by the Railway Signal Association.

The President:—If there are no objections to the specifications as read, they will be considered as having been adopted by the convention. The chairman of the Committee asks that we take next in order the conclusions appearing on pages 4 and 5. The Secretary will read conclusion No. 1.

The Secretary:—"(1) That lock and block with track circuit control, using intermediate automatic signals for following movements and abandoning the use of orders, be employed instead of the system of using automatics for both following and opposing movements as an adjunct to the order system for single-track work."

Mr. B. H. Mann (Missouri Pacific):—I would like to ask if the Committee would consider leaving out from the conclusion entirely everything after the word "employed," in the third line? The reason I make the request is that I believe the conclusion as it stands is inconsistent. It implies that the system spoken of in the last three lines is wrong; whereas, it seems to me, you can consider that system as an intermediate step to the system you consider in the first three lines. It does not necessarily follow that if you recommend the first system that you could not also have had previously on the road the automatic system as an adjunct to the train-order. You could therefore change over to the system recommended. In light of the fact of the rapid extension this year of the system that seems to be condemned, I question whether the Association ought to adopt this first conclusion. The system first recommended, using operators without orders and automatic signals, costs about twice as much for operation as do the automatic signals with orders. There may be some roads that do not feel in shape to expend that amount of money, but they can take the intermediate step, changing it a little later, as traffic warrants, to the system recommended. This means probably operators day and night at every station, in addition to the automatic signals.

Mr. Dunham:—The Committee is of the opinion that when a railroad has gone to the expense of installing a modern signal system, it should get all out of it that it can; that is to say, we believe that the order might just as well be executed by the operator, by means of signal indications, as to follow the present method and stop a great many trains. I do not know whether this is the point raised by Mr. Mann, but those are the views of the Committee.

Mr. Mann:—It seems to me the first conclusion should be as a recommendation in a transportation problem, and as it is such a recommendation, if the intermediate step should be allowed, the argument would be along the same line taken up this morning as to roadway, that some roads are not prepared to pay the cost per mile for the system recommended by the Committee, but they might be willing to pay half that cost.

Mr. L. C. Fritch (Illinois Central):—I agree with Mr. Mann that this is more of a transportation question than it is a maintenance of way question—that this should be in the form of a recommendation purely. I move, therefore, that this conclusion be changed to read, "That it is recommended," and then follow with the conclusion.

Mr. Mann:—Do I understand that the Committee is not willing to cross out everything in the conclusion after the word "employed?"

Mr. Dunham:—The Committee is willing to withdraw the first conclusion.

The President:—Withdraw it entirely?

Mr. Dunham:—Yes.

The President:—If there is no objection on the part of the convention, the Committee will be privileged to withdraw the conclusion. The Secretary will read the second conclusion.

The Secretary:—"(2) That the arrangement shown in Fig. A is good practice under certain conditions for use on single track line as a train-order signal and spacing-block signal, and that train-order signal be located to give the best view to approaching engine and trainmen."

The President:—If there is no objection to conclusion No. 2, it will stand approved as read.

The Secretary:—"(3) That distant signals may be used with train-order and block-signal, as shown in Fig. B. and that train-order signal be located to give the best view to approaching engine and trainmen."

The President:—Unless there is objection, conclusion No. 3 will be considered as having been adopted.

The Secretary:—"(4) That the arrangement shown in Fig. C be adopted when necessary to subdivide the block, and track circuit be used in the subdivided block to control the rear signal, and that train-order signal be located to give the best view to approaching engine and trainmen."

The President:—If there is no objection, conclusion No. 4 will stand approved as read.

Mr. Ewing:—I do not think it is quite in accordance with good practice to put Fig. A in service on a double track line, placing the signals all on one side, and requiring a man to look across one track to see the signals. The recommendation reads that "it is good practice under certain conditions for use on single-track line as a train-order signal and spacing-block signal." I think that the conclusion should cover what is good practice, and then modify the conclusion to suit a condition of that kind.

Mr. Dunham:—The Committee recognizes the point raised by Mr. Ewing as to Fig. A. That figure was submitted after a good deal of discussion; a number of the members were in favor of separating the signals and showing an arrangement similar to that in either Figs. C or D. However, other members thought that we should submit Fig. A, inasmuch as a great many miles of railroad are signaled in just that way. We, as a Committee, do not think that Fig. A represents the best practice.

Mr. Ewing:—My point was that the conclusion of the Committee should be on approved practice and recommended practice, and that deviations from that practice could be made to conform to a condition as shown on these diagrams.

The President:—If there is no objection to the conclusion, it will stand approved as read.

The Secretary:—"(5) That double-track arrangement be similar to single-track arrangement, as shown in Figs. A, B and C."

The President:—If there is no objection, conclusion No. 5 will stand approved as read.

The Secretary:—"(6) That the specifications for construction of telegraph block signal and connections be approved."

The President:—That conclusion has practically been acted upon by the acceptance of the specifications.

The Secretary:—"(7) That the standard specifications for mechanical interlocking and material for construction work, adopted by the Railway Signal Association, be endorsed as good practice."

Mr. Robert Trimble (Pennsylvania Lines):—We are not ready for that conclusion, are we?

The President:—The chair understands Mr. Trimble to mean that we are not ready to pass upon this conclusion until we have read the specifications.

Mr. Trimble:—Yes.

Mr. Dunham:—The specifications, as they appear on pages 14 to 27, have been the subject of a good deal of discussion in the Railway Signal Association. I think I can safely say they were discussed at eight or ten meetings, and perhaps four or five hours' discussion prevailed at each occasion. If we attempted to go through these specifications, some of us would find ourselves here until to-morrow night. However, we will discuss the specifications if the members so desire.

The President:—Does the convention care to go through these or adopt them as a whole, or bring them up by headings, and if objection is made to any particular item, take that up? There are a number of pages of technical work that has been formally adopted by the Railway Signal Association.

Mr. Mann:—If it is in order, I move that conclusion No. 7 be voted on without reading the specifications.

Mr. Trimble:—I do not know whether I am in order or not, but there are two or three clauses in the specifications which might be discussed before voting on that conclusion. I have in mind three clauses that might be changed.

Mr. Edwin F. Wendt (Pittsburg & Lake Erie):—I suggest that the "General Requirements" at least be read section by section. They are all of general importance, and I think we should at least go that far. The reason I ask that is this: In paragraph 3 it states that the "purchaser will furnish free transportation for necessary men, tools and material, etc." That is not good practice in some parts of our country at all. There may be some other provisions that are not good practice.

Mr. Trimble:—I will say what my objections are, if I am in order. They are along the same line as mentioned by Mr. Wendt. Paragraphs 2 and 3 are sections that we could not endorse. They are contrary to our practice, and it seems to me those clauses should be so worded that if a railroad company wished to furnish transportation for men and materials it could do so, and if it did not wish to do so, it could be omitted. It seems to me there ought to be alternate clauses covering the transportation. In regard to paragraph 12, it seems to me that that is hardly a good wording to have in a specification which is intended to be definite. The paragraph says, "In all particulars not mentioned in these specifications it is intended and understood that the best ruling practice at the time the work is performed will govern; and if any devices are furnished which have not been in general use, they shall be subject to the acceptance of the Signal Engineer before being placed in position." It occurs to me that that might lead to some confusion and difference of opinion.

The President:—Can we not save time by taking up the items to which objections are made under the head of "General Requirements?" If we endeavor to go into these specifications in detail it will take the balance of the afternoon and go into to-morrow.

Mr. Trimble:—I think you are quite right, and therefore make a motion in regard to paragraphs 2 and 3, which are the ones we cannot endorse, that these sections be so modified as to make the matter of transportation of men and material optional with the railroad company.

(The motion was carried.)

Mr. Wendt:—With regard to paragraphs 9 and 10, it is stated that the material and workmanship will be subject to the approval of the Signal Engineer. I believe the policy of this Association has been, as a rule, to use the words "Chief Engineer."

Mr. R. C. Barnard (Pennsylvania Lines):—Paragraph 6 will also have to be changed as to free transportation.

Mr. A. S. Baldwin (Illinois Central):—I believe it would be well to use the word "engineer" with a qualifying clause at the beginning of the specifications that the term "engineer" refers to the Chief Engineer or his duly authorized assistant. That puts it in proper legal form and prevents the contractor taking advantage of instructions that might be given him by a subordinate who was not duly authorized. We have adopted that practice on the Illinois Central under advice from our legal department.

The President:—The blank engineer?

Mr. Baldwin:—I think you disqualify the first clause by saying that.

The President:—You mean adding that in the first clause.

Mr. A. W. Johnston (New York, Chicago & St. Louis):—The objection to leaving out the title, or leaving a blank, is not important. The blanks vary, and it is customary, in getting up specifications, to leave blanks. I offer as an amendment that a blank be left in the specifications.

The President:—It is moved and seconded that in paragraph 9 and in other clauses of the same kind a blank space be left where the words "Signal Engineer" are used.

(The motion was carried.)

Mr. Trimble:—I move to strike out the entire paragraph 12 on page 15.

Mr. McDonald:—In regard to these radical changes that we are making in this report, I wish to say that this has already been adopted by the Railway Signal Association. I take it that they had good reasons for putting it in, and I would like the Committee to tell us their reasons for putting it in before we vote them out.

Mr. Dunham:—I believe I am safe in saying that the Committee has no objection to the elimination of the words "Signal Engineer." That may mean the Chief Engineer or the proper officer of the railroad company, as the Association may see fit. In regard to paragraph 12, the Committee discussed that at length more than perhaps any other paragraph in the specifications. It is the experience of a good many signal officers that no matter how carefully the specifications or contracts are made, from time to time some new devices are included in the contractor's figures, the result being that signal contractors would present a long bill of extras after the installation of each interlocking plant. It was therefore our idea to convey to the contractor that he must include in his proposal all fixtures and devices necessary to make the plant complete, and I should not like to see paragraph 12 cut out of the specifications.

Mr. W. B. Storey, Jr. (Atchison, Topeka & Santa Fe):—The Committee does not request us to adopt the specifications. They simply ask us to endorse them, and I have grave doubts whether, under their request, we have any right to amend them. They simply ask that we endorse them as a matter of good practice.

Mr. Mann:—I would like to ask again if the Committee considered that the Signal Engineer should not have the approval of these plans? I understand, from paragraph 9, that the Committee suggests that it should be subject to the approval of the Signal Engineer, apart from anyone else?

Mr. Dunham:—The Committee did not give that particular paragraph very much consideration. It was necessary to provide that some officer of the railroad company should approve the designs and materials furnished, and as a great many roads are represented in the signaling service by a Signal Engineer, we used that term. I think the Committee has no objection to using some other term meaning the same thing.

Mr. J. C. Mock (Detroit River Tunnel Company):—This paragraph is intended to prevent the furnishing of untried devices and materials that are being urged upon the railroads in lieu of the recognized standards. As worded, it may give rise to some question as to its intent, but some such clause ought to be in, because of the great variety of materials, both electrical and mechanical, that are used to make the complete installation of an interlocking plant. While I do not object to having this particular paragraph cut out, I would like to see something better substituted.

Mr. Trimble:—My principal objection to the paragraph was to the first three lines. If the Committee wishes to choke off devices, let us modify the paragraph to read like this: "Any devices furnished which are not in general use shall be subject to the acceptance of the engineer before being placed in position."

Mr. Baldwin:—I seconded Mr. Trimble's motion in regard to paragraph 12 because I believed it was not in line with good practice. We could not imagine a clause of this kind inserted in a specification for steel superstructure. I think the Committee is rather begging the question in leaving such an open clause as this in the specification. I would be willing to accept Mr. Trimble's modification if he left out the words, "if any devices have been furnished which have not been in general use." I think that should be altered to read, "If any devices are furnished, they should be subject to the acceptance of the engineer."

Mr. Mock:—I do not think a structure such as a bridge or a building is quite a parallel case, since we may describe minutely all materials for such structures, but we cannot do so in signaling and interlocking, because there are so many devices developing constantly that we could not afford to exclude improvements over present standards. I feel, therefore, that something should go in, and it seems to me Mr. Baldwin's suggested revision would enable us to judge to this extent the materials we would accept. However, I do not speak for the Committee as a whole.

The President:—The action now is to amend paragraph 12 to read: "If any devices are furnished, they shall be subject to the acceptance of the .... engineer before being placed in position."

Mr. Baldwin:—If the paragraph is left as it now reads, the contractor would have the right to compel you to accept a device that is in general use, one which you might not care to accept. You must be able to control the situation, but if the clause is left as it now reads you cannot control it. If the device is in general use, the contractor would have the right to put it in.

Mr. Trimble:—I understood from the remarks of the chairman of the Committee that this was a sort of saving clause, to obviate a long bill of extras. I think they have a fairly good saving clause in paragraph 1, which reads: "The contractor shall furnish all tools, materials and labor, except as may be hereinafter noted, to erect and complete the work in accordance with the intent of the plans and specifications, and anything that is obviously necessary to complete or make useful any part mentioned in specification shall be provided by the contractor, although such part is not shown by the plans." It seems to me that that as a saving clause is complete, and the paragraph that is proposed by Mr. Baldwin and myself renders the application of any devices subject to the acceptance of the Chief Engineer. I think that covers the situation entirely.

Mr. Dunham:—I think the gentleman's points are well taken, and I believe the Committee has no objection to the modification of the paragraph as suggested by Mr. Baldwin and Mr. Trimble.

The President:—Are you ready for the question on the alteration of paragraph 12?

Mr. McDonald:—How does the paragraph read?

The President:—"If any devices are furnished, they shall be subject to the acceptance of the .... engineer before being placed in position."

Mr. McDonald:—It seems to me the word "devices" ought to be made clearer. I do not think it is quite clear as it stands.

Mr. Barnard:—It occurs to me that perhaps the same end could be attained by omitting paragraph 12 and adding to paragraph 1 "shall be provided by the contractor, subject to the approval of the engineer." I would offer that as an amendment.

(The motion was lost.)

The President:—The action is now on the original motion, that paragraph 12 be amended to read, "any devices that are furnished shall be subject to the acceptance of the .... engineer before being placed in position."

(The motion was carried.)

Mr. Wendt:—There are two parties to a contract—the contractor and the company. Several of the other committees of the Association have presented specifications, and the usual practice has been to use the word "company." This Committee uses the words "purchasing company." I suggest that the practice be uniform, and that the word "company" be used.

The President:—That is to apply throughout the specifications.

(The motion was carried.)

Mr. Trimble:—I have one other suggestion. Paragraph 6 will have to be modified to correspond with the changes made in paragraphs 2 and 3. Paragraph 6 also refers to transportation, and I move it be modified to correspond with the action taken on paragraphs 2 and 3.

(The motion was carried.)

Mr. L. C. Fritch:—I would suggest that in view of the intelligent work that this Committee has done in working up these specifications, that we accept their judgment on the remainder of the specifications. I would move, therefore, that we adopt the remainder of the specifications as good practice, or approve them as good practice.

The President:—It is moved and seconded that the specifications for mechanical interlocking and material for construction work as amended be approved by the convention as being good practice. That does not mean that they are adopted formally as standard, but that they are approved as good practice. Discussion is in order.

Mr. Ewing:—The specifications as a rule are first-class. One item that comes to my attention is paragraph 49: "Pipe lines shall be used for connections to switches," etc., "not less than 1.65 lbs. per ft." I think the minimum should be a little heavier than that. We are increasing the length and weight of the switches, and 1.65 is a standard pipe that has been used ever since interlocking was put in service. My thought was that 1.65 is too light for a minimum.

Mr. Dunham:—That particular paragraph was handled pretty carefully by the Committee, and while it is true that pipe weighing 1.65 lbs. per ft. has been used a great many years, the Committee thought it was sufficiently heavy. There would be no objection to using heavier pipe if the company saw fit to go to the additional expense. However, cost was not considered by the Committee. We thought that pipe weighing 1.65 was first-class.

Mr. Ewing:—In regard to coupling, I had a severe lesson not long ago. The pipe coupling broke, and a clear signal was given with the switch in the wrong position. It seems to me that this is a matter of vital importance, and we ought to make a stronger coupling than is recommended.

Mr. Mock:—The question of weight per foot of one-inch pipe was thoroughly discussed and there seems to be no question about the weight specified here being strong enough when the pipe is properly made and properly supported, and in answer to Mr. Ewing's question on the use of four rivets for the coupling, this matter was gone into very carefully. Some roads use four rivets, but the additional cost and difficulty of making all four rivets useful in adding strength and the fact that the joint, properly made according to specifications, would be stronger than any other part of the pipe, leads us to believe that it would be better to use only two rivets.

(The motion was carried.)

Mr. Wendt:—On page 26 the specifications refer to the use of graphite. I am not opposed to that kind of paint, but I do not think these specifications should include reference to any particular kind of paint. I therefore move that reference to any particular kind of paint be stricken out.

The President:—Mr. Wendt's suggestion, as good as it may be, is out of order unless it is accepted by the Committee and the convention.

Mr. Dunham:—I believe the Committee would be perfectly willing to substitute the words "paint of an approved manufacture."

The President:—If there is no objection on the part of the convention, that will be incorporated.

Mr. Dunham:—I find that some of the members of the Committee object to making the suggested change.

The President:—You want the word "graphite" retained?

Mr. Dunham:—Yes.

The President:—In view of the objection of the Committee, it can only be taken up on a vote to reconsider. The Committee now desires to take up the question of automatic block signaling, shown on pages 28 and 29, of Bulletin 73.

Mr. Dunham:—The Committee was instructed to prepare specifications and plans for automatic block signals. We did not go further into the subject than to prepare plans showing recommended signal locations, and the plans of various arrangements of proposed automatic block signal locations are shown on pages 30 to 37, inclusive, varying from single-track to four-track layouts. The Committee would be glad to have the suggested locations discussed.

Prof. W. D. Pence (Purdue University):—I would like to inquire whether the matter that we just adopted is to be printed in the Manual?

The President:—That would depend upon the action of the Board of Direction in going over it. That has been endorsed as good practice, but not adopted as the standard of the Association. It would be for the Board of Direction to decide whether it was proper to print it.

Mr. McDonald:—I would like to ask the Committee if in stating that these various arrangements of signals are the most approved method, they know who has approved them. Has the Railway Signal Association approved these various diagrams for arrangements of signals? The Committee states positively that the Railway Signal Association has approved the conventions as far as they go. I would like to ask if the Railway Signal Association has approved the arrangement of signals as shown on the diagrams?

Mr. Dunham:—The several plans shown here have not been approved by the Railway Signal Association. They were prepared by this Committee, and various changes were made from time to time during the year, and the diagrams as now submitted are what the Committee believes to be good practice.

Mr. McDonald:—I believe we ought to treat the Railway Signal Association as a kind of skirmish line and let them fight this thing out. It would hardly be worth while for us to undertake to pass on these different locations until the matter has been fought out in their committee. Unless our Committee wishes to get an expression from this convention in regard to them, I move that the consideration of automatic block signals be deferred until the matter has been discussed and approved by the Railway Signal Association. I also move that the conventions which have been adopted by the Railway Signal Association be approved by this Association.

Mr. Dunham:—There is some feeling in the Committee that the Association should take some action on the locations shown on the plans. I might add that in the matter of block signal installations the question of signal locations is vital. Little progress can be made in the way of installing the system until the matter of location has been established, and it should not take very long for the convention to pass judgment on the matter of location of the signals. The Committee would therefore like some action by the convention on the matter.

Mr. McDonald:—I withdraw my motion in view of the explanation.

The President:—The motion is withdrawn with the consent of the second. Discussion is now in order on the location of automatic block signals.

Mr. W. A. D. Short (Illinois Central):—The Committee objects to having the diagrams of these locations referred back to them, as this is the result of very careful work by the Committee and is the best practice to-day. The matter of signal locations is of vital importance, and has been kept in view in planning these diagrams. The symbols and conventions submitted are those in use by all railroad companies equipped with signals and by all the signal companies. The chance of confusion has been reduced to a minimum as far as the symbols go, and the Committee wishes the action taken on this automatic signal layout to be final. We therefore object to its being referred back.

Mr. Mann:—It seems to me that Mr. McDonald's point, that it would be well to consider the recommendations of the Railway Signal Association in this regard is a good one, and it seems to me it might be well for our Committee to be instructed to confer with the Railway Signal Association on this subject, so as to be sure that we have uniform practice and do not recommend something to which the other association does not agree.

Mr. Short:—Referring to Mr. Mann's objection concerning the Maintenance of Way Association adopting these layouts, as shown in the Committee's report, owing to the possibility of their conflicting with the Railway Signal Association—for the information of the convention I might say that there is no committee in the Railway Signal Association that would show layouts of this sort. The committees of the Railway Signal Association are more on detail circuit layouts, etc., for getting the right results. These diagrams shown here are final results, and there is no committee in the Railway Signal Association that could take care of this as well as the Committee of the Maintenance of Way Association.

The President:—Is there any further discussion by the convention upon the subject of these signal locations?

Mr. Short:—I move that the several arrangements of signals as shown be adopted as standard practice in the matter of signal locations.

(The motion was carried.)

Mr. Short:—I should like to make the motion that the Association adopt as standard practice the conventions shown on pages 38 to 44, inclusive

The President:—That is conclusion No. 9 on page 5?

Mr. Short:—Yes, sir.

(The motion was carried.)

The President:—The tenth conclusion, relating to definitions, will be omitted.

Mr. Dunham:—The Committee would like the members to participate in some discussion of the several diagrams of signals illustrated on pages 48 to 53, inclusive. It may be in order to say that the signal shown in Fig. A is the one adopted by the Association in 1903. The Committee started out with this signal and added signals more or less in general use throughout the country, and the vote of the several members is given in the statements printed in connection with the illustrations. The Committee would like to refer more particularly to Fig. 7, which illustrates a signal with an upwardly-inclined arm. The Committee believes that this signal is correct in principle, and that the signals of the various types having the drop arm have weaknesses which are overcome entirely when the upward-travel arm is used.

Mr. Mann:—If a motion is in order, I move that the Committee be instructed to examine during the coming year a signal of this sort, an installation of which, I understand, is to be made, and make a report upon it.

(The motion was carried.)

Mr. McDonald:—I would like to ask what action the Committee desires to be taken in regard to this matter?

Mr. Dunham:—Some of the members of the Committee have expressed a desire for some discussion on the matter of the signal as illustrated in Fig. 7.

The President:—The Committee desires some expression of opinion on the part of the convention as to the merits or demerits of the upwardly-inclined arm, as shown in Fig. 7.

Mr. Dunham:—The Committee would be especially interested in any remarks or criticism that operating officers might have in regard to the use of this signal.

The President:—Is there any discussion upon the request of the Committee? If there is no discussion, the Committee will be relieved, with the thanks of the Association.

REPORT OF COMMITTEE NO. IV.—ON RAIL.

To the Members of the American Railway Engineering and Maintenance of Way Association:

The Committee on Rail submits the following report on some of the subjects assigned:

PIPED RAILS.—FREQUENCY OF OCCURRENCE, CAUSE AND RECOMMENDED REMEDY.

We find from reports received that piped rails are frequent in occurrence. We submit the following modification of the proposed specification of the A. S. C. E. on this subject:

"There shall be sheared from the end of the blooms formed from the top of the ingots not less than twenty-five per cent., and if, from any cause, the steel does not then appear to be solid, the shearing shall continue until it does. If, by the use of any improvements in the process of making ingots, the defect known as piping shall be prevented, the above shearing requirements may be modified."

SECTIONS.—RECOMMENDATIONS AS TO CHANGING STANDARD RAIL SECTIONS OF THE A. S. C. E.

We have no definite recommendation to make in regard to change of section, as we think that we do not have sufficient information on this subject.

We should like information from the members of the Association on the following: Cause and nature of failures in 70-lb., 75-lb., 80-lb., 85-lb., 90-lb. and 100-lb. rails.

We feel the necessity of treating each weight of rail separately in comparing the A. S. C. E. sections with other sections of the same weight under similar conditions.

STATISTICS AS TO LIFE OF RAILS.

The life of rails is affected by many conditions, such as alinement, profile, density of traffic and speed of trains.

We do not believe that figures prepared for one railroad will be useful to another railroad without considering the conditions mentioned above.

We recommend that such statistics be eliminated from the future work of the Committee.

STATISTICS AS TO BREAKAGE OF RAILS.

A great deal of information on this subject has been furnished to the Committee. This information is largely of a confidential nature, and it is the opinion of the Committee that it cannot properly be published in detail without the consent of the parties furnishing the information. We can say, however, that we find that all railroads are suffering from rail failures to such an extent that we are warranted in asking the manufacturers to comply with every requirement of our specifications and to do everything in their power to improve the quality of the rail.

We give below a summary, showing the large number of failures on a few of the important railroads with a heavy traffic.

Railroad No. 1.

Number of breakages of rails during the year or past two years, 537—one year, Sept. 30, 1904, to Oct. 1, 1905.

(a) Length of time rail has been in service: 1, 17 years; 4, 9 years; 43, 8 years; 22, 7 years; 3, 6 years; 3, 3 years; 22, 2 years; 439, 1 year.

(b) Date of rolling: 1 in 1888, 1 in 1895, 31 in 1896, 17 in 1897, 24 in 1898, 4 in 1902, 21 in 1903, 438 in 1904.

(c) General character of the breaks: Breaks between ties, 180; breaks on ties, 357. There were 224 flaws in 85-lb. rail and 80 flaws in 75-lb. rail; total flaws, 304.

Railroad No. 2.

Number of breakages of rails during the year or past two years: 215 in the last year.

(a) Length of time rail has been in service: 97 of these had seen two years' service or less.

(b) Date of rolling: 97 were rolled in 1903; balance from 1890 to 1905.

(c) General character of the breaks: Principally due to mashing.

Railroad No. 3.

(1) From August 1st, 1904, to August 1st, 1905, there were 196 breakages of 80-lb. steel rail.

(2) The causes of failure arise from defective material as well as manufacture.

Railroad No. 4.

Number of breakages of rails during the year 1904, 85's and 100's, 1,324 (nothing less than 85's considered).

(a) Length of time rail has been in service: 0 to 1 years, 182; 1 to 2 years, 95; 2 to 3 years, 105; 3 to 4 years, 67; 4 to 5 years, 79; more than 5 years, 275.

(b) Date of rolling of those in service 5 years and less: 1896, 1; 1897, 4; 1898, 15; 1899, 80; 1900, 72; 1901, 88; 1902, 59; 1903, 189; 1904, 13.

(c) General character of the breaks. Majority are square breaks: some crack through web (through bolt holes) and then break out through head or web. A few, where cropping of ingot has been too little, mash down in head with internal fissures.

Railroad No. 5.

(a) During one year 671 rails were removed which were broken or defective.

(c) General character of the breaks. A large number of these rails were removed from track before they broke. The majority of the broken and defective rails rolled in 1900, 1901, 1902, 1903 and 1904, showed piping.

Railroad No. 6.

(a) During the year ending June 30, 1905, had more than 200 rails to break on a main track mileage of a little over 4,000 miles.

(b) General character of the breaks. The 1899 rails are exceptionally hard. The cause of the breakages due to straightening at the mills where the webs were cracked, large numbers failing every year since laid. The breaks invariably show by longitudinal cracks in the webs. As a general rule they are removed before any failure takes place

DROP TEST AND SHRINKAGE CLAUSE.

Since the last meeting of the Association there has been a joint meeting of this Committee with the Committee of the A. S. C. E. on Rail Sections, at which meeting proposed revisions of sections and specifications were discussed. The joint committee agreed at this meeting to make no recommendations in regard to change of sections, but agreed upon the desirability of insisting upon two points in our specification, as follows: The desirability of a drop test from each heat of steel, and a shrinkage clause to control the finishing temperature.

We give below a comparison of our specification with the proposed A. S. C. E. specification on the drop test and shrinkage clause, and recommend the adoption of the A. S. C. E. clauses.

AM. RY. ENG. AND M. OF W. ASSOCIATION SPECIFICATION.

(3) One drop test shall be made on a piece of rail not less than 4 ft. and not more than 6 ft. long, selected from each blow of steel. The test piece shall be taken from the top of the ingot. The rail shall be placed head upwards on the supports, and the various sections shall be subjected to the following impact tests under a free falling weight:

	Weight of rail, lbs. per yard.	Height of drop.
	45 to and including 55	15 ft.
More than	55 to and including 65	16 ft.
More than	65 to and including 75	18 ft.
More than	75 to and including 85	20 ft.
More than	85 to and including 100	22 ft.

If any rail breaks, when subject to the drop test, two additional tests will be made of other rails from the same blow of steel, and if either of these latter tests fail, all the rails of the blow which they represent will be rejected, but if both of these additional test pieces meet the requirements, all the rails of the blow which they represent will be accepted.

(4) The number of passes and speed of train shall be so regulated that on leaving the rolls at the final pass the temperature of the rail will not exceed that which requires a shrinkage allowance at the hot saws of 6 in. for 85-lb. and 6⅛ in. for 100-lb. rails, and no artificial means of cooling the rails shall be used between the finishing pass and the hot saws. The above shrinkage allowance may be varied, if necessary, so as to give a finishing temperature of not exceeding 1,600 deg. Fahrenheit at finishing rolls for mills rolling from reheated blooms, and not exceeding 1,750 deg. Fahrenheit at finishing rolls for mills rolling direct from the bloom to finished rail.

A. S. C. E. SPECIFICATION.

Drop Test.—One drop test shall be made on a piece of rail not less than 4 ft. and not more than 6 ft. long, selected from each blow of steel. The test piece shall be taken from the top of the ingot. The rails shall be placed head upward on the supports, and the various sections shall be subjected to the following impact tests under a free falling weight:

70 to 79-lb. rails	18 ft.	90 to 100-lb. rails	22 ft.
80 to 89-lb. rails	20 ft.		

If any rail breaks when subject to the drop test, two additional tests may be made of other rails from the same blow of steel, also taken from the top of the ingots, and if either of these latter rails fail, all the rails of the blow which they represent will be rejected, but if both of these additional test pieces meet the requirements, all the rails of the blow which they represent will be accepted.

The drop-testing machine shall have a tup of 2,000 lbs. weight, the striking face of which shall have a radius of not more than 5 in., and the test rail shall be placed head upward on solid supports 3 ft. apart. The anvil block shall weigh at least 20,000 lbs., and the supports shall be part of, or firmly secured to, the anvil. The report of the drop test shall state the atmospheric temperature at the time the test was made.

The number of passes and speed of train shall be so regulated that on leaving the rolls at the final pass, the temperature of the rail will not exceed that which requires a shrinkage allowance at the hot saws for a 33-ft. rail of 100-lb. section, of 6 7-16 in., and 1-16 in. less for each 5-lb. decrease of section, these allowances to be decreased at the rate of 1-90 in. for each second of time elapsed between the rail leaving the finishing rolls and being sawn. No artificial means of cooling the steel shall be used after the rails leave the rolls, nor shall they be held before sawing for the purpose of reducing their temperature.

SPECIFICATIONS.

Difference between the A. S. C. E. and the Am. Ry. Eng. and M. of W. Association specifications:

The main difference between these two specifications are as follows:

CHEMICAL COMPOSITION.

Am. Ry. Eng. and M. of W. Association Specification.

(2) Rails of the various weights per yard specified below shall conform to the following limits in chemical composition:

	Per cent.				
	50 to 59 lbs.	60 to 69 lbs.	70 to 79 lbs.	80 to 89 lbs.	90 to 100 lbs.
Carbon	0.35-0.45	0.38-0.48	0.40-0.50	0.43-0.53	0.45-0.55
Phosphorus not to exceed	0.10	0.10	0.10	0.10	0.10
Silicon shall not exceed	0.20	0.20	0.20	0.20	0.20
Manganese	0.70-1.00	0.70-1.00	0.75-1.05	0.80-1.10	0.80-1.10

A. S. C. E. Specification.

Chemical Composition.—Rails of the various weights per yard specified below shall conform to the following limits in chemical composition:

	Percentage		
	70 to79 lbs.	80 to 89 lbs.	90 to 100 lbs.
Carbon	0.50-0.60	0.53-0.63	0.55-0.65
Phosphorus shall not exceed	0.085	0.085	0.085
Silicon shall not exceed	0.20	0.20	0.20
Sulphur shall not exceed	0.075	0.075	0.075
Manganese	0.75-1.00	0.80-1.05	0.80-1.05

We recommend the A. S. C. E. specification, with the addition of the following footnote: Carbon may be reduced to suit local conditions.

STRAIGHTENING RAILS.

The A. S. C. E. Committee has a specification in regard to straightening rails, which we think to be a desirable addition to our specification and which we recommend with some modification.

"Straightening.—Care must be taken in hot straightening the rails, and it must result in their being left in such a condition that they shall not vary throughout their entire length of 33 ft. more than 3 in. from a straight line in any direction, when delivered to the cold straightening presses. Those which vary beyond that amount, or have short kinks, shall be classed as second quality rails and be so stamped. The distance between supports of rails in the gagging press shall not be less than 42 inches."

Section 11 in our specifications should also be modified to read as follows:

"Rails shall be straight in line and surface when finished—the straightening being done while cold—smooth on head, sawed square at ends, variation to be not more than 1-32 in., and, prior to shipment, shall have the burr occasioned by the saw cutting removed and the ends made clean. No. 1 rails shall be free from injurious defects and flaws of all kinds."

ARRANGEMENT OF MATTER IN SPECIFICATIONS.

In the matter of arrangement, the A. S. C. E. specification appears to be better than our form, and it is possible that after the full discussion of the A. S. C. E. specification, which is to be had at the June convention, we may find it desirable for this association to adopt the A. S. C. E. specification, with the exceptions noted above, unless we find that we can otherwise improve upon it.

OPEN HEARTH STEEL RAILS.

There is a very strong tendency towards the use of open-hearth steel for rails, and the specifications proposed by the A. S. C. E. Committee, with some modifications, is offered for discussion. We are in favor of reducing the phosphorus as given in the A. S. C. E. specifications from .05 to .03

The A. S. C. E. specification for open-hearth rail is as follows:

"For Basic Open-hearth Rails.—The specifications for rails made by the Basic Open-hearth process shall be the same as for Bessemer rails, excepting that their chemical composition shall be:

	Percentage		
	70 to 79 lbs.	80 to 89 lbs.	90 to 100 lbs.
Carbon	0.53-0.63	0.58-0.68	0.65-0.75
Phosphorus shall not exceed	0.05	0.05	0.05
Silicon shall not exceed	0.20	0.20	0.20
Sulphur shall not exceed	0.06	0.06	0.06
Manganese	0.75-1.00	0.80-1.05	0.80-1.05"

We recommend the following chemical composition instead of the A. S. C. E. composition:

	Percentage		
	70 to 79 lbs.	80 to 89 lbs.	90 to 100 lbs.
Carbon	0.63-0.73	0.68-0.78	0.75-0.85
Phosphorus shall not exceed	0.03	0.03	0.03
Silicon	.075-0.20	.075-0.20	.075-0.20
Sulphur shall not exceed	0.06	0.06	0.06
Manganese shall not exceed	0.90	0.90	0.90

Respectfully submitted,

Wm. R. Webster, Consulting and Inspecting Engineer, Philadelphia, Pa., *Chairman.*

R. Montfort, Consulting Engineer, Louisville & Nashville Railroad, Louisville, Ky., *Vice-Chairman.*

F. E. Abbott, Inspecting Engineer, Lackawanna Steel Company, Buffalo, N. Y.

E. B. Ashby, Engineer Maintenance of Way, Lehigh Valley Railroad, South Bethlehem, Pa.

D. D. Carothers, Chief Engineer, Baltimore & Ohio, Baltimore, Md.

S. M. Felton, President, Chicago & Alton Railway, Chicago, Ill.

J. F. Hinckley, Chief Engineer, St. Louis & San Francisco Railway System, St. Louis, Mo.

Robt. W. Hunt, Consulting Engineer, Chicago, Ill.

J. W. Kendrick, Second Vice-President, Atchison, Topeka & Santa Fe Railway System, Chicago, Ill.

E. F. Kenney, Engineer of Tests, Pennsylvania Railroad, Philadelphia, Pa.

J. Kruttschnitt, Director of Maintenance and Operation, Harriman Lines, Chicago, Ill.

D. W. Lum, Chief Engineer Maintenance of Way and Structures, Southern Railway, Washington, D. C.

F. H. McGuigan, Fourth Vice-President, Grand Trunk Railway System, Montreal, Canada.

E. J. Pearson, Chief Engineer, C., M. & St. P. Ry. of Wash., Seattle, Wash.

H. T. Porter, Chief Engineer, Bessemer & Lake Erie Railroad, Greenville, Pa.

J. T. Richards, Chief Engineer Maintenance of Way, Pennsylvania Railroad, Philadelphia, Pa.

R. Trimble, Chief Engineer Maintenance of Way, N. W. System, Pennsylvania Lines, Pittsburg, Pa.

H. U. Wallace, Third Vice-President, J. G. White Co., New York, N. Y.

G. B. Woodworth, Rail Inspector, Chicago, Milwaukee & St. Paul Railway, Chicago, Ill.

Committee.

DISCUSSION.

The President:—We will now take up the report of the Committee on Rail, Mr. Wm. R. Webster, chairman. The chairman of the Committee suggests that the report be read, and, after being read, that it be discussed. Representatives of manufacturing companies who may be present are invited to take part in the discussion.

The Secretary:—"Piped Rails.—Frequency of occurrence, cause and recommended remedy.

"We find from reports received that piped rails are frequent in occurrence. We submit the following modification of the proposed specification of the A. S. C. E. on this subject:

"'There shall be sheared from the end of the blooms formed from the top of the ingots not less than twenty-five per cent., and if, from any cause, the steel does not then appear to be solid, the shearing shall continue until it does. If, by the use of any improvements in the process of making ingots, the defect known as piping shall be prevented, the above shearing requirements may be modified.'

"Sections.—Recommendations as to changing standard rail sections of the A. S. C. E.

"We have no definite recommendation to make in regard to change of section, as we think that we do not have sufficient information on this subject.

"We should like information from the members of the Association on the following: Cause and nature of failures in 70-lb., 75-lb., 80-lb., 85-lb., 90-lb. and 100-lb. rails.

"We feel the necessity of treating each weight of rail separately in comparing the A. S. C. E. sections with other sections of the same weight under similar conditions.

"Statistics as to Life of Rails.—The life of rails is affected by many conditions, such as alinement, profile, density of traffic and speed of trains.

"We do not believe that figures prepared for one railroad will be useful to another railroad without considering the conditions mentioned above.

"We recommend that such statistics be eliminated from the future work of the Committee.

"Statistics as to Breakage of Rails.—A great deal of information on this subject has been furnished to the Committee. This information is largely of a confidential nature, and it is the opinion of the Committee that it cannot properly be published in detail without the consent of the parties furnishing the information. We can say, however, that we find that all railroads are suffering from rail failures to such an extent that we are warranted in asking the manufacturers to comply with every requirement of our specifications and to do everything in their power to improve the quality of the rail.

"We give below a summary, showing the large number of failures on a few of the important railroads with a heavy traffic.

"Railroad No. 1.—Number of breakages of rails during the year or past two years, 537—one year, Sept. 30, 1904, to Oct. 1, 1905.

"(a) Length of time rail has been in service: 1, 17 years; 4, 9 years; 43, 8 years; 22, 7 years; 3, 6 years; 3, 3 years; 22, 2 years; 439, 1 year.

"(b) Date of rolling: 1 in 1888, 1 in 1895, 31 in 1896, 17 in 1897, 24 in 1898, 4 in 1902, 21 in 1903, 438 in 1904.

"(c) General character of the breaks: Breaks between ties, 180; breaks on ties, 357. There were 224 flaws in 85-lb. rail and 80 flaws in 75-lb. rail; total flaws, 304.

"Railroad No. 2.—Number of breakages of rails during the year or past two years: 215 in the last year.

"(a) Length of time rail has been in service: 97 of these had seen two years' service or less.

"(b) Date of rolling: 97 were rolled in 1903; balance from 1890 to 1905.

"(c) General character of the breaks: Principally due to mashing.

"Railroad No. 3.—(1) From August 1st, 1904, to August 1st, 1905, there were 196 breakages of 80-lb. steel rail.

"(2) The causes of failure arise from defective material as well as manufacture.

"Railroad No. 4.—Number of breakages of rail during the year 1904, 85's and 100's, 1324 (nothing less than 85's considered).

"(a) Length of time rail has been in service: 0 to 1 years, 182; 1 to 2 years, 95; 2 to 3 years, 105; 3 to 4 years, 67; 4 to 5 years, 79; more than 5 years, 275.

"(b) Date of rolling of those in service 5 years and less: 1896, 1; 1897, 4; 1898, 15; 1899, 80; 1900, 72; 1901, 88; 1902, 59; 1903, 189; 1904, 13.

"(c) General character of the breaks. Majority are square breaks; some crack through web (through bolt holes) and then break out through head or web. A few where cropping of ingot has been too little mash down in head with internal fissures.

"Railroad No. 5.—(a) During one year 671 rails were removed which were broken or defective.

"(c) General character of the breaks. A large number of these rails were removed from track before they broke. The majority of the broken and defective rails rolled in 1900, 1901, 1902, 1903 and 1904 showed piping.

"Railroad No. 6.—(a) During the year ending June 30, 1905, had more than 200 rails to break, on a main track mileage of a little over 4,000 miles.

"(b) General character of the breaks. The 1899 rails are exceptionally hard. The cause of the breakages due to straightening at the mills where the webs were cracked, large numbers failing every year since laid. The breaks invariably show by longitudinal cracks in the webs. As a general rule they are removed before any failure takes place."

Mr. Wm. R. Webster (Consulting and Inspecting Engineer):—If it is permitted, I would like to say that the Committee this morning received a report from another road, which may be termed "Railroad No. 7." It is as follows:

"In the past five years 2,850 rails failed on 400 miles of road; 20 per cent. of these were broken rails; 80 per cent. were mashed rails. The railroad company considered the mashed rails due to piping. Most of the failures were on 80-lb. rails manufactured in 1900."

The President:—You have heard the report of the Committee. The subject is now open for general discussion. We trust that we shall not only hear from the members and from the engineering side, but also from the manufacturers.

Mr. Chas. S. Churchill (Norfolk & Western):—In order to start discussion, I would make a motion that paragraph 4 on page 1 be adopted.

Mr. Webster:—On page 280 of the Railroad Gazette appear the specifications of the American Society of Civil Engineers, and in that part of the program they had 40 inches on an 8 by 8 block.

Mr. F. E. Abbott (Lackawanna Steel Company):—While I am a member of the Committee, I am not in favor of that as it has been read, and my reason is that I do not think this Association nor any other should state definitely how much should be sheared from the bloom. The matter is entirely one-sided. If we agree here that 25 per cent. shall be sheared from the bloom, we might assume that would settle it, but it will not. The Association will be perfectly safe in making the claim that sufficient shearing shall be done to eliminate piping. One reason for bringing this to your attention is that the manufacturers are likely to oppose it, and they will have very good reasons for doing so. If they can remove the piping by shearing 15 per cent., they will not agree to shear 25 per cent. The object in shearing is to get rid of the piping, and the only matter of agreement will be to reach the point where sufficient shearing is done to remove the piping. For that reason I think the Association will make a mistake to demand that 25 per cent. be sheared off.

Mr. Webster:—This matter was thoroughly discussed by the Committee. They say, "If, by the use of any improvements in the process of making ingots, defects known as piping shall be prevented, the above shearing requirements may be modified." As to going back to the old requirement, that sufficient be cut off to remove the piping, we have a large number of reports showing that does not accomplish the object. We as a Committee say what we think is a good thing to protect the railroad companies. If the manufacturers refuse to work to these specifications, it is up to them. We ask what we think is required to give better results than we get to-day.

The President:—Are you ready for the question?

(The motion was carried.)

Mr. Webster:—The Committee would like information, either now or during the year, in order to enable them to continue their work, as to cause and nature of failures in 70-lb., 75-lb., 80-lb., 85-lb., 90-lb. and 100-lb. rails.

Mr. A. L. Buck (Canadian Pacific):—The chairman of the Committee wishes to know how the 100-lb. section stands as compared with that of the 80-lb. section A. S. C. E. section. Our experience has been that the 100-lb. rail has failed in as great a proportion, if not greater, to its mileage as that of the 80-lb. rail rolled by the same company and in the same year, both rolled to the A. S. C. E. section.

Mr. Robert Trimble (Pennsylvania Lines):—I would like to make a few remarks which will probably give the Association a clue as to the kind of information we wish on that subject. The 85-lb. American Society of Civil Engineers rail is by some called a shallow-head rail; others have a rail which has a deeper head. Statements have been made that the American Society's rail is defective in having a shallow head, and it has been claimed that that head is so shallow that it fails by shearing off. We use the 85-lb. American Society section, and I have not seen any cases of that kind, although it has been reported to me that there have been such cases on our railroad, and it has been put to me this way: That the Pennsylvania Railroad 85-lb. rail, with a deeper head, has been better wearing and is stronger than the American Society section rail. If you will look at the 100-lb. rail of the American Society and compare it with the other 100-lb. rails, you will see that there is very little difference in the depth of the head. The difference is so little that you could hardly observe it. In the 85-lb. rail, the variation in the depth of the head is very marked, and we have the statement of the manufacturers that the 85-lb. American Society rail is a defective one. I am not sure about the other weights, but assume that the same would apply to the 80-lb. and to the 90-lb. sections. We are asking now for definite information to compare the American Society's section with other sections which have a deeper head, to find out whether we should have a deeper head or not in redesigning the section.

Mr. Webster:—I do not know whether it is necessary to ask that any action be taken to relieve us from future work on statistics as to the life of rails for the reasons given. The next point in the report is the drop test and the shrinkage clause. We would like some remarks on either of these.

The Secretary:—"DROP TEST AND SHRINKAGE CLAUSE.—Since the last meeting of the Association there has been a joint meeting of this Committee with the Committee of the A. S. C. E. on Rail Sections, at which meeting proposed revisions of sections and specifications were discussed. The joint committee agreed at this meeting to make no recommendations in regard to change of sections, but agreed upon the desirability of insisting upon two points in our specification, as follows: The desirability of a drop test from each heat of steel and a shrinkage clause to control the finishing temperature.

"We give below a comparison of our specification with the proposed A. S. C. E. specification on the drop test and shrinkage clause, and recommend the adoption of the A. S. C. E. clauses.

"Am. Ry. Eng. and M. of W. Association Specification.—(3) One drop test shall be made on a piece of rail not less than 4 ft. and not more than 6 ft. long, selected from each blow of steel. The test piece shall be taken from the top of the ingot. The rail shall be placed head upwards on the supports, and the various sections shall be subjected to the following impact tests under a free falling weight:

	Weight of rail. —lbs. per yard.—	Height of drop.
	45 to and including 55	15 ft.
More than	55 to and including 65	16 ft.
More than	65 to and including 75	18 ft.
More than	75 to and including 85	20 ft.
More than	85 to and including 100	22 ft.

"If any rail breaks when subject to the drop test, two additional tests will be made of other rails from the same blow of steel, and if either of these latter tests fail, all the rails of the blow which they represent will be rejected, but if both of these additional test pieces meet the requirements, all the rails of the blow which they represent will be accepted.

"(4) The number of passes and speed of train shall be so regulated that on leaving the rolls at the final pass the temperature of the rail will not exceed that which requires a shrinkage allowance at the hot saws of 6 in. for 85-lb. and 6⅛ in. for 100-lb. rails, and no artificial means of cooling the rails shall be used between the finishing pass and the hot saws. The above shrinkage allowance may be varied, if necessary, so as to give a finishing temperature of not exceeding 1,600 degrees Fahrenheit at finishing rolls for mills rolling from reheated blooms, and not exceeding 1,750 deg. Fahrenheit at finishing rolls for mills rolling direct from the bloom to finished rail.

"A. S. C. E. Specification.—Drop Test.—One drop test shall be made on a piece of rail not less than 4 ft. and not more than 6 ft. long, selected from each blow of steel. The test piece shall be taken from the top of the ingot. The rails shall be placed head upward on the supports, and the various sections shall be subjected to the following impact tests under a free falling weight:

70 to 79 lb. rails.................18 ft.	90 to 100-lb. rails...............22 ft.
80 to 89-lb. rails.................20 ft.	

"If any rail breaks when subjected to the drop test, two additional tests may be made of other rails from the same blow of steel, also taken from the top of the ingots, and if either of these latter rails fail, all the rails of the blow which they represent will be rejected, but if both of these additional test pieces meet the requirements, all the rails of the blow which they represent will be accepted.

"The drop testing machine shall have a tup of 2,000 lbs. weight, the striking face of which shall have a radius of not more than 5 in., and the test rail shall be placed head upward on solid supports 3 ft. apart. The anvil block shall weigh at least 20,000 lbs., and the supports shall be part of, or firmly secured to, the anvil. The report of the drop test shall state the atmospheric temperature at the time the test was made.

"The number of passes and speed of train shall be so regulated that on leaving the rolls at the final pass, the temperature of the rail will not exceed that which requires a shrinkage allowance at the hot saws for a 33-ft. rail of 100-lb. section, of $6\frac{7}{16}$ in., and $\frac{1}{16}$ in. less for each 5-lb. decrease of section, these allowances to be decreased at the rate of $\frac{1}{90}$ in. for each second of time elapsed between the rail leaving the finishing rolls and being sawn. No artificial means of cooling the steel shall be used after the rails leave the rolls, nor shall they be held before sawing for the purpose of reducing their temperature."

Mr. W. F. Tye (Canadian Pacific):—I move that the American Society requirements relative to the drop test be adopted.

Mr. Webster:—The requirement is practically the same as our own, with a very slight difference.

(The motion was carried.)

Mr. Tye:—In order to start discussion, I would move that the American Society requirements regarding shrinkage be amended by substituting $6\frac{1}{4}$ in. in place of $6\frac{7}{16}$ in. as the allowance for 100-lb. sections. My reason for this is that I am not quite clear what effect the last portion will have, which states: "These allowances are to be decreased," etc. I am under the impression that the allowance given is larger than the allowance in our own specification, and I think the allowance in our own specification is quite high enough. I have not here the information as to the time which lapses between the time the rail leaves the finishing rolls and being sawn. I am, of course, aware that it is different in each mill.

Mr. Webster:—I will say that the allowance we give is from the instant the rail leaves the rolls. We commence allowance or correction for time from then.

Mr. Tye:—What is that time?

Mr. Webster:—We have the different reports. I think you will find it to be about twenty seconds. It will give practically the same allowance as yours. That has been gone into pretty carefully. Do you remember your allowance?

Mr. Tye:—What we have been able to attain is 6 in. for 80-lb. rails; but we have been trying to get better.

Mr. Webster:—On 30 or 33-ft. rails?

Mr. Tye:—Thirty-three-ft. rails.

Mr. Webster:—Six inches is less than you would have in five seconds. According to this, you would have 6⅛ in. If you have 15 seconds, which is the average time, you would have 6 in. I will tell you frankly that the Committee have gone into this very carefully, and we will of course go over it again if it is referred back to us, but we do not want a motion to change it.

Mr. Tye:—My object in making the motion was to elicit information.

Mr. Webster:—Then we will take it up and report at a later time.

Mr. Tye:—I will change my motion and ask that it be referred back to the Committee.

Mr. Webster:—That is the course that was followed yesterday with reference to the Committee on Iron and Steel Structures. After a committee has done its best work, it should not be reversed on the floor, unless there is good reason.

Mr. Tye:—Most of the committees are reversed on the floor very frequently.

The President:—Does the chair understand your motion to be that this matter be referred back to the Committee?

Mr. Tye:—Yes.

Mr. Webster:—The Committee will be glad to go into it again and make a further report at the next meeting.

(The motion was lost.)

Mr. Churchill:—I now move that the recommendation of the Committee on the matter of the shrinkage clause be adopted.

(The motion was carried.)

The Secretary:—"Specifications.—Difference between the A. S. C. E. and the A. R. E. & M. of W. Association specifications:

"The main difference between these two specifications are as follows:

"Chemical Composition.—Am. Ry. Eng. & M. of W. Association Specification:

"(2) Rails of the various weights per yard specified below shall conform to the following limits in chemical composition:

	Per cent.				
	50 to 59 lbs.	60 to 69 lbs.	70 to 79 lbs.	80 to 89 lbs.	90 to 100 lbs.
Carbon	0.35-0.45	0.38-0.48	0.40-0.50	0.43-0.53	0.45-0.55
Phosphorus not to exceed	0.10	0.10	0.10	0.10	0.10
Silicon shall not exceed	0.20	0.20	0.20	0.20	0.20
Manganese	0.70-1.00	0.70-1.00	0.75-1.05	0.80-1.10	0.80-1.10

"A. S. C. E. Specification:

"Chemical Composition.—Rails of the various weights per yard specified below shall conform to the following limits in chemical composition:

	Percentage		
	70 to 79 lbs.	80 to 89 lbs.	90 to 100 lbs.
Carbon	0.50-0.60	0.53-0.63	0.55-0.65
Phosphorus shall not exceed	0.085	0.085	0.085
Silicon shall not exceed	0.20	0.20	0.20
Sulphur shall not exceed	0.075	0.075	0.075
Manganese	0.75-1.00	0.80-1.05	0.80-1.05

"We recommend the A. S. C. E. specification, with the addition of the following footnote: Carbon may be reduced to suit local conditions."

Mr. Tye:—I move that the American Society's requirements regarding chemical composition be adopted.

Mr. Webster:—With the footnote?

Mr. Tye:—Without the footnote.

Mr. Webster:—As a member of the Committee I would like to amend the motion to the effect that the American Society's requirement for chemical composition be adopted. Some of the members claim it is easier to reduce the carbon than increase it. I therefore move that the clause be accepted with the footnote.

Mr. Tye:—My objection is to the footnote. I would like to see the footnote changed to read that phosphorus may be reduced where the conditions will permit. I know it is possible to get phosphorus in certain sections lower than this, but the carbon should be kept up.

Mr. Webster:—We thought we had gone about as far as we could on the phosphorus question. I know some of the roads have succeeded in getting lower phosphorus. We would like to have an expression from the members on the phosphorus question because it is vital.

Mr. Tye:—The Canadian Pacific has succeeded in certain sections in getting lower phosphorus than .085. I think when it is possible to get it that we should do so.

Mr. Webster:—So do we, and another footnote might be added, "Wherever possible."

The President:—The motion before the house is to adopt the requirements of the American Society of Civil Engineers for chemical composition, with the footnote appearing on page 5.

Mr. George Thackray (Cambria Steel Company):—I would respectfully suggest, so far as the carbon is concerned, that it is about right, but when you come to consider the question of low phosphorus, namely, .085 per cent., in Bessemer rails, you are at once met by the practical difficulty that there does not exist in this or any other country from which we draw our ore supplies a sufficient quantity of ore to make the total tonnage of rails of that composition when the other needs of the trade are considered, and you are then attempting what is practically impossible. We are all aiming at perfection, and think low phosphorus is better than high; but we must not shut our eyes to the fact that it cannot be had for everything, and I want to call the attention of the Association and of the Committee to that particular point and ask them to think it over

Mr. Webster:—Mr. Tye remarked that he thought .085 phosphorus too high, because he thought the railroads were getting to lower phosphorus.

Mr. Thackray:—One railroad might obtain low phosphorus rails, but if they are getting them they are doing so at the expense of the rest of the railroads, because there is not enough to go around

Mr. W. M. Camp (Railway and Engineering Review):—Some years ago it was the practice to allow a higher limit to the railroads in the West. I would like to ask whether that practice is still in force.

Mr. Webster:—There are various conditions due to the mills using different ore. With Cuban ore, they could meet it in the East, whereas they could not meet it in the West.

Mr. A. L. Buck (Canadian Pacific):—I do not quite get the force of the remarks of Mr. Thackray about the necessity of the use of high phosphorus rail, regardless, on the ground that it is impossible to obtain sufficient quantities of ore of low-grade phosphorus to produce sufficient quantities of steel to meet the demands of the country. This appears like an admission that proper material was not being used in the manufacture of rails.

Mr. H. T. Porter (Bessemer & Lake Erie):—I rise for a little information. Our rules state that "No report shall be published in the Proceedings unless it shall have been acted upon by the convention;" also, "Reports received after December 31st will not come before the following convention, will be withheld from the public press, published in a Bulletin after the convention, and considered at the next convention." This Bulletin was not issued until about a half hour before this meeting convened, and I would like to ascertain what action the convention proposes to take on this report. I do not want to obstruct the proceedings of the Association, but I think it very important that members should have an opportunity of considering and investigating a report before adopting specifications, as is done in the case of the other committees.

The President:—The chair will state that Mr. Porter is correct in saying that the rules provide that reports received after December 31st will not be presented to the convention. The Board of Direction, however, has the privilege of granting permission to present such report, and request was made to the Board that this report be allowed to be presented at this meeting. The chairman of the Committee also stated that such conclusions as the Association was not prepared to pass upon should be referred back to the Committee for further consideration and report. Mr. Webster, have you anything to say upon this feature?

Mr. Webster:—I take occasion at this time to thank the Board of Direction for giving us the privilege of bringing the matter up now, and also thank Mr. Fritch for putting this matter in print. We did not finish our committee work until 5 o'clock Tuesday afternoon. About 6 o'clock we gave the report to Mr. Fritch, and yesterday afternoon we had it in printed form. I think that is a record for quick work that no other association has equaled, and we are under great obligations to Mr. Fritch for helping us out in such a splendid way.

Now, all the members of this Association, I think, have seen the report of the committee of the American Society of Civil Engineers, which was made in January. Since that report was published I made a request of the Board of Direction to bring it up for discussion. That is all we have done. If there is anything in the report that the members do not wish to accept, we will be glad to have it referred back to us; but I do take exception to any vote to reverse the action of this Committee—or any other committee, for that matter—on a subject to which they have given considerable thought and study. Let us have it as an unwritten law to refer back to a committee any portion of a report that is not acceptable for further consideration, and give one committee the same treatment that we give another.

Mr. W. A. Bostwick (Carnegie Steel Company):—As a matter of information I would like to ask the Committee if these recommendations are intended to be known as literal specifications or as an approximate specification? Criticism would naturally be guided considerably by the decision on that question.

Mr. Webster:—The Committee has submitted a specification, which, if lived up to, would give a satisfactory rail. The matter has been thoroughly discussed, and we have also carefully considered the information secured in regard to the breakage of rails. The present specifications are not securing us rails that are giving the service that should be expected from rails rolled from good steel made under good conditions. We have obtained a large mass of data on this subject, sufficient to satisfy anyone that the rails we are getting are not giving satisfaction. We want a better rail. We have asked that the manufacturers state what objections they have to complying with the specifications, and what percentage of their rails they can make under the requirements.

Mr. Porter:—Are we to understand that the adoption of the different sections of this report would mean that they would be the specifications of the Association; that they would amend the present specification and become the authorized version?

Mr. Webster:—Yes, where we have added any matter. We have further stated that after the discussion of the American Society specifications at the June convention we may be able to adopt them as a whole. In that connection I want to have read, later, a letter from Mr. Jos. T. Richards, a member of the committee of the American Society of Civil Engineers, showing the desire on his part to work in harmony with this Association. The conditions are very similar, and we hope to get a joint specification from the two societies.

Mr. Porter:—I have, with such spare time as I have had at my disposal, looked into the question of rails and find it a very interesting subject. There are several features of this specification that were only brought before the Committee yesterday.

Mr. Webster:—I want to call Mr. Porter's attention to the fact that he received a letter about two months ago, as did every other member of the Committee, in which every point that was brought up at the committee meeting yesterday was mentioned.

Mr. Porter:—I have the letter here, and would be glad to have it read.

Mr. Webster:—In the letter referred to it was stated that the specifications of the American Society of Civil Engineers and their report would be subject to discussion at this time. We have not brought in any point not covered in their specification except a suggested modification. Each member of the Committee was also furnished with a copy of the replies received from railroad companies, tabulated by Mr. Fritch.

Mr. Porter:—I received the tabulation mentioned, but it simply gave information concerning the number of rails broken on certain railroads and the year in which they were rolled, but it did not give details sufficiently to draw conclusions therefrom.

Mr. Webster:—We are not asking the Association to do anything in regard to the abstract questions connected with this report.

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis):—I rise to a point of order that this discussion is out of order.

The President:—The point is well taken.

Mr. Buck:—I think that the majority of the members present believe that the specifications of the American Society of Civil Engineers are a theoretical specification that has never been met. The road with which I am connected has perhaps in round numbers six hundred miles of rail rolled practically under these specifications, and which are now in the second year of their service. I have observed these rails very closely as well as rails of different mills rolled under practically the specifications of this Association, and I believe that this proposed specification as to chemical composition is about right.

While we have failures in the high carbon rails, they are not resulting from the chemistry, but from the physical condition or qualities of the rail. Without exception, so far, the failure has resulted from a pipe, flaw or seam. The metal itself has not failed, but has demonstrated that it is sufficiently hard to withstand the loads and service imposed without flattening out or mashing down, as is the case generally with the carbon rails rolled since 1896. These latter rails as well as being soft in metal were in many instances badly piped, and often failed by the pipe in the ball of the rail giving down so as to cause a drooping in the running surface of the rail that would soon lead to the destruction of the rail. This class of failure has been eliminated by the high carbon rails, but undoubtedly as many pipes exist in the ball of the rail as formerly and are kept from failing by the superior strength or hardness of the metal. The pipes that are causing the high carbon rails to fail are those that exist in the flange or base of the rail, this being explained by the base having to sustain a tensile strain instead of one of compression. While we have had more failures in our high carbon rails than is desirable, they are largely localized, showing that the prime cause is one of manufacture and not general. On one division where the soft or low carbon rails utterly failed and were replaced by these high carbon rails, there is yet scarcely a failure. This division is among our first for heavy and fast traffic, and the comparison of the service of these latter rails with that of the former ones is certainly encouraging.

The weakness yet to be eliminated by the manufacturers is the piping. Once that is overcome I believe we will have a rail that will prove as satisfactory under our heavy traffic as the early light section steel rails did under their traffic.

Mr. Webster:—As a matter of fact, I understand you have less phosphorus in your rails, and the amount of discard is less than the specification calls for—it is a little lower than that.

Mr. Buck:—I would refer the discussion of the chemical composition to Mr. Tye, who is more familiar with it.

Mr. Tye:—The phosphorus in the rails which we use, made from Lake Superior ore, is the same as this specification—.085. In the case of rails made from Eastern ores, the phosphorus is .075. Our discard, however, was only to cut off the ragged ends, and after cutting off the point that did not seem solid to go 12 in. further into seemingly solid material, and to keep on cutting until the solid material was reached.

Mr. Webster:—I have prepared some tables showing the amount of shrinkage for different weights of rails, as referred to in the specifications, and in the case of Mr. Tye, using an 80-lb. rail, the shrinkage, according to this table, is 6 in. for a time limit of 15 seconds, or a quarter of a minute, which corresponds exactly with the shrinkage called for in your specification.

Mr. Tye:—That information answers my question of yesterday. I still believe that even a 6-in. allowance for shrinkage is too great, because we all know that one of the most important things in getting a good rail is to have it rolled at a low temperature. The smaller your allowance for shrinkage, the lower the temperature.

Mr. H. C. Griswold (Illinois Steel Company):—I have had some experience with a rail rolled practically to this chemical requirement—an 80-lb. rail. The carbon was .55 to .65, and the phosphorus .085. This rail gave very poor service. It was exceedingly hard and broke square through the section and by cracking through the web; by irregularly cracking about horizontally or longitudinally through the web. In a number of cases where I examined these cracks it was plain to be seen how the rails had been broken. They had been struck by the section-men with their spike mauls in gaging the track, and the blows from the spike mauls had started very small irregular cracks. These cracks would gradually enlarge, and finally, if the rails were not removed from the track, they would break. We made monthly inspections of this rail, which was rolled in 1899, and I suppose they are still making them. We usually took the rails out before they would break. I inspected, not a great while ago, ten cracked rails, and out of these ten, nine had these spike maul marks. The reason for treating the rail in this rough way was that the spikers had only their gage and spike mauls at hand, and if the rail came within a sixteenth or an eighth of an inch of the gage they would tap it in the web with the spike maul, and these cracks started in that way gradually open up. It is my opinion that a rail rolled under this specification would prove to be a very tender rail and one easily broken through shock.

Mr. Tye:—We have had no such experience as the last speaker mentions. We have now had at least four different orders of 65,000 tons, each rolled to these specifications. As you know, the Canadian Pacific runs through a rather cold country, and yet we have had no such breaks as he speaks of. We have had no square breaks either in the head or the web, and we have very few breaks of any kind. That, in our experience, is in marked contrast to what we had when the rails were rolled under the old specifications. As to our breaks, as Mr. Buck explained, I think I am safe in saying that 90 per cent.—probably more—come in the base, and in every case show they were due to pipes, clearly demonstrating that the discard was not sufficient. I believe that this trouble will be well met by this requirement regarding discard.

Mr. Trimble:—I did not understand the name of the road to which Mr. Griswold referred.

Mr. Griswold:—The experience had was on the Louisville & Nashville. A roadmaster on an adjoining division also noticed this same trouble and called attention to it. It was Mr. Brumley, who is now Principal Assistant Engineer of the Illinois Central. Perhaps he will give some additional light on the subject, if he is present.

Mr. Webster:—Do you think that these rails were tender, as you term it, or brittle, due to the .085 phosphorus?

Mr. Griswold:—I think it was due to the high carbon and the phosphorus being too high for that high carbon.

Mr. Webster:—Then you do not think we are unreasonable in asking for .085 phosphorus?

Mr. Griswold:—Have you asked for such high carbon?

Mr. Webster:—I would call your attention to the footnote which is attached to the clause, referring to a lower carbon, which reads:

"Carbon may be reduced to suit local conditions." If a road wants lower carbon, it can use that phosphorus for the lower carbon.

Mr. Griswold:—What would be the local condition?

Mr. Webster:—The local conditions might be at the steel mills, finishing the rails with 7-in. shrinkage, which would give large grain, and make it desirable to keep the carbon down. Another mill might finish with 5 in. or 3 in. shrinkage, and the carbon might be a little higher. The local conditions might be on the track—a cold or a hot climate. That has been given by the Committee in general terms, and if in placing your next order for rails, you would take into consideration the local conditions governing the mill, I think you will get better results.

Mr. Griswold:—The rails I refer to were laid in a rather warm climate, and practically all the breakages started from their being struck in the web. That is a practice which is very common, and if the rail had not been so hard, it would not have started the cracks.

Mr. Webster:—Then you would not recommend such high carbon on future orders for rail?

Mr. Griswold:—I do not think that it has been done since then.

Mr. Abbott:—In connection with the specification of the American Society of Civil Engineers, it would be interesting to hear from the railroads that have used what is regarded as high-carbon rails. The mills raise some objection to increasing the carbon in the rails under the revised specification. They can roll them—they can roll as many high-carbon as low-carbon rails, but they cannot pass the drop test called for with the same degree of safety. In other words, the railroad engineers raise the carbon, which they anticipate will make a harder rail, and they also keep up the drop test required on lower carbon rails. They work somewhat against themselves in that regard. If the railroad engineers get a harder rail, they do not want to put a drop test on it which is going to destroy the best steel, or that will result in discarding the best steel. Further, it is not altogether certain that the higher carbons thus far put out are exactly what the engineers want. I have in mind one road—a very large system—which ordered the higher carbon rails. I think they were trying for an average of .58. That was in accordance with their engineer's ideas, and he is a good man, a metallurgical engineer, and a student of rails. That carbon was granted, and these rails went into service; they also broke in service. The operating department immediately called on the engineer to lower his carbon, which he did. The operating department was afraid to continue the use of the high-carbon rails, or, in other words, to increase their tonnage of that kind of rail. What we ought to learn at this meeting is what success the engineers have who are using the high-carbon rails, and whether or not in their opinion the breakage is increased, with the use of that kind of steel. If the breakage has been large, whether it is always the fault of the steel, or possible changes in the rolling stock, and other things which have been changed simultaneously with the use of the harder rails.

Mr. Buck:—Perhaps I did not make myself clear. In the case of the former rails there were probably one hundred rails that failed to one of these harder or high-carbon rails, but not in the same way; they failed by rolling out of shape and mashing down and had to be removed by the mile, while the high-carbon rails have failed by breakage. I have watched the matter very carefully for the last few years and I feel safe in saying that not one per cent. as many of the high-carbon rails will be removed from the track in ten years as of the soft rails. We have in their chemical composition the requisite hardness to carry the wheel loads and not deform the shape of the rail. The point to overcome is the piping. If we can eliminate the piping in the manufacture of the rail I am confident that the high-carbon rail will stand the service test. If there is anyone present who has had high-carbon rails in service I would like them to give us the results of their experience. One gentleman spoke about his finding on investigation that some rails had split from the blows of spike mauls in setting the rails up to gage. I do not think a spike maul will split a structurally sound rail. We may make a rail jagged, but not split it. I notice in this list of failures that one road reports a large number of failures by square breaks. Evidently that road has based its report on that made by the section-men. I have examined a great many reported square breaks, and I feel confident that if they make a careful examination they will find, as I did, that the break resulted from a seam, a pipe, or a flaw, or a nick in the flange, the last causing a square break. The pipes that are giving us trouble are those in the flange of the rail, usually near the middle or under the web of the rail. This pipe running from 6 to 18 in. in length and after extending nearly the depth of the flange and running out of the base up a seam whose walls are smooth, and sometimes the smooth walls are as much as one-eighth of an inch deep.

Mr. J. H. Wallace (Southern Pacific):—The specifications of the Southern Pacific Company, under which we have been purchasing rails for several years past, calls for what is classed as "high-carbon" steel. Under these specifications the rails received have averaged about .55 carbon and phosphorus not in excess of .085. We do not find that this rail is brittle. I have not the figures at hand, but am satisfied that we have experienced less trouble from broken rails than most of the roads quoted by the Committee in their report. Nearly all of our breakages are due to imperfections in the rail, probably from piped ingots. A flaw of this character, if in the head, causes the head to spread and break down; if in the base or web, causes breaks of various forms. We are all agreed that excess of phosphorus is bad and are desirous of keeping this element as low as possible. I am opposed to increasing the allowable amount of phosphorus, and think we should fix the limit regardless of the mill men; that our specifications should call for a rail such as we think it should be, without any reference to what the mill men are able to furnish. We should not attempt to compromise with them. If the mills are unable to furnish what we call for, and a compromise is necessary, it should be made by our principals when making contracts.

Mr. Thackray:—I would like to call the attention of the members to the fact that the specifications of the American Society of Civil Engineers, which we now have under consideration, have not been endorsed or passed upon by that society. They have merely been presented to the society at their January convention, and are to be discussed hereafter, so that when you are considering these specifications you are not dealing with an accomplished fact.

Mr. Webster:—I would like to make a further explanation in regard to Mr. Thackray's statement. The majority report and the minority report on these specifications were accepted at the January conventions, and I think it will come up; we refer to that in this present report. We hope to bring before that society through its committee anything that is done here at this meeting to-day. We would like very much to arrive at a joint specification, and I will ask our Secretary to read an abstract from the letter of Mr. Jos. T. Richards, Chief Engineer of Maintenance of Way of the Pennsylvania Railroad, chairman of the Committee on Rail of the American Society of Civil Engineers.

The Secretary:—"Referring to the last paragraph of your letter, asking me to give my views in the matter that will be before your meeting on March 19th, I would say that I do not believe that I can add anything to the report of the Committee on Rail Sections of the American Society of Civil Engineers. My idea would be for our Committee, of which you are chairman, and the American Railway Engineering and Maintenance of Way Association to consider the American Society's report and make such comments as they wish, and if the several committees can keep their recommendations pretty closely on the same lines, it would give us less embarrassment than if the committees were to become widely separated. I do not see any reason why the several committees, intermingled as they are very much, should not join in a report. Of course, there may be some slight differences, as we had by minority reports in our American Society committee, but these are not serious matters considered as a whole."

Mr. Webster:—In further explanation of what has been read, I would say that in my minority report to the American Society I did object to the high carbon, and at my request this additional footnote was added, which we have been discussing: "Carbon may be reduced to suit local conditions." In regard to what Mr. Abbott said in regard to the high-carbon rails not meeting this drop test, we do not expect them to meet it under the present conditions of rolling. We think that the rails are finished too hot. I mean all rails. We want better conditions. The reason we want better conditions in rolling is that the present rails are not giving satisfaction. As a committee, we tell you what we deem would give you a better rail, and it is for you to accept it or refer it back to the Committee.

The President:—The chair will now put the question on the original motion, for the adoption of the requirements of the American Society of Civil Engineers, including the footnote

(The motion was carried.)

The Secretary:—"STRAIGHTENING RAILS.—The A. S. C. E. Committee has a specification in regard to straightening rails, which we think to be a desirable addition to our specification and which we recommend with some modification.

"Straightening.—Care must be taken in hot straightening the rails, and it must result in their being left in such a condition that they shall not vary throughout their entire length of 33 ft. more than 3 in. from a straight line in any direction, when delivered to the cold straightening presses. Those which vary beyond that amount, or have short kinks, shall be classed as second quality rails and be so stamped. The distance between supports of rails in the gagging press shall not be less than 42 inches."

"Section 11 in our specifications should also be modified to read as follows:

"Rails shall be straight in line and surface when finished—the straightening being done while cold—smooth on head, sawed square at ends, variation to be not more than $\frac{1}{32}$ in., and, prior to shipment, shall have the burr occasioned by the saw cutting removed and the ends made clean. No. 1 rails shall be free from injurious defects and flaws of all kinds."

Mr. Churchill:—I move the adoption of the recommendation of the Committee as just read.

Mr. Abbott:—I am not in favor of that clause as it reads. It is an addition, something new in the specification, to include anything of that character. It is another case where the engineers take the position of placing restrictions on the mills in their operation. It leads to an interference with operation, and to a rejection of material, or reclassification of material, which may be entirely good. The American Society committee have a clause of this character in their proposed specification, in which they make the limit 5 in., and it does not appear why this Committee should immediately come out with something like 40 per cent. different from what the other committee suggested. In the first place, it is something new in the specification, and they have evidently endeavored to get in line to meet the mills. What they are trying to do is to get something that is practicable, something that is fair, and we step in and add something that we are almost certain will meet with objection on the part of the manufacturers. Therefore I think if this Committee puts in the clause, it should not be changed from the American Society recommendation. Any mill in rolling rails will endeavor to have them come through so that by the time they are cooled they will be nearly straight; the more nearly they are straight the better it is for the mill and the road buying the rails. No mill would fill its hotbed with rails showing 5-in. camber; that would be against the interest of the mill. Ordinarily they would try to keep it down to one inch and make rails perfectly straight, if possible; but if by mishap the rails should come through that had a camber of 3¼ in., the mill would expect to straighten those rails and make them first quality, and they would object to a clause of this kind in the specifications which would require putting such rails in the second class. The probability is that there would be a small percentage of rails that would even reach this condition; but the mills regard it as an unfair restriction to load up our specifications with things on which the railroad engineers and mills could not agree. For that reason I think if it is put in at all, it should be a greater distance than 3 in.

Mr. Trimble:—I think Mr. Abbott has given all the argument we need to leave this clause in the specification as we have it. He says there is a small proportion of the rails which have a camber of 3 in. when they reach the hotbed. That was the information that was given to the Committee—that a large proportion of the rails did not reach anything like that figure. We know that rails are injured in the gagging press in straightening the rails.

Mr. P. E. Carhart (Illinois Steel Company):—I take it that these specifications are intended to be general; that is, applicable to all standard rail sections—whether balanced or unbalanced—that are used by the leading railway companies. The large-headed rail will, of necessity, demand more cambering than the small-headed rail. It is impossible to control the cambering of these rails to such an extent as to bring them within the limits named in these specifications. In Chicago the atmospheric conditions have a great deal to do with this matter. We often have a drop of twenty to forty degrees in temperature in a few hours' time, hence this sudden change from a hot south wind to a cold north wind, passing over the hotbeds, will produce a corresponding change in the cambered rails. Those receiving the cold air first will be cambered more than the others. The requirements you name in your specifications are altogether too theoretical. What you want is not so much theoretical, but practical working conditions.

Mr. Webster:—I regret very much that Mr. E. F. Kenney, Inspecting Engineer of the Pennsylvania Railroad, is not here, for since the American Society specifications were proposed, Mr. Kenney has made a special study of this matter of straightening of rails, visiting the gag press of different mills, and it was at his request that we reduced the 5-in. limit to 3 in. I am pleased that Mr. Carhart referred to the matter of unbalanced sections and undesirable sections in rolling. We have too many sections to-day, and if you try to follow what is considered good practice in using a cambering machine, it may result in throwing out some sections. I refer to the difference in finishing temperature between the flange and the head. If you have an unbalanced section, or thin flange, it gets cool much quicker in the head, and you have to stretch the flange enough to correspond with the shrinkage of the hotter metal in the head. You cannot put the work on the head at low enough temperature to elongate the particles. What we want to do is to get rid of some of the sections which Mr. Carhart referred to, and this straightening clause may do that by bringing it to the attention of the engineers that they are using a bad section.

Mr. Carhart:—I do not think that any rail specification has been drawn up that will have such an influence on the roads using their own section during the past fifteen years as to get them to change for the reason cited by Mr. Webster.

Mr. Thackray:—It might be well to call attention to the fact that it was only last January that the committee of the American Society of Civil Engineers, of which I happen to be a member, discussed this question quite fully, with the information before them at that time, not more than two months ago, and they were led to believe that 5 in. was the right figure. I certainly do not know of anything that has happened in the last two months which would change that. It was considered quite carefully at the time.

Mr. Webster:—Nothing has happened, Mr. Thackray, except the report of Mr. Kenney, who has watched the rolling of the rails at your mill, as well as at some of the other mills.

Mr. Thackray:—Mr. Kenney had the facts on which the 5-in. specification was drawn?

Mr. Webster:—I beg to differ; Mr. Kenney was not a member of the American Society committee.

Mr. Thackray:—He was at the meeting.

Mr. Webster:—No; Mr. Richards was there, but not Mr. Kenney. Mr. Kenney has made it his particular business since then to make a study of this matter, and given us the benefit of his experience. We do not want anything unreasonable. We want this fully discussed. We have all observed the effect of the camber and have shown you that you can do better work. We have a mass of information referring to rails broken by reason of the gagging marks. Mr. Kenney gave us some information concerning rails which had broken twelve days after being put in service, due to the supports of the gagging press being too near together. He said they were 27 in. apart on a 100-lb. rail. They increased them to 42 in., and trouble ceased.

Mr. A. J. Himes (New York, Chicago & St. Louis):—We had some 75-lb. rails rolled recently which had a camber much greater than 5 in., but they were straightened in the gagging press, and I am strongly in favor of any reasonable limitation on the curvature of the rail before it is straightened.

Mr. Webster:—I do not want to prolong this discussion unnecessarily, and do not wish to commit the members of the Committee to have this referred back for further consideration. I call for the question.

Mr. Abbott:—I want to make a little explanation. We would expect the mills naturally to make an objection to a limit of 3 in. I would explain why Mr. Kenney proposed to put that in: He said it was in order to require the mills to adjust their cambering rolls properly, and not allow a lot of rails to go through with excessive camber. The mills ordinarily would not do that; they would correct it in their own interest; but in a large mill a considerable number of rails might pass through before that could be done. I know of one mill in particular where 36 rails might pass through the mill before the matter could be attended to. If it develops that the cambering rolls are curving too much, it is often not practicable to fix them without stopping the mill. The mill will run till all hot bars in process of rolling were put through, making perhaps thirty to forty rails. Then the mill would be "blown down," as the mill men say, and the cambering rolls corrected. But you can see that before that could be done there would be thirty to forty rails on the hotbed with too large a camber, according to these specifications. The mills would claim that they would put these rails in good order by making them straight as required. They would feel they were restricted too much with a limit of 3 in., and would not want to grant it, with the constant danger of being required to reclassify as large a tonnage of rails as described.

Mr. Webster:—I regret it if I have given you a wrong impression of Mr. Kenney's proposition. He does not want you to stop the mill, but to make quick changes. He wants good rails If there are a lot of rails coming up which he thinks are being gagged too much, he wants something in the specifications to say these rails should go into the seconds. He is a practical man, and he claims 3 in. is sufficient, basing it on a record he has made from actual observation since this 5-in. clause was suggested.

(The motion of Mr. Churchill was carried.)

The President:—The Committee asks the chair to announce that they are willing to abandon the discussion on the paragraph headed "Arrangement of Matter in Specifications," on page 6, and invite written discussion, to be sent to the chairman of the Committee as early as practicable, or throughout the year.

Mr. McDonald:—Before the Committee is dismissed, I think the action we have taken to-day should be ratified by the convention, in order that there may be no question as to its legality under the rules. I move, therefore, that the rules, so far as the consideration of this report is concerned, be suspended.

(The motion was carried.)

Mr. Webster:—On behalf of the Committee, I desire to thank the railway companies for the full information they have given us in regard to wear of rails and breakages of rails, and I would like the sense of the meeting whether it would be desirable to publish a tabulation giving the results of this investigation, without giving the names of the roads. That is, would it be of any service to you if the results were given more in detail than is given in the case of the few roads referred to in the present report.

I also take occasion to thank Mr. Fritch for securing this information and tabulating the results. It saved the Committee a great deal of work, and we are under obligations to him.

The reason I ask for this expression is that we called for the information as confidential, and we do not wish to publish anything that any road would prefer not to have published. If any road giving us information has a representative here, and will speak on the subject, we would be glad to have him do so.

The President:—If there is no further discussion, the Committee will be excused with the thanks of the convention.

REPORT OF COMMITTEE NO. VIII.—ON MASONRY.

To the Members of the American Railway Engineering and Maintenance of Way Association:

Your Committee held two meetings at Cleveland, O., on June 20 and 21, 1905, with the following attendance: Messrs. E. C. Brown, W. B. Hanlon, C. H. Moore, G. H. Scribner, Jr., J. W. Schaub and Prof. G. F. Swain.

The second meeting of the General Committee was held at Chicago December 20, 21 and 22, 1905, the following members being present: Messrs. E. C. Brown, John Dean, C. W. Boynton, G. H. Scribner, Jr., J. W. Schaub, Job Tuthill and H. W. Parkhurst.

The sub-committee on waterproofing met in Chicago on December 9, Messrs. A. O. Cunningham, C. W. Boynton and Prof. W. K. Hatt being present.

Your Committee has no changes to recommend in the matter pertaining to the work of the Masonry Committee appearing in the Manual of Recommended Practice.

CONCRETE FAILURES.

The Committee recognizes that many failures of concrete structures, plain and reinforced, are continually taking place, due to various causes, and can be classified under the following heads:

(1) Improper design.

(2) Premature or improper loading.

(3) Improper materials, proportions or workmanship.

At present no details of any failures will be given, but the several members of the Committee have considerable information at hand, which will be presented in due time.

The Committee desires to have the individual members of the Association call attention to any failures coming to their knowledge, and give the chairman all the information available, and, if possible, obtain the data from the engineer in charge of the work; otherwise it may not be reliable.

WATERPROOFING MASONRY—METHODS, RESULTS, COST AND RECOMMENDED PRACTICE.

Inasmuch as this subject is under consideration by the Joint Committee on Concrete and Reinforced Concrete, and as the Masonry Committee is fully represented on special committees appointed by the Joint Committee dealing with this matter, it was deemed advisable not to take independent action at this time, but to recommend that this subject be reassigned for next year, with instructions that the Committee keep in close touch with any action taken by the Joint Committee above referred to, in order that the conclusions of the two committees might coincide.

WATERWAYS FOR CULVERTS

The sub-committee having this subject under consideration has not been able to meet during the year, and has not therefore prepared a formal report. However, the chairman has presented an article on "The Requisite Waterway for Railroad Culverts," which will appear in a later Bulletin.

SPECIFICATIONS FOR STONE MASONRY.

GENERAL.

1. Stone masonry shall be built of the kinds specially designated, with such arrangements of courses and bond as shown on the drawings or as directed. The stone shall be hard and durable, free from seams or other imperfections, of approved quality and shape, and in no case have less bed than rise, and shall be laid on their broadest beds, well bonded and solidly bedded. When liable to be affected by freezing, no unseasoned stone shall be laid. Stone.

*2. Dressing must be the best of the kind specified for each class of work. Dressing.

*3. Beds and joints or builds must be square with each other, and dressed true and out of wind. Hollow beds will not be allowed.

*4. All stone must be dressed for laying on natural beds.

*5. Margin drafts must be neat and accurate.

*6. Pitching must be done to true lines and exact batter.

*7. The sand and cement should be mixed dry and in small batches in proportions as directed, on a suitable platform, which must be kept clean and free from all foreign matter; then water is to be added, and the whole remixed until the mass of mortar is thoroughly homogeneous, and leaves the hoe clean when drawn from it. It must not be retempered after it has begun to set. Mortar.

*8. All stones must be laid on natural beds. Each stone must be settled into place in full bed of mortar. Laying.

*9. No stone must be dropped or slid over the wall, but must be placed without jarring the stones already laid.

*10. No heavy hammering will be allowed on the wall after a course is laid.

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*See amendment, page 602.

Laying.

*11. If a stone becomes loose after the mortar is set, it must be relaid with fresh mortar.

*12. Each stone must be cleansed and dampened before laying.

*13. Stones must not be laid in freezing weather unless allowed by the Engineer. If allowed, they must be freed from ice, snow or frost by warming, and laid in mortar made of heated sand and water, or, with proper precautions, mixed with brine in proportions of one pound of salt to 18 gallons of water, when the temperature is 32 degrees Fahrenheit. Add one ounce of salt for every degree of temperature below 32 degrees Fahrenheit.

*14. Stones must be laid to exact lines and levels so as to give the required bond and thickness of mortar in beds and joints.

Pointing.

*15. Mortar in beds and joints of exposed faces must be removed to a depth of one (1) in. before it has set. No pointing shall be done until the wall is complete and mortar set, nor when frost is in the stone. Wet the joints and fill again with mortar made of equal parts sand and Portland cement. It must be pounded in with "set-in" or calking tool, and finished with a beading tool the width of the joint, used with a straight-edge.

CLASSIFICATION.

Classification.

*16. Stone masonry will be classified under the following heads: Bridge and Retaining Wall Masonry, Arch Masonry, Culvert Masonry, and Dry Masonry.

BRIDGE AND RETAINING WALL MASONRY.

Bridge and Retaining Wall Masonry.

17. Bridge and Retaining Wall Masonry shall consist of two classes: (a) Ashlar, (either coursed or broken-coursed), and (b) Rubble.

*ASHLAR BRIDGE AND RETAINING WALL MASONRY.

Ashlar Bridge and Retaining Wall Masonry.

*18. (a) In Ashlar Bridge and Retaining Wall Masonry (either coursed or broken-coursed), the stone must be large and well-proportioned.

*19. No course to be less than fourteen (14) in. nor more than thirty (30) in. thick; the thickness of courses to diminish regularly from bottom to top.

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*See amendment, pp. 602, 603.

20. The beds and joints or builds of face stones shall be fine-pointed, so that the mortar layer shall not exceed one-half (½) in. in thickness when the stones are laid. **Dressing.**

*21. Joints in face stone must be full to the square for a depth equal to at least one-half the height of the course, but in no case less than twelve (12) in.

*22. The exposed surface of each face stone will be rock-faced, and the edges pitched to true lines and exact batter; the face to have no projections over three (3) in. beyond the pitch lines. **Facing or Surface Finish.**

23. A chisel draft one and one-half (1½) in. wide shall be cut at each exterior corner.

*24. No holes for stone hooks will be permitted to show in exposed surfaces. They must be handled with clamps, keys, lewis or dowels.

25. Stretchers shall be not less than four (4) ft. long, and to have at least one and a quarter times as much bed as thickness of the course. **Stretchers.**

26. Headers shall be not less than four (4) ft. in length. They shall occupy one-fifth of the face of the wall, and no header shall have less than eighteen (18) in. width of face, and where the course exceeds eighteen (18) in. height, the width of face shall not be less than the height of course. Headers shall hold the size in the heart of the wall that they show on the face, and be so arranged that a header in a superior course shall be placed between two headers in a course below: but no header shall be laid over a joint, and no joint shall occur over a header. They shall be similarly disposed in the back of the wall, interlocking with those in the face when the thickness of the wall will admit. When the wall is too thick to admit of such arrangement, stones of not less than four (4) ft. in length shall be placed transversely in the heart of the wall to bond the two opposite sides of it. **Headers.**

27. Backing shall be large, well-shaped stone, roughly bedded and jointed; the bed joints not to exceed one (1) in., and vertical joints generally not to exceed two (2) in. No part or portion of vertical joints shall have a greater dimension than six (6) in., which void shall be thoroughly filled with spalls full bedded in cement mortar or filled with concrete. At least one-half of the backing stones shall be of the same size and character as the face stone and with parallel beds. **Backing.**

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*See amendment, page 603.

28. When face stone is backed with two courses, neither course shall be less than eight (8) in. thick.

29. When the wall is three (3) ft. thick or less, the face stone shall pass entirely through and no backing be allowed.

Backing. 30. If the Engineer so directs, the backing may be entirely of concrete, or back laid with headers and stretchers, as specified above, and heart of wall filled with concrete.

Bond. 31. The bond of stone on face, back and heart of wall shall not be less than twelve (12) in. Backing shall be laid to break joints with the face stone and with one another.

Coping. *32. Coping will be dimension stone, holding full size throughout, proportioned for its loading, as marked on the drawings.

*33. The beds, joints and top will be fine-pointed.

*34. The location of joints will be determined by the position of the bed plates, and must be shown on the drawings.

Locks. 35. When required, in the judgment of the Engineer, coping stones, stones in the wings of abutments, and the stones on piers shall be secured together with iron cramps or dowels, their position being indicated by the Engineer.

*RUBBLE BRIDGE AND RETAINING WALL MASONRY.

Rubble and Retaining Wall Masonry. 36. (b) Rubble Bridge and Retaining Wall Masonry will consist of stones roughly squared, laid in irregular courses. The beds must be parallel, roughly dressed, and lie horizontally in the wall. The bottom stones shall be large selected flat stones. The wall must be compactly laid, having at least one-fifth the surface of the back and face headers, so arranged as to interlock, having all the spaces in the heart of the wall filled with suitable stones and spalls, thoroughly bedded in cement mortar or filled with concrete. The face joints must not be more than one (1) in. in thickness.

ARCH MASONRY.

Arch Masonry. 37. Arch Masonry shall consist of the arch ring only, or that portion between the intrados and extrados, and shall be of two classes: (a) Ashlar Arch Masonry, and (b) Rubble Arch Masonry.

ASHLAR ARCH MASONRY.

Ashlar Arch Masonry. *38. The voussoirs must be full size throughout, and must have bond not less than thickness of the stone and dressed true to templet.

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*See amendment, page 603.

*39. The number of courses and depth of voussoirs will be shown on the drawings.

40. The joints of the voussoirs and the intrados shall be fine-pointed. Mortar joints shall not exceed three-eighths (3/8) in.

41. The exposed surface of the ring stone shall be smooth or rock-faced, with a marginal draft. **Ashlar Arch Masonry.**

42. Voussoirs shall be carried up simultaneously from both bench walls.

*43. Backing may consist of large stones shaped to fit the arch bonded to the spandrel and laid in full beds of mortar. Concrete may also be used for backing.

44. If waterproofing is required, a thin coat of mortar or grout shall be applied for a finishing coat upon which shall be placed a covering of suitable waterproofing material.

45. Centers shall not be struck until directed.

*46. Bench walls, piers, spandrels, parapets, wing walls and copings will be built under the specifications for Ashlar Bridge and Retaining Wall Masonry.

RUBBLE ARCH MASONRY.

*47. The voussoirs must be full size throughout, and must have bond not less than thickness of the stone. **Rubble Arch Masonry.**

*48. The depth of voussoirs will be shown on the drawings.

49. The beds need only be roughly dressed so as to bring them to radial planes.

50. Mortar joints shall not exceed one (1) in.

51. The exposed surface of the ring stones shall be rock-faced, and the edges pitched to true lines.

52. Voussoirs shall be carried up simultaneously from both bench walls.

*53. Backing may consist of large stones shaped to fit the arch bonded to the spandrel and laid in full beds of mortar. Concrete may also be used for backing.

54. If waterproofing is required, a thin coat of mortar or grout

*See amendment, page 603.

shall be applied for a finishing coat upon which shall be placed a covering of suitable waterproofing material.

55. Centers shall not be struck until directed.

*56. Bench walls, piers, spandrels, parapets and wing walls will be built under the specifications for Rubble Bridge and Retaining Wall Masonry.

CULVERT MASONRY.

Culvert Masonry.

*57. Culvert Masonry must be laid in cement mortar. The character of stone used and quality of work must be similar to that specified for Rubble Bridge and Retaining Wall Masonry.

*58. One-half the top stones of the side walls must extend entirely across the wall.

*59. The covering must be of sound, strong stone, at least twelve (12) in. thick, or as shown on drawings. They must be roughly dressed so as to make close joints with each other, and must lap their whole width at least twelve (12) in. over the side walls. They must be doubled under high embankments, as directed by the Engineer or shown on the drawings.

*60. The end walls must be covered with suitable coping.

DRY MASONRY.

Dry Masonry.

*61. Dry Masonry will include dry retaining walls and slope walls.

DRY RETAINING WALLS.

Dry Retaining Walls.

*62. Dry Retaining Walls will include all dry rubble work for retaining embankments or similar work.

*63. Flat stone at least twice as wide as thick will be used. Beds and joints to be roughly dressed square to each other and to face of stone.

*64. Joints not to exceed three-quarters (¾) in.

*65. The different sizes of stone must be evenly distributed over the whole face of wall, generally keeping the largest stone in the lower part of wall.

*See amendment, pp. 603, 604.

*The work shall be well bonded and present a reasonably true and smooth surface, free from holes or projections. This wall is double-faced and self-sustaining.

SLOPE WALLS.

*67. Slope walls shall be built of such thickness and slope as may be required by the Engineer. No stones which do not reach through the wall shall be used in their construction. Stones shall be placed at right angles to the slopes. This wall is single faced and built with steep slope simultaneously with the embankment which it is to protect. **Slope Walls.**

*See amendment, page 604.

CO-OPERATION WITH THE JOINT COMMITTEE ON CONCRETE AND REINFORCED CONCRETE.

The information given below is abstracted from the minutes and reports made to the Joint Committee.

Owing to the importance and magnitude of the work of the Joint Committee, it was found necessary to first develop the organization, in order that the investigations might be carried on to the best advantage, and that the final conclusions be perfectly reliable.

MEETINGS.

During the past year, the Joint Committee held five meetings, as follows: January 17, New York; June 21, Cleveland; June 30, Atlantic City; October 11, New York; December 14, New York.

At the October (1905) meeting the Committee on Ways and Means submitted a report showing that the amount of $1,049 had been expended during the year for material, labor, transportation, etc.

The following resolution was unanimously adopted:

"That it is the sense of the meeting that the Committee on Ways and Means be instructed to raise five thousand dollars to defray the expenses of the Joint Committee for the year ending September 30, 1906."

On December 14, 1905, the Committee on Tests presented a report, of which the following is an abstract:

The Joint Committee was appointed primarily for the purpose of providing, through the various Societies represented, definite information concerning the properties of concrete and reinforced concrete, and to recommend factors and formulas required in the design of structures in which this material is used. While the Joint Committee has thus far accomplished little toward formulating a report, it has nevertheless acquired a definite knowledge of the work such a report demands.

The tests made prior to the appointment of the Committee were scattered and somewhat fragmentary, and while yielding information of considerable value, the limited scope of the work, lack of uniformity of conditions and methods, and failure to properly report details concerning tests or to complete the investigations, render the results insufficient for the formulation of a report. The Committee, therefore, decided that it was desirable to conduct tests along certain lines. Until recently the only channel open to the Committee for conducting such investigations were the laboratories of the technological institutions and perhaps a few others.

At the meeting of the Joint Committee, held during the International Engineering Congress at the World's Fair, St. Louis, in October, 1904, the Committee on Tests was instructed to inaugurate investigations at such technological institutions and other laboratories possessing the requisite facilities and which would undertake the work. Accordingly, during the last school year, tests were made under this Committee's direction in the laboratories of some twelve engineering schools. The results have been reported to the Committee on Tests, and the compilation is nearly ready for presentation to the Joint Committee. The plan adopted by the Joint Committee involved direction and inspection of this work by the Committee on Tests. This the Committee was unable to do, through lack of funds with which to pay the expenses of inspectors and other assistants.

The following is a suggested program of the investigations to be made by the Joint Committee from which a schedule is to be prepared as the tests progress:

PROPOSED PROGRAM FOR THE INVESTIGATION OF CONCRETE AND REINFORCED CONCRETE.

(1) Examination of Constituent Materials: Sands, gravels, stone, stone screenings, slags, cinders, etc., to be collected by a special representative of the Testing Laboratory sent out for that purpose.

(a) Examination of Deposit as to the extent and nature of the material from which the samples are collected.

(b) Physical Tests in the Laboratory:

(1) Mineralogical examination.
(2) Specific gravity.
(3) Weight per cubic foot.
(4) Sifting (Granularmetric composition).
(5) Percentage of silt and character of same.
(6) Percentage of voids.
(7) Character of stone as to percentage of absorption, porosity, permeability, compressive strength and behavior under treatment.

(c) Chemical Analysis as to the character of the stone, silt, etc., used in tests.

(2) Tests of Mortars made with a Typical Portland Cement and sand, gravel and stone screenings. The Typical Portland Cement to be prepared by thoroughly mixing a number of brands, each of which must meet certain requirements:

The wide area over which the technical schools are scattered renders the expense of providing uniform materials and of inspecting the preparation of the test pieces and the execution of tests very great. Besides, the work cannot generally be carried on uniformly throughout the year, but must be concentrated into a few months. This is a serious difficulty in any series of tests.

However, in the progress of these investigations, there will necessarily be considerable experimental work in opening up certain phases of a problem, as, for example, the study of proper methods to be followed, the sources of error to be guarded against, the probable cause of a given phenomenon, that would be of material help in planning the work, or in corroborating the results of other tests; and it would seem wise to secure the co-operation of the technical schools, utilizing their facilities to the extent indicated in carrying on investigations.

The entire Joint Committee has been divided into a number of sub-committees for the purposes of collating existing literature and the results of previous investigations. These results, when compiled, will serve, with the recommendation of each Committee, as a guide in formulating the future work of the Joint Committee. The results of the compilations of the various sub-committees shall be turned over to the Committee on Tests for their consideration and to be reported by them to the Joint Committee. If it is found that there is a reasonable concordance in certain lines it would seem undesirable for the Committee on Tests to plan more than a few confirmatory experiments. In those lines where there is no agreement the Committee work must necessarily be more extensive in order to be conclusive.

ORGANIZATION.

At the meeting of January 17, an outline of organization was read and adopted as by-laws governing the Committee.

On June 21, these rules of organization were slightly changed and on October 11 amended rules were adopted making several important changes. The rules of organization, as they now stand, are as follows:

RULES OF ORGANIZATION.

MEMBERS.—The membership of the Joint Committee shall consist of the members of the Special Committee on Concrete and Reinforced Concrete appointed by the American Society of Civil Engineers, and the members of the similar Committees appointed by the American Society for Testing Materials, the American Railway Engineering and Maintenance of Way Association, and the Association of American Portland Cement Manufacturers.

The membership may be enlarged by vote of a majority of the voting members, authorizing the addition to the Committee of representatives of any other technical organization engaged in similar lines of investigation.

Applications for such memberships will not be received from individuals, but only from the proper officers of the organizations desiring representation.

Officers and Their Election.—The officers shall be a Chairman, a Vice-Chairman, and a Secretary.

The Chairman shall be the Chairman of the Special Committee of the American Society of Civil Engineers.

The Vice-Chairman shall be appointed by the Chairman.

The Secretary shall be elected by the Joint Committee, but must be a member of the Special Committee of the American Society of Civil Engineers.

The Secretary shall receive a salary to be fixed by the Joint Committee.

Duties of Officers.—It shall be the duty of the Chairman to call and preside at all meetings of the Joint Committee, and he shall be ex-officio a member of all Committees. He shall sign all orders on the Chairman of the Committee on Ways and Means for the payment of money. He shall have the power to fill all vacancies occurring in any sub-committee and to appoint such other sub-committees as may be necessary to carry out the object of the Special Committee on Concrete and Reinforced Concrete.

The Vice-Chairman shall, in the event of disability or absence of the Chairman, perform all duties of the Chairman.

It shall be the duty of the Secretary to give all notices of meetings of the Joint Committee, and to attend all meetings of the same. He shall keep a record of all proceedings of such meetings, and shall transmit to all members a copy of the minutes of each meeting of the Committee. He shall prepare and keep a correct list of sub-committees, and have custody of the rules, books of records, and all other documents belonging to the Joint Committee and copies of all minutes of all its sub-committees. He shall draw and attest all orders on the Committee on Ways and Means, and perform such other duties as usually pertain to the office of Secretary, or as the Joint Committee or its Chairman may require.

Sub-Committees.—There shall be two sub-committees as follows. each consisting of six members appointed by the Chair: Committee on Ways and Means; Committee on Tests.

In appointing any of the above Committees, three members shall be selected from the Special Committee of the American Society of Civil Engineers and one from each of the committees appointed by the other Associations represented on the Joint Committee.

The duties of these Committees shall be as follows:

The Committee on Ways and Means shall be charged with the duty of collecting funds to carry on this work, and shall, through their Chairman, have custody of such funds subject to the order of the Chairman of the Joint Committee, attested by the Secretary. The Chairman shall give a proper bond and shall have annual certified audits of all accounts.

The Committee on Tests shall be charged with the general conduct of the tests, collation and discussion of the results of tests, and the apportioning of the work of testing among different laboratories, and shall, subject to the approval of the Chairman, appoint inspectors to oversee tests made for this Committee.

STANDING COMMITTEES.

By the new rules, two Standing Committees are provided as follows:

Committee on Ways and Means: R. W. Lesley, Chairman; J. E. Greiner,* Olaf Hoff, A. L. Johnson, A. O. Cunningham,* Edward M. Hagar.

Committee on Tests: Richard L. Humphrey. Chairman; A. N. Talbot, W. K. Hatt,* Olaf Hoff, George F. Swain,* Spencer B. Newberry.

SPECIAL COMMITTEES.

At the meeting of October 11, the ten special committees to collate existing literature and results of previous investigations, referred to above, were appointed, as follows:

HISTORICAL.

J. R. Worcester,* Chairman.
R. W. Lesley.
George F. Swain.*
F. E. Turneaure.*
R. E. Griffiths.

CONCRETE.

(a) Study of Aggregates, Proportions and Mixing.

Olaf Hoff, Chairman.
William B. Fuller.
W. P. Taylor.
Sanford E. Thompson.
George S. Webster.
Frank Beckwith.*

(b) Physical Characteristics, Waterproofing, Etc.

A. O. Cunningham,* Chairman.
E. Lee Heidenreich.
Sanford E. Thompson.
Samuel Tobias Wagner.
C. W. Boynton.*

(c) Strength and Elastic Properties.

J. E. Greiner,* Chairman.
Charles M. Mills.*
W. P. Taylor.
George S. Webster.
Gilbert H. Scribner, Jr.*

BEAMS.

(a) Simple Beams.

F. E. Turneaure,* Chairman.
J. E. Greiner.*
C. C. Schneider.*
J. R. Worcester.*
A. O. Cunningham.*

(b) Tee Beams, Floor Slabs, Etc.

Samuel Tobias Wagner, Chairman.
J. W. Schaub.*
E. Lee Heidenreich.
Gaetano Lanza.
Frank Beckwith.*

*Members of Am. Ry. Eng. and M. W. Assn.

COLUMNS.

Gaetano Lanza, Chairman.
William B. Fuller.
Edgar Marburg.
Leon S. Moisseiff.
Henry H. Quimby.

FAILURES OF CONCRETE STRUCTURES.

Emil Swensson, Chairman.
J. W. Schaub.*
A. L. Johnson.
Gilbert H. Scribner, Jr.*
George F. Swain.*

FIRE RESISTING QUALITIES.

C. W. Boyton,* Chairman.
C. C. Schneider.*
A. L. Johnson.
Norman D. Fraser.
Edward M. Hagar.

ARCHES.

Henry H. Quimby, Chairman.
Emil Swensson.
Edgar Marburg.
Charles M. Mills.*
Leon S. Moisseiff.

COOPERATION WITH THE UNITED STATES GEOLOGICAL SURVEY.

The cooperation of the United States Geological Survey with the Joint Committee on Concrete and Reinforced Concrete was under consideration for some time prior to its presentation to the Joint Committee. Towards the close of the World's Fair at St. Louis, efforts were commenced to secure from Congress an appropriation to continue the work which had been inaugurated by the Association of American Portland Cement Manufacturers. The matter was taken up in Congress towards the close of 1904 and the appropriation was acted upon in March, 1905.

It is believed that the present Congress will make a larger appropriation for the continuance of the work than was made last year, and should Congress fail to make an appropriation, arrangements are now under way for raising the requisite funds for keeping the work going.

At the meeting of the Joint Committee in Cleveland, on June 21, 1905, it was decided to cooperate with the Geological Survey, and the Committee's representatives on the Government Advisory Board were requested to advise as to the plan for this cooperation.

At the meeting of the Committee held at Atlantic City, on June 30, 1905, the following plan of cooperation was adopted:

*Members of Am. Ry. Eng. and M. W. Assn.

PROPOSED BASIS OF COOPERATION BETWEEN THE UNITED STATES GEOLOGICAL SURVEY AND THE JOINT COMMITTEE ON CONCRETE AND REINFORCED CONCRETE.

(1) The Geological Survey to cooperate with the Committee in securing and distributing supplies or materials to be used in this work at the laboratories with which from time to time it may be found feasible to cooperate.

(2) The Geological Survey to cooperate with the Committee in providing for the labor and forms necessary in making these investigations effective at these laboratories.

(3) The Geological Survey will send an expert who will visit each of these laboratories from time to time during the year, with a view to unifying the methods and collating the results of such investigations at each of these laboratories; and who will report to the members of this Joint Committee from time to time what investigations are being conducted at different laboratories under this arrangement; and also provide for the collation and publication of previous data in cooperation with the Joint Committee on Concrete and Reinforced Concrete.

(4) The results of these investigations at such laboratories, subject to the approval of the Advisory Board, will be published promptly, from time to time, by the Geological Survey, in such manner as to give full credit to the proper person and laboratory; and the results may also be published simultaneously by the institution with which this laboratory is associated.

(5) The Geological Survey will obtain from the secretaries the mailing lists of the Societies represented in the Joint Committee on Concrete and Reinforced Concrete and mail all bulletins issued under the direction of the Geological Survey to their members.

By this plan the program of the Committee on Tests is to be carried out in the Government laboratories. These laboratories known as the "Structural Materials Testing Laboratories," have been organized and are under the direction and supervision of the present Chairman of the Committee on Tests. It was also decided to conduct investigations at such institutions as the Committee on Tests might elect, under the direction of the Committee and the inspection of the representative of the Government laboratories. Accordingly arrangements have been made for carrying on tests at the Universities of Illinois, Purdue and Wisconsin and possibly Columbia. These tests consist of determinations of the effect at different ages of varying percentages of round, square and flat bars of steel of different elastic limit, using the same concrete; of the bond under similar conditions; of the properties of tee-beams; of the effect of loading beams centrally, and at 2, 4 and 8 points; of the shearing strength of concrete; of the tensile strength and modulus of elasticity of concrete in tension in length of 12 feet;

of the effect of different methods of reinforcing a beam for diagonal tension.

THE ADVISORY BOARD.

An Advisory Board on Fuels and Structural Materials was created by invitation of the Secretary of the Interior, because it was thought the work could be best carried on judiciously under the advice of a number of qualified and interested engineers. The various organizations and railroads invited have appointed representatives, and the final appointment of these representatives will probably be made by the President of the United States before this report appears. This Advisory Board passes on the program to be followed in the investigations, and as the Joint Committee is largely represented on this Board, there will, of course, be no difficulty in carrying out a program which is deemed advisable by the Joint Committee.

DEFINITIONS OF MASONRY TERMS APPLIED TO RAILROAD CONSTRUCTION.

Masonry.—All constructions of stone or kindred substitute materials in which the separate pieces are either placed together, with or without cementing material to join them, or where not separately placed, are encased in a matrix of firmly cementing material.

CLASSIFICATION OF MASONRY.

KIND.	Material.	Description.	Manner of Work.	Dressing.	
				Joints or Beds.	Face or Surface.
Bridge and Retaining Wall.	Stone	Dimension	Coursed	Smooth	Smooth Rock-faced
		Ashlar	Coursed Broken-coursed	Smooth Fine pointed Rough p'ted	Smooth Rock-faced
		Rubble	Uncoursed	Rough p'ted Scabbled	Rock-faced
	Concrete	Reinforced Plain Rubble			
Arch.....	Stone	Ashlar	Coursed	Smooth Fine pointed	Smooth Rock-faced
		Rubble	Uncoursed	Rough p'ted Scabbled	Rock-faced
	Concrete	Reinforced Plain			
	Brick	No. 1	English Bond Flemish Bond		
Culvert........	Stone	Rubble Dry	Uncoursed	Rough p'ted Scabbled	Rock-faced
	Concrete	Reinforced Plain Rubble			
Dry............	Stone	Rubble	Uncoursed		

Masonry, Bridge and Retaining Wall.—Masonry of stone or concrete, designed to carry the end of a bridge span or to retain the abutting earth or both.

Masonry, Arch.—That portion of the masonry in the arch ring only, or between the intrados and the extrados.

MASONRY, CULVERT.—Flat-top masonry structure of stone or concrete, designed to sustain the fill above and to permit of the free passage of water.

MASONRY, DRY.—Masonry in which stones are built up without the use of mortar.

CONCRETE.

CONCRETE.—A compact mass of broken stone, gravel or other suitable material assembled together with cement mortar and allowed to harden.

REINFORCED CONCRETE.—Concrete which has been reinforced by means of metal in some form, so as to develop the compressive strength of the concrete.

RUBBLE CONCRETE.—Concrete in which rubblestone are imbedded.

BRICK.

BRICK.—NO. 1.—Hard burned brick, absorption not to exceed 2 per cent. by weight.

CEMENT.

CEMENT.—A preparation of calcined clay and limestone, or their equivalents, possessing the property of hardening into a solid mass when moistened with water. Cements are divided into four classes: Portland, Natural, Puzzolan and Silica cement. (See each.)

PORTLAND CEMENT.—This term is applied to the finely pulverized product resulting from the calcination to incipient fusion of an intimate mixture of properly proportioned argillaceous and calcareous materials, and to which no addition greater than 3 per cent. has been made subsequent to calcination.

NATURAL CEMENT.—This term shall be applied to the finely pulverized product resulting from the calcination of an argillaceous limestone at a temperature only sufficient to drive off the carbonic acid gas.

PUZZOLAN.—An intimate mixture of pulverized granulated furnace slag and slaked lime, which, without further calcination, possesses hydraulic properties.

COURSED AND BOND.

COURSED.—Laid with continuous bed joints.

BROKEN COURSED.—Laid with parallel, but not continuous, bed joints.

UNCOURSED.—Laid without regard to courses.

English Bond.—That disposition of bricks in a structure in which each course is composed entirely of headers or of stretchers.

Flemish Bond.—That disposition of bricks in a structure in which the headers and stretchers alternate in each course, the header being so placed that the outer end lies on the middle of a stretcher in the course below.

DRESSING.

Dressing.—The finish given to the surface of stones or to concrete.

Smooth.—Having surface, the variations of which do not exceed one-sixteenth-inch from the pitch line.

Fine Pointed.—Having irregular surface, the variations of which do not exceed one-quarter inch from the pitch line.

Rough Pointed.—Having irregular surface, the variations of which do not exceed one-half inch from the pitch line.

Scabbled.—Having irregular surface, the variations of which do not exceed three-quarters inch from the pitch line.

Rock-Faced.—Presenting irregular projecting face, without indications of tool mark.

DESCRIPTIVE WORDS.

Abutment.—A supporting wall carrying the end of a bridge or span and sustaining the pressure of the abutting earth. The abutment of an arch is commonly called a bench wall.

Arris.—The external edge formed by two surfaces, whether plain or curved, meeting each other.

Ashlar.—A squared or cut block of stone with rectangular dimensions.

Backing.—That portion of a masonry wall or structure built in the rear of the face. It must be attached to the face and bonded with it. It is usually of a cheaper grade of work than the face.

Batter.—The slope or inclination of the face or back of a wall from a vertical line.

Bed.—The top and bottom of a stone. (See Course Bed; Natural Bed; Foundation Bed.)

Bed Joint.—A horizontal joint, or one perpendicular to the line of pressure.

Bench Wall.—The abutment from which an arch springs.

Bond.—The mechanical disposition of stone, brick or other building blocks by over-lapping to break joints.

Build.—A vertical joint.

Centering.—A temporary support used in arch construction. (Also called Centers.)

CLAMP.—An instrument for lifting stone so designed that its grip on the surface of the stone is increased as the load is applied. That portion engaging the stone is of wood attached to a steel shoe, which in turn is hinged to the shank of the clamp in such a manner as to adjust itself to the surface of the body lifted.

COPING.—A top course of stone or concrete, generally slightly projecting, to shelter the masonry from the weather, or to distribute the pressure from exterior loading.

COURSE.—Each separate layer in stone, concrete or brick masonry.

COURSE BED.—Stone, brick or other building material in position, upon which other material is to be laid.

CRAMPS.—Bars of iron having the ends turned at right angles to the body of the bar, which enter holes in the upper side of adjacent stones.

CULVERT.—A small covered passage for water under a roadway or embankment.

DIMENSION STONE.—(1) A block of stone cut to specified dimensions.

DIMENSION STONE.—(2) Large blocks of stone quarried to be cut to specified dimensions.

DOWELS.—(a) Straight bars of iron which enter a hole in the upper side of one stone and also a hole in the lower side of the stone next above.

DOWEL.—(b) A two-piece steel instrument used in lifting stone. The dowel engages the stone by means of two holes drilled into the stone at an angle of about 45 degrees pointing toward each other. The dowel is not keyed in place.

DRAFT.—A line on the surface of a stone cut to the breadth of the chisel.

EXPANSION JOINT.—A vertical joint or space to allow for temperature changes.

EXTRADOS.—The upper or convex surface of an arch.

FACE.—The exposed surface in elevation.

FACING.—In concrete: (1) A rich mortar placed on the exposed surfaces to make a smooth finish.

(2) Shovel facing by working the mortar of concrete to the face.

FINAL SET.—A stage of the process of setting marked by certain hardness. (See Cement Specifications.)

FLUSH.—(Adj.) Having the surface even or level with an adjacent surface.

(Verb.) (1) To fill. (2) To bring to a level. (3) To force water to the surface of mortar or concrete by compacting or ramming.

Footing.—A projecting bottom course.

Forms.—Temporary structures for giving concrete a desired shape.

Foundation.—(1) That portion of a structure, usually below the surface of the ground, which distributes the pressure upon its support.

(2) Also applied to the natural support itself; rock, clay, etc.

Foundation Bed.—The surface on which a structure rests.

Grout.—A thin mortar either poured or applied with a brush.

Header.—A stone which has its greatest length at right angles to the face of the wall, and which bonds the face stones to the backing.

Initial Set.—An early stage of the process of setting, marked by certain hardness. (See Cement Specifications.)

Intrados.—The inner or narrow concave surface of an arch.

Joint.—The narrow space between adjacent stones, bricks or other building blocks, usually filled with mortar.

Lagging.—Strips used to carry and distribute the weight of an arch to the ribs or centering during its construction.

Lewis.—A four-piece steel instrument used in lifting stone. (The lewis engages the stone by means of a triangular shaped hole into which it is keyed.)

Lock.—Any special device or method of construction used to secure a bond in the work.

Mortar.—A mixture of sand, cement or lime, and water, used to cement the various stones or brick in masonry, or to cover the surface of same.

Natural Bed.—The surfaces of a stone parallel to its stratification.

Parapet.—A wall or barrier on the edge of an elevated structure for protection or ornament.

Paving.—Regularly placed stone or brick forming a floor.

Pier.—An intermediate support for arches or other spans.

Pitch.—(Verb) To square a stone.

Pitched.—Having the arris clearly defined by a line beyond which the rock is cut away by the pitching chisel so as to make approximately true edges.

Pointing.—Filling joints or defects in the face of a masonry structure.

Retaining Wall.—A wall for sustaining the pressure of earth or filling deposited behind it.

Ring Stones.—The end voussoirs of an arch.

Riprap.—Rough stone of various sizes placed compactly or irregularly to prevent scour by water.

Rubble.—Field stone or rough stone as it comes from the quarry. When it is of large or massive size it is termed block rubble.

RUBBED.—A fine finish made by rubbing with grit or sandstone.

SET.—(Noun) The change from a plastic to a solid or hard state.

SLOPE WALL.—A wall to protect the slope of an embankment or cut.

SOFFIT.—The under side of a projection.

SPALL.—(Noun) A chip or small piece of stone broken from a large block.

SPANDREL WALL.—The wall at the end of an arch above the springing line and extrados of the arch and below the coping or the string course.

STRETCHER.—A stone which has its greatest length parallel to the face of the wall.

VOUSSOIRS.—The individual stones forming an arch. They are always of a truncated wedge form.

WING WALL.—An extension of an abutment wall to retain the adjacent earth.

CONCLUSIONS.

Your Committee arrives at the following conclusions, and recommends their adoption:

(1) That the Specifications for Stone Masonry be adopted as being good practice.

(2) That the Definitions of Masonry terms and Classification of Masonry be approved.

Respectfully submitted,

E. C. BROWN, Engineer Maintenance of Way, Union Railroad, Port Perry, Pa., *Chairman.*

JOHN DEAN, Civil Engineer, Chicago, Ill., *Vice-Chairman.*

FRANK BECKWITH, General Supt., Indiana Harbor Railroad, Chicago.

C. W. BOYNTON, Chief Inspector, Cement Dept. Ill. Steel Co., Chicago.

A. O. CUNNINGHAM, Chief Engineer, Wabash Railroad, St. Louis, Mo.

W. B. HANLON, Civil and Mining Engineer, Cleveland, O.

W. K. HATT, Professor of Applied Mechanics, Purdue University, Lafayette, Ind.

C. H. MOORE, Engineer of Grade Crossings, Erie R. R., New York, N. Y.

H. W. PARKHURST, Consulting Engineer, Chicago, Ill.

J. W. SCHAUB, Consulting Engineer, Chicago, Ill.

G. H. SCRIBNER, JR., Contracting Engineer, Chicago, Ill.

G. F. SWAIN, Professor of C. E., Mass. Institute of Technology, Boston.

JOB TUTHILL, Eng. B. & B., Pere Marquette R. R., Detroit, Mich.

E. P. WEATHERLY, Resident Engineer, Chicago, Burlington & Quincy Railroad, St. Joseph, Mo. *Committee.*

AMENDMENTS.

2. Dressing shall be the best of the kind specified for each class of work.

3. Beds and joints or builds shall be square with each other, and dressed true and out of wind. Hollow beds will not be allowed.

4. All stone shall be dressed for laying on natural beds.

5. Margin drafts shall be neat and accurate.

6. Pitching shall be done to true lines and exact batter.

7. The sand and cement shall be mixed dry and in small batches in proportions as directed, on a suitable platform, which must be kept clean and free from all foreign matter; then water is to be added, and the whole remixed until the mass of mortar is thoroughly homogeneous, and leaves the hoe clean when drawn from it. It shall not be retempered after it has begun to set. Mechanical mixing to produce the same result may be permitted.

8. All stones shall be laid on natural beds. Each stone shall be settled into place in full bed of mortar.

9. No stone shall be dropped or slid over the wall, but shall be placed without jarring the stones already laid.

10. No heavy hammering shall be allowed on the wall after a course is laid.

11. If a stone becomes loose after the mortar is set, it shall be relaid with fresh mortar.

12. Each stone shall be cleansed and dampened before laying.

13. Stones shall not be laid in freezing weather unless allowed by the engineer. If allowed, they shall be free from ice, snow or frost by warming, and laid in mortar made of heated sand and water, or, with proper precautions, mixed with brine in proportions of one pound of salt to 18 gallons of water, when the temperature is 32 degrees Fahrenheit. Add one ounce of salt for every degree of temperature below 32 degrees Fahrenheit.

14. Stones shall be laid to exact lines and levels so as to give the required bond and thickness of mortar in beds and joints.

15. Mortar in beds and joints of exposed faces shall be removed to a depth of not less than one (1) in. before it has set. No pointing shall be done until the wall is complete and mortar set, nor when frost is in the stone. Wet the joints and fill again with mortar made of equal parts sand and Portland cement. It shall be pounded in with "set-in" or calking tool, and finished with a beading tool the width of the joint, used with a straight-edge.

16. Stone masonry shall be classified under the following heads: Bridge and Retaining Wall Masonry, Arch Masonry, Culvert Masonry, and Dry Masonry.

ASHLAR MASONRY IN BRIDGES AND RETAINING WALLS.

18. (a) In Ashlar Masonry in Bridges or Retaining Walls (either coursed or broken coursed), the stone shall be large and well-proportioned.

19. No course shall be less than fourteen (14) in. nor more than thirty (30) in. thick; the thickness of courses to diminish regularly from bottom to top.

21. Joints in face stone shall be full to the square for a depth equal to at least one-half the height of the course, but in no case less than twelve (12) in.

22. The exposed surface of each face stone shall be rock-faced, and the edges pitched to true lines and exact batter; the face to have no projections over three (3) in. beyond the pitch lines.

24. No holes for stone hooks shall be permitted to show in exposed surfaces. They must be handled with clamps, keys, lewis or dowels.

32. Coping shall be dimension stone, holding full size throughout, proportioned for its loading, as marked on the drawings.

33. The beds, joints and top shall be fine-pointed.

34. The location of joints shall be determined by the position of the bed plates, and must be shown on the drawings.

36. Change heading to read: "Rubble Masonry in Bridges and Retaining Walls."

38. The voussoirs shall be of full size throughout, and must have bond not less than thickness of the stone and dressed true to templet.

39. The number of courses and depth of voussoirs shall be shown on the drawings.

43. Backing shall consist of large stones shaped to fit the arch bonded to the spandrel and laid in full beds of mortar. Concrete may also be used for backing.

46. Bench walls, piers, spandrels, parapets, wing walls and copings shall be built under the specifications for Ashlar Masonry in Bridges and Retaining Walls.

47. The voussoirs shall be full size throughout, and must have bond not less than thickness of stone.

48. The depth of voussoirs shall be shown on drawings.

53. Backing shall consist of large stones shaped to fit the arch bonded to the spandrel and laid in full beds of mortar. Concrete may also be used for backing.

55. Bench walls, piers, spandrels, parapets and wing walls shall be built under the specifications for Rubble Masonry in Bridges and Retaining Walls.

57. Culvert Masonry shall be laid in cement mortar. The character of stone used and quality of work shall be similar to that specified for Rubble Masonry in Bridges and Retaining Walls.

58. One-half the top stones of the side walls shall extend entirely across the wall.

59. The covering must be of sound, strong stone at least twelve

(12) in. thick, or as shown on drawings. They shall be roughly dressed so as to make close joints with each other, and must lap their whole width at least twelve (12) in. over the side walls. They shall be doubled under high embankments, as directed by the engineer or shown on drawings.

60. The end walls shall be covered with suitable coping.

61. Dry Masonry shall include dry retaining walls and slope walls.

62. Dry retaining walls shall include all dry rubble work for retaining embankments or similar work.

63. Flat stone at least twice as wide as thick will be used. Beds and joints to be roughly dressed square to each other and to face of stone.

64. Joints not to exceed three-quarters (¾) in.

65. The different sizes of stone shall be evenly distributed over the whole face of wall, generally keeping the largest stone in the lower part of wall.

66. The work shall be well bonded and present a reasonably true and smooth surface, free from holes or projections. This wall is double-faced and self-sustaining.

67. Slope walls shall be built of such thickness and slope as may be required by the engineer. No stones which do not reach through the wall shall be used in their construction. Stones shall be placed at right angles to the slopes. This wall is single faced and built with steep slope simultaneously with the embankment which it is to protect.

DISCUSSION.

The President:—Before discussing the report of the Committee on Masonry, the chair desires to announce, as outlined in the opening address on Tuesday, that, on invitation of President Roosevelt, the American Railway Engineering and Maintenance of Way Association is officially represented by three of its members on the National Advisory Board on Fuels and Structural Materials. During the past year and at the present time investigations of these subjects are being conducted under the direction of the United States Geological Survey at St. Louis. You are also aware that your Committee on Masonry has a sub-committee on concrete and reinforced concrete, which, jointly with similar committees of the American Society of Civil Engineers, the American Society for Testing Materials and the Association of American Portland Cement Manufacturers, is co-operating with the Geological Survey in these investigations, especially in regard to concrete and reinforced concrete, and is depending largely, if not entirely, on the results of these investigations, which will enable it to formulate a report.

The Congress of the United States has now under consideration an appropriation of $350,000 for the continuance of this work, and of this amount $100,000 is to be devoted to structural materials, that is, cement, mortars and concrete. The appropriation will form an item in the sundry civil appropriation bill, which will be reported to the House of Representatives about the latter part of the coming month.

Your sub-committee on Masonry is deeply concerned in the passage of this appropriation; indeed, its whole future work is dependent upon securing this appropriation. It is very desirable, therefore, that every member of this Association communicate with the members of Congress from his district and urge upon them the importance of this appropriation.

The chairman of the Committee on Masonry desires to make a statement relative to the separation of the sub-committee on concrete and reinforced concrete from the main Committee on Masonry, the Committee on Masonry to continue with the general subjects of masonry, and a special committee of three or more, as may be decided, to take up the question of reinforced concrete.

Mr. E. C. Brown (Union Railroad):—This Committee is on the general subject of masonry. It has been suggested that possibly there might be some conflict between the work of the sub-committee of the special committee on reinforced concrete and the standing committee. This, however, I think, can be adjusted, and it is the unanimous recommendation of this Committee that such action be taken by our Board of Direction. The general subject of concrete and reinforced concrete is broad and particularly interesting, and being followed up by committees of the associations which together form the joint committee; therefore it seems a very proper time for this work to be turned over to a special committee rather than to continue as a part of the function of this Committee through its sub-committee.

The work of the Masonry Committee during this year has been confined principally to the formulation of a specification for stone masonry, and some little investigation along three separate lines laid out by the Board of Direction at the beginning of the year. Our report deals with these matters on pages 71 and 72, except the specifications for stone masonry, and you will observe that nothing in the shape of a formal report on any of the three items is ready for presentation. If it is the pleasure of the convention, we would like to invite your attention at once to the specifications for stone masonry, and in connection with that the modified classification on page 87. The predecessor of this classification was adopted, or at least accepted favorably, by the Association three years ago. In the formation of these new specifications for stone masonry we found it was necessary to simplify and at the same time amplify to a certain extent that classification. As was suggested a little while ago by the chairman of another committee, we hope no hasty action will be taken by the convention in reversing entirely the recommendations of the Committee, and we invite discussion of the subject. I think that the two parts of the report which I call particular attention to, that is, the specifications for stone masonry and the classification of masonry, will have to be borne in mind at the same time during the discussion.

The President:—The Secretary will read the various items under the heading "Specifications for Stone Masonry."

The Secretary:—"Specifications for Stone Masonry.—General.—Stone. (1) Stone masonry shall be built of the kinds specially designated, with such arrangements of courses and bond as shown on the drawings or as directed. The stone shall be hard and durable, free from seams or other imperfections, of approved quality and shape, and in no case have less bed than rise, and shall be laid on their broadest beds, well bonded and solidly bedded. When liable to be affected by freezing, no unseasoned stone shall be laid.

"Dressing. (2) Dressing must be the best of the kind specified for each class of work.

"(3) Beds and joints or builds must be square with each other, and dressed true and out of wind. Hollow beds will not be allowed.

"(4) All stone must be dressed for laying on natural beds.

"(5) Margin drafts must be neat and accurate.

"(6) Pitching must be done to true lines and exact batter.

"Mortar. (7) The sand and cement should be mixed dry and in small batches in proportions as directed, on a suitable platform, which must be kept clean and free from all foreign matter; then water is to be added and the whole remixed until the mass of mortar is thoroughly homogeneous, and leaves the hoe clean when drawn from it. It must not be retempered after it has begun to set."

Mr. C. F. Loweth (Chicago, Milwaukee & St. Paul):—In the first paragraph I notice it says, "stone masonry shall be," and in the second paragraph it says "dressing must be," and later on in paragraph 7 it says "should be." In some of the succeeding paragraphs it reads "may be" or "will be." I think in our specifications heretofore we have used the words "shall be," and I suggest that when the specifications are finally printed that the words "shall be" be substituted for "may be" or "could be," or any other similar expression.

The President:—The Committee accepts the change.

Mr. Loweth:—Paragraph 7 as read would not permit the use of mixing mortar in a concrete mixer or other mechanical mixer. I think it is economical to use a mechanical mixer of small size on small jobs of masonry.

Mr. Brown:—You object to the reference to the hoe?

Mr. Loweth:—I object to the requirement that it shall be mixed on a suitable platform. I would suggest a change like this: "The sand and cement shall be thoroughly mixed," and omit everything else until we come to the words, "until the mass of mortar is thoroughly homogeneous," etc.

Mr. A. S. Baldwin (Illinois Central):—There are some valuable points in that paragraph. I move that it be made to begin with the words, "The sand and cement, unless mixed mechanically, should be mixed dry," and the rest of it is good to apply to the ordinary methods of mixing.

Mr. A. L. Buck (Canadian Pacific):—I would like to ask if the gentleman has made mortar in a mixer that was suitable for use in laying first-class masonry.

Mr. Loweth:—Yes, sir.

Mr. C. H. Fake (Mississippi River & Bonne Terre):—The last paragraph is not quite clear, whether that means that mortar may be used even if it is retempered.

Mr. Robert Moore:—I suggest that the same result might be secured by adding the sentence, "Mechanical mixing, to produce the same result, may be permitted."

The President:—The Committee accepts that suggestion.

The Secretary:—"Laying. (8) All stones must be laid on natural beds. Each stone must be settled into place in full bed of mortar."

Mr. L. C. Fritch (Illinois Central):—I would ask the Committee if they are always able to tell what is the natural bed of the stone. Take, for instance, the oolitic limestone.

Mr. Brown:—No; I presume, strictly speaking, it is not possible, at least for the ordinary stone layer. If, however, the question is so difficult of decision, it is to be supposed that there would not be so much difference as to whether it was laid on a natural bed or otherwise.

I am under the impression that this restriction is all right, for it certainly appears in all stone masonry specifications that we have examined, and I think that there is no objection to leaving it in there from my point of view.

Mr. L. C. Fritch:—The only point is that with the oolitic limestone, or Bedford stone, it often raises a question, and sometimes the stone is rejected because the engineer claims it is not laid on its natural bed, when in fact he cannot tell anything about it. Stone is often rejected by the engineer claiming it is not being laid on its natural bed when really it does not make any difference in Bedford limestone whether you lay it on the natural bed or not.

Mr. John Dean (Civil Engineer):—If it is laid with the seam as its natural bed, then the weather will not get into it. In other words, it will not flake off, as it would if laid edgewise.

Mr. L. C. Fritch:—That does not take place in a homogeneous stone like oolitic limestone.

Mr. Dean:—Where the thing comes down so fine as that the matter should be left with the engineer.

Mr. L. C. Fritch:—The point I am trying to make is that in the homogeneous stone it often has the effect of throwing out a stone that is perfectly good and placing an undue burden on the contractor, when it is unreasonable, and it occurs to me that there might be something interjected here to show that all stone except unstratified stone must be laid on a natural bed.

Mr. J. W. Schaub (Consulting Engineer):—I think Mr. Fritch has on his own road some good examples of Bedford stone not laid on its natural bed that has been destroyed by frost, and I think he should be able to give us some information on the subject. I refer to the viaduct on Sixtieth Street. Since that stone has been disintegrated the masonry has been faced with a coating of concrete, and the result is that you have a masonry wall with a concrete face which is an extraordinary condition, but you have a better wall than you had before.

Mr. R. Modjeski (Consulting Engineer):—As far as I can remember, the stone in the Sixtieth Street viaduct was made of a mixed Bedford stone, containing some bluestone, which very often will disintegrate. I do not think taking Bedford stone from the upper layer of quartz and setting it on edge will injure it.

Mr. L. C. Fritch:—I am not familiar with the case at Sixtieth Street Mr. Schaub speaks of. I do not know that anyone can tell whether Bedford stone is laid on its natural bed or not, unless, as Mr. Modjeski states, it is the top layers which show the line of the bed or the drill mark, or something of that kind.

Mr. Modjeski:—That question came up on a recent piece of work and the contractor asked us if we would allow the setting of a stone different from its natural bed, and our ruling was that when the separation is not perceptible, we would allow him to set it on edge or any way he chose.

Mr. Schaub:—When that stone was set on the Sixtieth Street viaduct, I do not think anyone could tell where the natural bed was, and it was only developed after two winters, when the action of the frost developed the natural bed and resulted in spalls dropping down on the heads of passengers. It seems to me it would be unwise to eliminate this clause from the specifications, because it is uncertain as to what that stone will do, especially if it is full of sap. The stone at Sixtieth Street was full of sap when laid, and under those conditions no doubt it would be unwise to set it on edge.

Mr. L. C. Fritch:—My purpose was not to eliminate the paragraph, but to modify it in some way that would prevent any discussion that might work an injustice upon the contractor in case stone were not laid exactly on its natural bed, where it made no difference. In this particular case at Sixtieth Street I do not think it would have made much difference if the stone had been laid the other way. If that stone was laid before it was seasoned, that is perhaps the cause of the failure of it, and then there is a difference in that stone between the true oolitic and what is called the foreign oolitic, or commonly known as the bastard oolitic. If you do not get the true oolitic, the chances are it will disintegrate and go to pieces, no matter in what manner it is laid.

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis):—I knew of but two stones which would be excepted under this ruling, and these are granite and marble. I have had experience with so-called homogeneous limestone, and my observation is that although the natural bed does not appear when the stone is first brought out, it develops as soon as either frost or coal gas acts on it, and if it is to be modified at all, I think it would be as well to say, "With the exception of granite and marble." I do not think it is necessary to put them on their natural bed.

Mr. Buck:—From the experience of the preceding speakers and my own I am in favor of leaving the paragraph stand, and when the structure of the stone is such as to make it difficult to distinguish its bed after having been removed from the quarry, make it obligatory on the part of the contractor to bring the stone from the quarry with its bed so designated that there will be no trouble in getting it properly placed in the work.

Mr. Loweth:—It is not a question whether or not the stone is laid on its natural bed but also the pressure it has to bear. A stone laid on its edge in a masonry wall certainly takes a pressure or strain that it did not take in its natural state in the rock. That is another reason why we should let the paragraph stand as it is written.

Prof. A. N. Talbot (University of Illinois):—The general opinion is that stone should be laid upon its natural bed, and that it will disintegrate from the action of frost and atmospheric changes if laid in any other position. Whether the natural bed may be determined from the appearance of the stone is quite another question from the requirements for putting it in a certain position.

The President:—Is there anyone present from the United States Geological Survey?

Mr. Richard L. Humphrey (Consulting Engineer):—I would state, in connection with the investigation of the strength of stone, in large cubes, laid on side, the homogeneous stone—like some types of sandstone, perhaps harder than the stone Mr. Fritch referred to—where there was no natural quarry bed, gave quite different results under compression, whether the load was applied against the bed or in the direction of the bed, and I think it is an important thing for the engineer to satisfy himself that the stone is being laid on the natural bed for the reason of its greater strength.

Prof. W. K. Hatt (Purdue University):—When stone comes to my laboratory for the purpose of test, it is set on its natural bed, whenever we are able to distinguish its natural bed. We do not seem to be able to detect the bedding in the Bedford limestone. One case has come under my observation in which some Bedford stone steps were put in the entrance to a building exposed to the weather. As far as one could see the stones were cut and laid on their natural bed. Since that time oblique seams have developed in the steps and have resulted in bad spalling. One who is an expert in the examination of rocks with the microscope might determine the presence of these seams that are invisible to the naked eye.

Mr. L. C. Fritch:—I have in mind a case where an important bridge was built with Bedford stone, and a very prominent engineer insisted that that stone should be laid on its natural bed. It developed quite a discussion between the contractor and engineer in charge, resulting in throwing out some stone which was perfectly good and working a hardship on the contractor. Everyone knows that where the seams of stone can be determined, or where the natural bed can be determined, it should of course be laid upon its natural bed; but the question is, should we make provision in the case of homogeneous stone, where it is not essential to lay it on its natural bed?

Mr. Robert Moore:—I would suggest to put in, "wherever the natural bed cannot easily be determined it must be noted at the quarry."

Mr. L. C. Fritch:—The point is that this paragraph places in the hands of the engineer a weapon that he uses without sufficient knowledge to use it properly.

Mr. Brown:—I do not think that alters the case any. If it is not good to put the stone on its edge, it ought not to be so laid. If a certain character of stone is being used, of which it is difficult to determine its natural bed, that only means that extra precautions must be taken on the part of the contractor or his supply man and the engineer.

The President:—There being no motion before the house, the Secretary will continue the reading.

The Secretary:—"(9) No stone must be dropped or slid over the wall, but must be placed without jarring the stones already laid.

"(10) No heavy hammering will be allowed on the wall after a course is laid.

"(11) If a stone becomes loose after the mortar is set, it must be relaid with fresh mortar.

"(12) Each stone must be cleansed and dampened before laying.

"(13) Stones must not be laid in freezing weather unless allowed by the engineer. If allowed, they must be freed from ice, snow or frost by warming, and laid in mortar made of heated sand and water, or, with proper precautions, mixed with brine in proportions of one pound of salt to 18 gallons of water, when the temperature is 32 degrees Fahrenheit. Add one ounce of salt for every degree of temperature below 32 degrees Fahrenheit.

"(14) Stones must be laid to exact lines and levels so as to give the required bond and thickness of mortar in beds and joints."

Mr. Loweth:—I would like to inquire what the Committee considers as the proper precautions to take in mixing water with brine.

Mr. Dean:—We only use this as a precaution for the engineer. If it is properly cleaned, heated, and free from all ice, snow and frost, then it is just a question for the engineer whether he would use salt or not; that is an alternative.

The Secretary:—"Pointing. (15) Mortar in beds and joints of exposed faces must be removed to a depth of one (1) in. before it has set. No pointing shall be done until the wall is complete and mortar set, nor when frost is in the stone. Wet the joints and fill again with mortar made of equal parts sand and Portland cement. It must be pounded in with 'set-in' or calking tool, and finished with a beading tool the width of the joint, used with a straight-edge."

Mr. Loweth:—I think for a mass of masonry a depth of one inch is hardly sufficient. My observation is that it would soon come out, and I would move to change the beginning of the paragraph to read, "Mortar in beds and joints of exposed faces must be removed to a depth of three inches before it has set."

Mr. Geo. W. Kittredge (Cleveland, Cincinnati, Chicago & St. Louis):—I would amend that motion by saying "not less than one inch." That is a better way to put it than as it is written. I agree with the former speaker that one inch is not sufficient in all cases.

The President:—The Committee will accept the suggestion of "not less than one inch."

The Secretary:—"Classification. (16) Stone masonry will be classified under the following heads: Bridge and Retaining Wall Masonry, Arch Masonry, Culvert Masonry, and Dry Masonry.

"Bridge and Retaining Wall Masonry.—(17) Bridge and Retaining Wall Masonry shall consist of two classes: (a) Ashlar (either coursed or broken-coursed), and (b) Rubble.

"Ashlar Bridge and Retaining Wall Masonry.—(18) In Ashlar Bridge and Retaining Wall Masonry (either coursed or broken-coursed), the stone must be large and well-proportioned.

"(19) No course to be less than fourteen (14) in. nor more than thirty (30) in. thick; the thickness of courses to diminish regularly from bottom to top."

Mr. Moore:—It seems to me that the terms "Ashlar, Bridge and Retaining Wall Masonry" are not logical. Ashlar work can be used either in a bridge or in a retaining wall. In other words, would not "Ashlar Masonry" be sufficiently descriptive without regard to the particular use to which it is put?

Mr. Brown:—That brings up a point that we expected to be raised, which has been discussed, and which I referred to in my opening remarks. Ashlar may be used in bridge masonry and retaining wall masonry or even in culvert masonry, and if you refer to the diagram on page 87 you will see that the first column of that classification deals with "kind." The ashlar does not occur until the third column, which is headed "description." This specification which we are discussing is a specification for bridge and retaining wall masonry built of ashlar.

Mr. Moore:—It sounded as though the "ashlar bridge and retaining wall" was part of the name of the masonry.

Mr. Brown:—Under the general heading just above is "Bridge and Retaining Wall Masonry." Further along is given "Rubble Bridge and Retaining Wall Masonry."

Mr. L. C. Fritch:—If it is in order, I would make a motion that the convention accept the classification of masonry for the reason that it is a definition and should be discussed by correspondence, and anywhere in the specifications where these definitions occur they should be accepted unless objected to in writing.

Mr. Brown:—It would seem to me that before we proceed further with the discussion of the specification that our rule that definitions are not to be discussed on the floor of the convention should be suspended, perhaps, and this classification discussed, for it has a vital bearing on the specifications. If this classification is to be thrown out, it vitiates very much of the force of these specifications we have drawn up.

The President:—The chair would rule that the classification of masonry is not a definition, and discussion is in order on the part of the convention.

Mr. C. S. Churchill (Norfolk & Western):—What probably causes us trouble is the term in the heading, "Ashlar Bridge and Retaining Wall Masonry," whereas you mean "Ashlar Masonry in Bridges and Retaining Walls."

The President:—The Committee accepts Mr. Churchill's suggestion.

Mr. Loweth:—Under the heading, "description," in the classification of Masonry, we find "dimension, ashlar and rubble." I do not find anything in the classification that corresponds with the ashlar bridge and retaining wall masonry.

Mr. Brown:—That description was put in to take care of the stone that is used in bridge and retaining wall masonry, referring to special copings and specially cut stones, which frequently form part of that kind of masonry. We do not often build a piece of masonry entirely of stone, called by strict construction dimension stone; nevertheless dimension stone frequently enters into the construction of that kind of masonry.

The President:—There being no motion before the convention, the Secretary will continue the reading.

The Secretary:—"Dressing. (20) The beds and joints or builds of face stone shall be fine-pointed, so that the mortar layer shall not exceed one-half (½) in. in thickness when the stones are laid."

Mr. Brown:—I have a point we desire to call attention to. We attempted to simplify the various names under which dressing is expressed, and we ask you to note on page 89 our description of these terms. I call your attention to this, so that if there is any objection to the use of the name of the dressing in any of these following paragraphs, it may be discussed.

The Secretary:—"(21) Joints in face stone must be full to the square for a depth equal to at least one-half the height of the course, but in no case less than twelve (12) in.

"Facing or Surface Finish. (22) The exposed surface of each face stone will be rock-faced, and the edges pitched to true lines and exact batter; the face to have no projections over three (3) in. beyond the pitch lines."

Mr. Modjeski:—In the case of granite masonry, it would seem that 12 inches back of the face would be quite a hardship.

The Secretary:—"(23) A chisel draft one and one-half (1½) in. wide shall be cut at each exterior corner."

Mr. Kittredge:—I think that is one of the cases where the word "may" could be used better than the word "shall." I do not think it is important to the integrity of the wall or the appearance of the structure that it shall have a draft line. I make that as a motion.

Mr. Loweth:—I think that would leave room for a great deal of doubt, when work was being constructed, whether the engineer would have a right to insist on a chisel draft or whether the contractor was obliged to furnish it. It seems to me we ought not to be ambiguous in the specification, but the engineer should cover it in his request for bids on the work.

Mr. A. J. Himes (New York, Chicago & St. Louis):—There seems to be some confusion among the members of the Association as to whether these specifications shall be considered merely as recommendations or are to be followed in writing other specifications, in which case the use of the term "may" would seem to be eminently proper, or whether the specifications are to be used as specifications for doing the work without revision.

As a matter of fact, some of the specifications recommended by the Association are already in use. Mr. Schneider told us that he was doing work under the specifications drawn up by the Committee on Iron and Steel Structures. I think there is no question that in many instances the specifications recommended by the various committees will be used directly without modification or revision in the letting of contracts. In such case it would be eminently proper that the term "shall" should be used. It seems to me that this is the idea in submitting these specifications to the Association, that they may be used in writing contracts without revision, and for that purpose the term "shall" should be used.

Mr. Kittredge:—I do not view this classification in just the light the last speaker has put it. I view these descriptions or classifications as a guide in regard to the structure you are to build. In making a detailed specification for the construction of any particular piece of work, you would indicate either by your specifications or your plans whether or not there were draft lines on the work, and so far as a wall or ashlar abutment is concerned, it is not necessary for your equipment that there should be draft lines. It was for that reason that I suggested the word "may."

(The motion was lost.)

The Secretary:—"(24) No holes for stone hooks will be permitted to show in exposed surfaces. They must be handled with clamps, keys, lewis or dowels.

"Stretchers. (25) Stretchers shall be not less than four (4) ft. long, and to have at least one and a quarter times as much bed as thickness of the course.

"Headers. (26) Headers shall be not less than four (4) ft. in length. They shall occupy one-fifth of the face of the wall, and no header shall have less than eighteen (18) in. width of face, and where the course exceeds eighteen (18) in. height, the width of face shall not be less than the height of course. Headers shall hold the size in the heart of the wall that they show on the face, and be so arranged that a header in a superior course shall be placed between two headers in a course below; but no header shall be laid over a joint, and no joint shall occur over a header. They shall be similarly disposed in the back of the wall, interlocking with those in the face when the thickness of the wall will admit. When the wall is too thick to admit of such arrangement, stones of not less than four (4) ft. in length shall be placed transversely in the heart of the wall to bond the two opposite sides of it.

"Backing. (27) Backing shall be large, well-shaped stone, roughly bedded and jointed; the bed joints not to exceed one (1) in., and vertical joints generally not to exceed two (2) in. No part or portion of vertical joints shall have a greater dimension than six (6) in., which void shall be thoroughly filled with spalls fully bedded in cement mortar or filled with concrete. At least one-half of the backing stones shall be of the same size and character as the face stone and with parallel beds.

"(28) When face stone is backed with two courses, neither course shall be less than eight (8) in. thick.

"(29) When the wall is three (3) ft. thick or less, the face stone shall pass entirely through and no backing be allowed.

"Backing. (30) If the engineer so directs, the backing may be entirely of concrete, or back laid with headers and stretchers, as specified above, and heart of wall filled with concrete.

"Bond. (31) The bond of stone on face, back and heart of wall shall not be less than twelve (12) in. Backing shall be laid to break joints with the face stone and with one another.

"Coping. (32) Coping will be dimension stone, holding full size throughout, proportioned for its loading, as marked on the drawings.

"(33) The beds, joints and top will be fine-pointed.

"(34) The location of joints will be determined by the position of the bed plates, and must be shown on the drawings.

"Locks. (35) When required, in the judgment of the engineer, coping stones, stones in the wings of abutments, and the stones on piers shall be secured together with iron cramps or dowels, their position being indicated by the engineer.

"Rubble and Retaining Wall Masonry. (36) Rubble Bridge and Retaining Wall Masonry will consist of stones roughly squared, laid in irregular courses. The beds must be parallel, roughly dressed, and lie horizontally in the wall. The bottom stones shall be large selected flat stones. The wall must be compactly laid, having at least one-fifth the surface of the back and face headers, so arranged as to interlock, having all the spaces in the heart of the wall filled with suitable stones and spalls, thoroughly bedded in cement mortar or filled with concrete. The face joints must not be more than one (1) in. in thickness."

Mr. Loweth:—Should not the heading be changed there as in the other case to read, "Rubble Masonry in Bridges and Retaining Walls?"

Mr. Brown:—Yes.

Mr. Himes:—Paragraph 36 reads, "having all spaces in the heart of the wall filled with suitable stones and spalls, thoroughly bedded in cement mortar or filled with concrete." I would like to raise a question there as to the advisability of incorporating in the specification the method to be pursued in so filling the heart of the wall. In my experience in building masonry I have found the only satisfactory way to have the stones thoroughly bedded is to deposit the mortar first and then bed the spalls in that, and I have found a great deal of difficulty with masons in getting them to do the work in that manner. I have found it very difficult to get the heart of the wall well filled with mortar unless it is done in that way. The question I would like to raise for discussion is whether it would be wise to incorporate in the specification a statement as to the method of depositing the mortar and stone in the heart of the wall.

Mr. Brown:—The paragraph says, "thoroughly bedded in cement mortar." I do not believe you will get it thoroughly bedded unless you fill it with mortar.

Mr. Himes:—That is my interpretation, but sometimes the contractors argue to the contrary.

Mr. Brown:—We do not consider it necessary to specify precisely the method of filling the spalls in there. If we specify the spalls shall be thoroughly bedded, the method is up to the engineer.

Mr. Dean:—If a lot of stone is thrown in, and the mortar is thrown over it, that is not bedding it.

The Secretary:—"Arch Masonry. (37) Arch Masonry shall consist of the arch ring only, or that portion between the intrados and extrados, and shall be of two classes: (a) Ashlar Arch Masonry, and (b) Rubble Arch Masonry.

"(41) The exposed surface of the ring stone shall be smooth or rock-faced, with a marginal draft.
and dressed true to templet.

"(39) The number of courses and depth of voussoirs will be shown on the drawings.

"(40) The joints of the voussoirs and the intrados shall be fine-pointed. Mortar joints shall not exceed three-eighths (3/8) in.

"(41) The exposed surface of the ring stone shall be smooth or rock-faced, with a marginal draft.

"(42) Voussoirs shall be carried up simultaneously from both bench walls.

"(43) Backing may consist of large stones shaped to fit the arch bonded to the spandrel and laid in full beds of mortar. Concrete may also be used for backing.

"(44) If waterproofing is required, a thin coat of mortar or grout shall be applied for a finishing coat, upon which shall be placed a covering of suitable waterproofing material.

"(45) Centers shall not be struck until directed.

"(46) Bench walls, piers, spandrels, parapets, wing walls and copings will be built under the specifications for Ashlar Bridge and Retaining Wall Masonry.

"Rubble Arch Masonry. (47) The voussoirs must be full size throughout, and must have bond not less than thickness of the stone.

"(48) The depth of voussoirs will be shown on the drawings.

"(49) The beds need only be roughly dressed, so as to bring them to radial planes.

"(50) Mortar joints shall not exceed one (1) in.

"(51) The exposed surface of the ring stones shall be rock-faced, and the edges pitched to true lines."

Mr. L. C. Fritch:—I suggest that the following words be added to that paragraph: "Unless otherwise directed." As it reads now, it would seem to make it obligatory.

Mr. A. S. Baldwin (Illinois Central):—That also seems to apply to paragraph 41. In that paragraph who is to determine? Shall it be left to the contractor?

Mr. Brown:—I suppose the plans would indicate that, or it would be specified in the contract.

The Secretary:—"(52) Voussoirs shall be carried up simultaneously from both bench walls.

"(53) Backing may consist of large stones, shaped to fit the arch bonded to the spandrel and laid in full beds of mortar. Concrete may also be used for backing.

"(54) If waterproofing is required, a thin coat of mortar or grout shall be applied for a finishing coat, upon which shall be placed a covering of suitable waterproofing material.

"(55) Centers shall not be struck until directed.

"(56) Bench walls, piers, spandrels, parapets and wing walls will be built under the specifications for Rubble Bridge and Retaining Wall Masonry.

"Culvert Masonry. (57) Culvert Masonry must be laid in cement mortar. The character of stone used and quality of work must be similar to that specified for Rubble Bridge and Retaining Wall Masonry.

"(58) One-half the top stones of the side walls must extend entirely across the wall.

"(59) The covering must be of sound, strong stone, at least twelve (12) in. thick, or as shown on drawings. They must be roughly dressed so as to make close joints with each other, and must lap their whole width at least twelve (12) in. over the side walls. They must be doubled under high embankments, as directed by the engineer or shown on the drawings.

"(60) The end walls must be covered with suitable coping."

Mr. Garrett Davis (Chicago, Rock Island & Pacific):—I would suggest that there is less stress on culvert covers under high embankments than there is under shallow embankments—less reason for doubling under a high embankment than there is under an embankment less than eight feet high.

Prof. W. D. Pence (Purdue University):—The term "high embankments" is an interesting one, as to what it means. I do not suppose it would be proper to specify definitely what it means in specifications of this kind, but it would be interesting to know, if we have time to have an expression of opinion. The point Mr. Davis brings up here is an important one in some kinds of structures.

Mr. Brown:—I think the double covering stones in culverts would depend very much on the character of the stone and the thickness of covering used, and it was the intention to leave that largely to the discretion of the engineer, of course.

The Secretary:—"Dry Masonry. (61) Dry Masonry will include dry retaining walls and slope walls.

"Dry Retaining Walls. (62) Dry Retaining Walls will include all dry rubble work for retaining embankments or similar work.

"(63) Flat stone at least twice as wide as thick will be used. Beds and joints to be roughly dressed square to each other and to face of stone.

"(64) Joints not to exceed three-quarters (¾) in.

"(65) The different sizes of stone must be evenly distributed over the whole face of wall, generally keeping the largest stone in the lower part of wall.

"(66) The work shall be well bonded and present a reasonably true and smooth surface, free from holes or projections. This wall is double-faced and self-sustaining."

Mr. L. C. Fritch:—I would suggest that the Committee change the last sentence to read, "The wall should be double-faced and self-sustaining."

Prof. Pence:—That is rather an unusual thing to say in specifications—an explanatory sentence of what is intended in the design.

Mr. Brown:—We are willing to omit that sentence. As it is covered in our definitions anyway, it would perhaps be best to eliminate it.

The President:—If there is no objection, the last sentence of paragraph 66 will be stricken out.

The Secretary:—"Slope Walls. (67) Slope walls shall be built of such thickness and slope as may be required by the engineer. No stones which do not reach through the wall shall be used in their construction. Stones shall be placed at right angles to the slopes. This wall is single faced and built with steep slope simultaneously with the embankment which it is to protect."

Mr. C. H. Ewing (Philadelphia & Reading):—The specifications appear rather incomplete without embodying in them a specification for cement, particularly in mason work; cement is vital to the life of the structure. We have gone somewhat into detail as to the quality of the stone, but we have not as yet said anything as to the cement. I would recommend that for the next year the Committee prepare a standard specification for cement, and embody it in the specifications.

Mr. Brown:—This Committee has already prepared standard specifications for cement, which are two or three years old, and that has already been covered by the recommendations.

Mr. Ewing:—I did not know that. I would move, therefore, that the cement specifications be embodied in the specifications for stone masonry.

Mr. C. W. Boynton (Illinois Steel Company):—The intention of the Committee is that wherever cement or concrete is mentioned, we apply our standard specifications, and it seems hardly necessary to make the cement and concrete specifications a part of the stone masonry specifications.

Prof. Pence:—Is there not something in Mr. Ewing's suggestion that should have attention—the matter of a reference of these specifications to the standard cement specifications, that it would tie the two together and avoid the lapse he speaks of?

Mr. Ewing:—What brought out this subject in my mind was a remark by Mr. Churchill this morning in reference to some structures built on our road about 1840—rubble arches that partially failed, but were distorted only on account of the mortar of the joints. Otherwise the arches would have remained in good shape to-day. Some are in good order, but it was the mortar in the joints that caused these arches to fail. It seems to me, therefore, that it is very necessary that we either embody the complete specifications for cement here, or include, as has been suggested by Prof. Pence, a reference to those specifications, and make them a part of the stone masonry specifications.

The President:—The chairman of the Committee states that the Committee has no objection to embodying a paragraph of that kind, referring to the standard cement specifications of the Association.

Mr. Boynton:—In reference to the headings that have been changed —"Ashlar Masonry in Bridges and Retaining Walls," etc.—in our classification we do not recognize such a thing as ashlar masonry, and in our definitions we define an ashlar block; but ashlar masonry does not appear. If we introduce it in our headings, we will necessarily have to revise our classification and our definitions. It seems we should get around the difficulty of an unpopular expression in some other way.

Mr. Kittredge:—It seems to me that with the discussion we have had on that subject, the matter could be left to the Committee for such revision as they deemed proper. I have faith in the Committee that it can solve the question in a way that will be satisfactory, and if a motion is necessary, I will make this in the form of a motion.

(The motion was carried.)

Mr. L. C. Fritch:—I would move that the classification of masonry, as shown on page 87, be adopted by the convention as a whole, with such modifications as are necessary to meet the changes that have been made in the wording of the specifications, which shall be left to the Committee to modify.

(The motion was carried.)

The President:—If there is no objection, the report of the Committee will be accepted as amended, and the Committee relieved, with the thanks of the Association.

Mr. Loweth:—What is the result of the acceptance of this report? Have we accepted these specifications for stone masonry?

The President:—Yes, sir, as amended.

Mr. Loweth:—I do not understand that that was done by formal vote.

The President:—If there is no objection, they stand approved.

Mr. Loweth:—As long as we have not adopted them by formal vote, I want to make a motion that the specifications for stone masonry be referred back to the Committee for revision, and to report at the next meeting. It seems to me that these specifications are not as concise and free from ambiguity as they could be made. They cover the ground pretty well, but I think they can be gotten up in very much better form.

Mr. McDonald:—I would like to ask Mr. Loweth if his objections are based simply on grammatical and rhetorical arrangement, or whether they involve essential changes in the meaning of the paragraphs?

Mr. Loweth:—In reply to the question of Mr. McDonald, I would say that in going over these specifications we have made a great many suggestions for changes. I think there are a great many others that could have been suggested and brought forth if there had been time. I feel that, as they stand, even with the corrections which have been made, that they contain a great many ambiguities, and certainly are of less value than they will be when threshed over again and put in better form; and I know the Committee can very well do it.

Mr. Brown:—That means that the substance and intent you do not care to have changed, if we express it in a little more precise form, or more concise form. Is that your idea?

Mr. Loweth:—I think it covers not only the form of the specifications, but the wording of the different paragraphs, and to quite a considerable extent the subject-matter of the specifications.

Mr. Brown:—I do not recall any objection to the subject-matter having been made, with the exception of one or two minor points which the Committee was willing to adopt right on the moment. In other words, we would like to have instructions as to whether, in general, the substance of our specifications meet the idea of the Association, or whether the desired revision and reference back is for the purpose of clearing the wording of ambiguities, and such matters only. It would be practically nothing more than a reiteration.

Mr. Moore:—I should like to ask whether Mr. Loweth's motion means that these specifications shall not be printed again for the information of the members, because, even though subject to further revision, they might be very useful. They can be printed with the understanding that the Committee has them under advisement for further revision.

The President:—The chair would state, for the information of Mr. Moore, that, under our practice, the specifications will be printed in the Proceedings, but will be excluded from the Manual of Recommended Practice.

Mr. McDonald:—My object in asking Mr. Loweth was to know whether he would be willing to leave that matter of editing the report to the Committee, rather than have them consider it another year, when it would be brought back and probably treated in the same way.

Mr. Dean:—We have made quite a departure this year. The old first, second and third class masonry are done away with. Now we bring this down to a classification such as ashlar and rubble. Does that meet with your approval, or do you want to go back to the old idea?

(The motion was lost.)

Mr. Baldwin:—There is a point I would like to bring up in connection with these specifications that is a general one. On several occasions it has been brought out that quite a considerable difference would come in the results, whether certain words were used, such as "shall" or "may." It was also brought out very clearly that it is intended that these specifications as prepared shall be such that they can be actually used and be serviceable. At the same time we have passed over several points that leave something in dispute, some uncertainty on the part of the contractor. I believe it would be very helpful if we could have the specifications so arranged that by the erasure of one word or another, that is, one put above another, the engineer in letting the contract could choose whichever method he preferred; and, furthermore, he would have the benefit, in going over the specifications, of having his attention directed to these points. As a rule, we give an outline plan that would not be gone into in detail, and it leaves something open for dispute between the contractor and the engineer. To illustrate, under paragraph 41, it reads, "The exposed surface of the ring stone shall be smooth or rock-faced, with a marginal draft." That makes a great deal of difference to the contractor when he comes to put that up. If we had the classification worded, "The exposed surface of the ring stone shall be," and directly under that "must be," "with marginal draft," we would have something that would be of assistance to the engineer in letting his contract, because when he would glance over the contract, his attention would be called to these things.

Mr. Brown:—The Committee is agreed that Mr. Baldwin's suggestion is a very good one, and it would not be a very difficult matter to make the arrangement he suggested, and unless there is objection on the part of someone else, we would be very glad to consider that and introduce it into the final form of these specifications.

Mr. Buck:—How would it read after the Committee had changed it in accordance with the suggestion?

Mr. Brown:—I do not know that the Committee would want to be taken on short order and arrange that and hold to it now. The idea is well fixed in our minds—that is, the idea of what we want to accomplish. I do not know that the two methods of dressing should each be printed so that one should be erased or not. If that arrangement should be found not to burden the whole document too much, it might be introduced. That would be a matter the Committee would not like to commit itself on offhand.

Prof. Pence:—Mr. Baldwin merely proposed that we should have the alternative use of "must" or "shall." It seems to me that would not be a difficult matter. I supposed he was speaking of the alternative kinds of dressing.

Mr. Buck:—I think the paragraph as it stands is exactly right. It is good practice. The suggestion to change it so that it could alternate would not make it any better than it is.

Mr. Schaub:—It seems to me the whole matter could be simplified by merely adding to paragraph 41 the words, "as specified."

Mr. Baldwin:—I do not mean this to apply to this particular paragraph necessarily. Here are two alternate methods, and I wanted to call the attention of the engineer, in going through his specifications, to the fact that there was more than a single proposition there. It is of great assistance in letting contracts to have your attention called to things that may be lost sight of. The engineer does not wish to go through each line of a specification to see whether or not everything is clear.

Mr. Humphrey:—Why could not that be simplified by placing the two phrases one above the other, indicating with an asterisk that the engineer should strike out one or the other? You could put on the top line, "the masonry shall be smooth-faced," and directly underneath it, "rock-faced, with marginal draft," and signify that the engineer should indicate the character of finish desired by striking out one or the other of those phrases.

The President:—The question is on the advisability of inserting alternate words in the specifications. There is no motion.

Mr. Churchill:—It seems to me that the Committee have stated very clearly that they can handle the question and will handle it in case there are any particular paragraphs that can be improved in any manner, and that they will correct any verbiage. I think, therefore, that the report of the Committee should be accepted, and I make that motion.

Mr. Modjeski:—I would offer as an amendment that the specifications for masonry, as read and amended, be approved in substance as a preliminary draft, and that the Committee be requested to present to the next convention revised specifications, taking into consideration the points developed in this discussion, or which may develop in discussion hereafter.

Mr. Brown:—I sincerely hope that the amendment will be voted down, for the reason we think we ought to dispose of this matter right now. The substance of this specification does not seem to be attacked. The only questions which may arise at all are of minor importance, such as Mr. Churchill has mentioned, in phraseology and rhetoric. I sincerely hope that the convention will allow the specifications to stand as approved, with the understanding that these minor corrections, which may be termed editing, may be done either by the Committee or by the Committee on Publications, and that the specifications may appear in the Manual of Recommended Practice.

(The amendment was lost, and the original motion carried.)

Mr. Brown:—I rise now to a matter of privilege. A member of our Committee, who is also a member of the Advisory Board on Fuels and Structural Materials, desires to make a statement regarding the action of the Government in helping along the work.

Mr. Humphrey:—I have heard some little criticism and comment relative to the work which is being done in the investigation of structural materials, on the ground that there has been a great deal of talk and very little action. The work was inaugurated last April, under two Government appropriations, one for five thousand dollars and the other for seven thousand five hundred dollars. As the first item was a deficiency appropriation, it was necessary to use the money at once in the purchase of equipment; this left seven thousand five hundred dollars to carry on the work during the year. When I say to you that we have some fourteen assistants in the laboratory at St. Louis, Mo., and that they have examined some seventy-seven samples of sands, gravels and crushed stone in different parts of the country, all of which were donated by the people who owned the deposits and were carried by the railroads free of charge; that the steel for use in the reinforced concrete was donated by the steel manufacturers, and the cement by the cement manufacturers, you will understand the magnitude of the work necessary in providing for these assistants and in securing the co-operation of the railroads and the owners of the various deposits from which samples were obtained. There was insufficient money, and we have done the best we could; there is in preparation at the present time a bulletin which will appear before the end of this half year telling of the work which was done during the past year, and also setting forth the work which has been done at various technological institutions under the supervision of the Joint Committee. It requires a good deal of time and effort to organize. Our organization at St. Louis, which is now the laboratory of your Committee on Concrete and Reinforced Concrete, is fairly under way. We hope to get one hundred thousand dollars from the United States Government; it seems reasonably sure that we will get it. We hope that every member interested in the work will communicate with his congressman endorsing this work, because it is only through such action that we will secure the appropriation. We will accomplish more next year than we did this year. What I desire to bring before the members of this organization is the need of co-operation on the part of the railroads in enabling us to obtain characteristic samples from deposits of sand, gravel and stone—which form the constituent parts of concrete. This is the first thing we must get information on as the basis of the final report on concrete and reinforced concrete. If we must purchase all this material, pay the freight as well as the expenses of the inspector who inspects it, it will quickly exhaust the appropriation. So that, when we appeal to the members connected with the various railroads to assist us in this matter, I trust you will understand the reasons why we are doing it, and after the samples are furnished to realize that it takes time before the material can be tested and a report made. As a matter of fact, we have thus far accomplished a very great deal under adverse conditions.

As stated before, we tested some seventy-seven samples last year; these tests extend over a year, embracing periods of one month, three months, six months and a year, and were made regularly and systematically. While we have been doing a great deal of talking, as has been said, we have also been doing a great deal of work, with a limited amount of money. Therefore we hope you will have patience, as we feel that the coming year will show the value and extent of the work we are endeavoring to do, and with which your sub-committee is so cordially and heartily co-operating. I thank you, gentlemen.

REPORT OF COMMITTEE NO. VI.—ON BUILDINGS.

To the Members of the American Railway Engineering and Maintenance of Way Association:

The Board of Direction has formulated the following outline for the guidance of the Committee on Buildings in making its annual report:

(I.) The relative advantages and disadvantages of circular, square, or other special designs of roundhouses, and the recommended general principles of practice as to the conditions influencing the choice of any particular design.

(II.) Smoke jacks—various designs and material, life, cost and recommended practice.

(III.) Roundhouse doors—descriptions and sketches of the various designs, and recommended practice.

(IV.) Definitions.

(V.) Transmit all papers connected with the standard form of contract for railroad buildings to Committee No. XII.

Several meetings have been held, which have been well attended, and some of the work has been done by correspondence, and the conclusions reached are the best views of your Committee.

As heretofore, the discussions and the conclusions are intentionally made as definite and as concise as is possible.

(I.) THE RELATIVE ADVANTAGES AND DISADVANTAGES OF CIRCULAR, SQUARE, OR OTHER SPECIAL DESIGNS OF ROUNDHOUSES, AND THE RECOMMENDED GENERAL PRINCIPLES OF PRACTICE AS TO THE CONDITIONS INFLUENCING THE CHOICE OF ANY PARTICULAR DESIGN.

(Reference is made to Vol. 6, pp. 687-689, and to Bulletin No. 68, page 123.)

A—CIRCULAR ROUNDHOUSE.

ADVANTAGES:

(a) It is the logical shape when a turntable is used (a modern turntable, properly constructed, of ample capacity, is a reliable structure).

(b) Ordinarily it is the most economical design for ground space.

(c) It requires only one "jack" per stall.

(d) With its use the cost of handling locomotives in and out, and of turning them, is a minimum.

(e) This shape allows good command of the work in the house by the foreman.

(f) This design gives the best facilities for furnishing natural light around the engine end of the locomotive.

(g) Artificial light can be provided at least cost.

(h) It affords better facilities for locating benches and lockers.

(i) It gives maximum room at the engine end and economizes space at the tender end of the locomotive.

(j) With equal facilities for work, and ventilation, the cubical capacity per stall in a circular house is comparatively small; consequently heating is more economical.

(k) At the expense of roofing over the turntable, the loss of heat by open doors may be reduced to a minimum.

(l) One operator and one power equipment will handle all engines going in and out.

DISADVANTAGES:

(a) The locomotives are tied up when the turntable is out of service.

(b) Loss of heat from open doors, one outside door per stall being usually used.

(c) Difficulty in increasing the length of the stalls after they are constructed.

B—RECTANGULAR HOUSES.

Rectangular houses may be classed under two general heads, viz.:—

(a) Through rectangular houses.

(b) Transverse table houses.

THROUGH RECTANGULAR HOUSES.

This form of house is illustrated on an inset opposite page 688, in Vol. 6, of the Proceedings of our Association, and consists of a series of parallel tracks running lengthwise of the house with a system of lead tracks and switches at each end outside of the house and a system of double slip switch crossovers in the house, to be used in running engines around one another.

The advantages and disadvantages following do not apply to the small rectangular house, open at one end only, with capacity for two to four locomotives.

ADVANTAGES:

(a) This arrangement may fit some particular location, or shape of property where length but not width can be had.

(c) Locomotives can be readily handled, providing in case of emergency there will be no confusion in operating the double slip switches and no derailment occurs at them.

(c) Locomotive standing room can be increased for longer machines, by changing the location of the pits and also of the crossover track system, or by increasing the length of the house and readjusting the tracks at the end.

DISADVANTAGES:

(a) Assuming that all locomotives will enter at one end and depart at the other, it will be necessary to turn at least one-half of them before they are put into the house, and the same number again after they go out, in order to save the use of two jacks per engine stall throughout the house.

(b) Either two turntables or "Y" tracks, one at each end, will have to be used or the locomotive will have to be run from end to end outside to be turned before and after going to the house.

(c) Loss of heat from doors in opposite ends of the house being open at one time, will be very great.

(d) There is no space for work benches, or for storing parts of engines temporarily, without blocking the running space for other locomotives.

(e) Locomotives cannot be required to arrive at one end and depart at the other without cutting down materially the capacity of the house by keeping several of the tracks open.

(f) If crossover clearances are maintained, and tracks are kept open for running, there will be a large amount of space in the house per effective stall, consequently the cost of heating and of lighting will be comparatively large.

TRANSVERSE TABLE HOUSES.

This house consists of a series of parallel engine pits, usually running crosswise of the house, the locomotives being handled to and from them by means of a transverse table, located either inside or outside of the building, depending on the conditions and the requirements.

ADVANTAGES:

(a) The capacity of the house can be readily increased by extensions and additions of other transfer tables on the same depressed tracks.

(b) Cranes can be used to advantage in this form of a rectangular house if necessary.

(c) This design is favorable for use in connection with a machine shop or an erection shop, where the transfer table or tables can be used in common for both.

(d) When the transfer table is covered, heat may be saved. One door, however, will have to be opened many times instead of each of many doors occasionally. There will, in this case, be an economy in the smaller number of doors needed.

(e) Adaptability for some special locations.

DISADVANTAGES:

(a) On account of the necessity for the use of a turntable as well as a transfer table, the cost of operation and of maintenance will be high; the turntable will have to be used for about one-half the engines when coming in as well as when going out.

(b) The increased time for handling locomotive when the turntable work is included.

(c) The arrangement of parallel tracks in an engine house does not give the best disposition of the floor space, for when the spacing is made to suit the requirements around the engine end there will be room to spare at the tender end.

CONCLUSION.

Your Committee therefore has made the following conclusions, and recommends as general principles of practice that—

The circular form of an engine house is, in general, the preferable design, with possibly the follownig exceptions:

(a) At branch terminals, or similar points, where not more than three or four locomotives are housed at one time and where it is more economical to provide a "Y" track than a turntable, or where it is not necessary to turn the locomotives, a thorough rectangular house, with switches at one end only, may be desirable, or

(b) At shops where a transfer table is used and an engine house is to be added, and at special locations, the transfer table house may be desirable.

(II.) SMOKE JACKS—VARIOUS DESIGNS AND MATERIAL. LIFE, COST AND RECOMMENDED PRACTICE.

The design and construction of jacks are at the present time in a state of rapid transition from the small diameter, adjustable castiron form to a fixed jack of large size, with a large size flue and a damper, made of various materials. These large jacks were at first made of wood, but are now being made more and more of castiron, asbestos board and other non-corrosive and non-combustible materials, as fast as the manufacturers are able to adjust the construction to the new designs. The arguments in favor of the large fixed jacks are evident, some of which are:

The modern large locomotive requires larger jacks to take care of the smoke, particularly from green fires.

The necessity for quick service in the roundhouse makes the frequent adjustment of the location of the locomotive desirable to facilitate inspection and repairs. These movements frequently result in the separation of the stack from the jack. This difficulty is overcome by the use of the large jack.

A saving in labor is secured, as there is no work to be done in adjusting the jacks to the stacks each time a locomotive enters the house. This saving, and the general better atmospheric conditions prevailing, offset the loss of the increased draught caused by the small jacks acting as extensions of the stacks.

The life of the jacks is determined by the kind of material used, and there are no reasons why the same material cannot be used in the large as has been used in the small jacks. The cost will increase with the size, but the advantages in favor of the larger size are so great that the cost should not be a determining factor.

Cast-iron jacks with bottom openings 3½ to 4 ft. wide and from 10 to 12 or more ft. long, tapering gradually upward to a flue of a reasonable length, and 3½ to 4 ft. in diameter, with a damper, will cost from $175.00 to $225.00 each, erected.

CONCLUSION.

Your Committee therefore has made the following conclusions, and recommends as general principles of practice that—

The engine house smoke jack should be fixed, the bottom opening should be not less than forty-two (42) in. wide, and long enough to receive the smoke from the stack at its limiting positions, due to the adjustment of the driving wheels to bring the side rods in proper position for repairs. The bottom of the jack should be as low as the engines served will allow, and it should be furnished with a drip trough, the slope upward should be gradual to the flue, the size of the flue for the largest locomotives should be not less than forty-two (42) in. in diameter; a damper should be provided in the flue—easily adjusted from the floor. And the material used should be non-combustible and non-corrosive.

(III.) ROUNDHOUSE DOORS—DESCRIPTION OF THE VARIOUS DESIGNS, AND RECOMMENDED PRACTICE.

The various designs of roundhouse doors will include the following: Swinging, Rolling, Folding, Lifting and Sliding.

(a) Swinging Doors.—Have the advantage of being:—

Comparatively cheap for first cost.

Glass can be used in them.

Small doors can be built in the larger ones.

They are, however, exposed to the wind, and liable to be blown against a locmotive and damaged.

If struck, they are liable to serious damage.

(b) Rolling Doors.—Are now made of wood slats or of metal; they cost about sixty cents per square foot erected.

Small doors or glass are not placed in the large doors.

They are not exposed to damage by wind.

If struck, the damaged slats are easily repaired.

They fit snugly along the sides and at the bottom.

(c) Folding Doors.—Are made of wood.

Glass and small doors can be used in them.

They are not exposed to damage by wind.

If struck, they are liable to be seriously damaged.

(d) Lifting Doors.—Are made of wood.
Glass and small doors can be used in them.
They are not exposed to damage by wind.
If struck, they are liable to be seriously damaged.

(e) Sliding Doors.—Do not fit tightly; the hangers rust and fail.
Glass and small doors can be used in the large ones.
One-half of the doors are necessarily closed all the time.
They are not exposed to damage by wind.
If struck, they are liable to serious damage.

The tendency to depart from the use of the swinging door, and the introduction of the various kinds of wooden doors of other designs being of such recent date, your Committee has not been able to find a door that has all the virtues and none of the faults of the other doors.

CONCLUSION.

Your Committee, therefore, has made the following conclusions, and recommends as general principles of practice that—

Roundhouse doors should be made of non-corrosive material; they should be easily operated, fit snugly, be easily repaired and maintained, and should not be exposed to damage by wind, directly or indirectly, and should admit of the use of small doors.

The particular kind of door that will suit a given case can be determined only by giving the proper value to the different factors enumerated above.

(IV.) DEFINITIONS.

Your Committee has not had a clear understanding as to the requirements under this heading, and consequently wishes to simply report progress.

(V.) BUILDING CONTRACT DATA.

Transmit all papers connected with the standard form of contract for railroad buildings to Committee No. XII.

This material having been fully compiled and the conclusions therefrom having been presented in the report appearing in Vol. 6, it has been thought desirable not to lose the valuable information collected, therefore it has been published in Bulletin No. 68, October, 1905, and is now available in proper form for the use of Committee No. XII.

Respectfully submitted,

A. R. Raymer, Assistant Chief Engineer, Pittsburg & Lake Erie Railroad, Pittsburg, Pa., *Chairman.*

E. D. B. Brown, Contracting Engineer, Chicago, Ill., *Vice-Chairman.*
G. F. Bristol, Building Engineer, Pere Marquette Railroad, Detroit, Mich.
M. Coburn, Engineer Maintenance of Way, Vandalia Railroad, Terre Haute, Ind.
H. M. Cryder, Principal Assistant Engineer, Wabash Railroad, St. Louis, Mo.
B. C. Gowen, Chief Engineer, Wis. & Mich. Railroad, Peshtigo, Wis.
E. C. Macy, Superintendent, Thos. Phee Co., St. Croix Falls, Wis.
H. M. Steele, Chief Engineer, Central of Georgia Railway, Savannah, Ga.

Committee.

DISCUSSION.

The President:—The report of the Committee on Buildings is before you. The chairman of the Committee, Mr. A. R. Raymer, asks that the paragraphs in regard to the relative advantages and disadvantages of circular, square or other forms of roundhouses be read and discussed.

The Secretary:—"Circular Roundhouse—Advantages.

"(a) It is the logical shape when a turntable is used (a modern turntable, properly constructed, of ample capacity, is a reliable structure).

"(b) Ordinarily it is the most economical design for ground space.

"(c) It requires only one 'jack' per stall.

"(d) With its use the cost of handling locomotives in and out, and of turning them, is a minimum.

"(e) This shape allows good command of the work in the house by the foreman.

"(f) This design gives the best facilities for furnishing natural light around the engine end of the locomotive.

"(g) Artificial light can be provided at least cost.

"(h) It affords better facilities for locating benches and lockers.

"(i) It gives maximum room at the engine end and economizes space at the tender end of the locomotive.

"(j) With equal facilities for work, and ventilation, the cubical capacity per stall in a circular house is comparatively small; consequently heating is more economical.

"(k) At the expense of roofing over the turntable, the loss of heat by open doors may be reduced to a minimum.

"(l) One operator and one power equipment will handle all engines going in and out.

Disadvantages:

"(a) The locomotives are tied up when the turntable is out of service.

"(b) Loss of heat from open doors, one outside door per stall being usually used.

"(c) Difficulty in increasing the length of the stalls after they are constructed.

"B—Rectangular Houses.—Rectangular houses may be classed under two general heads, viz.:—

"(a) Through rectangular houses.

"(b) Transverse table houses.

"Through Rectangular Houses.—This form of house is illustrated on an inset opposite page 688, in Vol. 6 of the Proceedings of our Association, and consists of a series of parallel tracks running lengthwise of the house, with a system of lead tracks and switches at each end outside of the house, and a system of double slip switch crossovers in the house, to be used in running engines around one another.

"The advantages and disadvantages following do not apply to the small rectangular house, open at one end only, with capacity for two to four locomotives.

"ADVANTAGES:

"(a) This arrangement may fit some particular location, or shape of property where length but not width can be had.

"(c) Locomotives can be readily handled, providing in case of emergency there will be no confusion in operating the double slip switches and no derailment occurs at them.

"(c) Locomotive standing room can be increased for longer machines, by changing the location of the pits and also of the crossover track system, or by increasing the length of the house and readjusting the tracks at the end.

"DISADVANTAGES:

"(a) Assuming that all locomotives will enter at one end and depart at the other, it will be necessary to turn at least one-half of them before they are put into the house, and the same number again after they go out, in order to save the use of two jacks per engine stall throughout the house.

"(b) Either two turntables or 'Y' tracks, one at each end, will have to be used or the locomotive will have to be run from end to end outside to be turned before and after going to the house.

"(c) Loss of heat from doors in opposite ends of the house being open at one time, will be very great.

"(d) There is no space for work benches, or for storing parts of engines temporarily, without blocking the running space for other locomotives.

"(e) Locomotives cannot be required to arrive at one end and depart at the other without cutting down materially the capacity of the house by keeping several of the tracks open.

"(f) If crossover clearances are maintained, and tracks are kept open for running, there will be a large amount of space in the house per effective stall, consequently the cost of heating and of lighting will be comparatively large.

"TRANSFER TABLE HOUSES.—This house consists of a series of parallel engine pits, usually running crosswise of the house, the locomotives being handled to and from them by means of a transfer table, located either inside or outside of the building, depending on the conditions and the requirements.

"ADVANTAGES:

"(a) The capacity of the house can be readily increased by extensions and additions of other transfer tables on the same depressed tracks.

"(b) Cranes can be used to advantage in this form of a rectangular house if necessary.

"(c) This design is favorable for use in connection with a machine shop or an erection shop, where the transfer table or tables can be used in common for both.

"(d) When the transfer table is covered, heat may be saved. One door, however, will have to be opened many times instead of each of many doors occasionally. There will, in this case, be an economy in the smaller number of doors needed.

"(e) Adaptability for some special locations.

"DISADVANTAGES:

"(a) On account of the necessity for the use of a turntable as well as a transfer table, the cost of operation and of maintenance will be high; the turntable will have to be used for about one-half the engines when coming in as well as when going out.

"(b) The increased time for handling locomotive when the turntable work is included.

"(c) The arrangement of parallel tracks in an engine house does not give the best disposition of the floor space, for when the spacing is made to suit the requirements around the engine end there will be room to spare at the tender end."

The President:—If there are no objections to the arguments for and against the various types of houses, they will stand approved.

The Secretary:—"CONCLUSION. Your Committee therefore has made the following conclusions, and recommends as general principles of practice that—

"The circular form of an engine house is, in general, the preferable design, with possibly the following exceptions:

"(a) At branch terminals, or similar points, where not more than three or four locomotives are housed at one time, and where it is more economical to provide a 'Y' track than a turntable, or where it is not necessary to turn the locomotives, a through rectangular house, with switches at one end only, may be desirable; or

"(b) At shops where a transfer table is used and an engine house is to be added, and at special locations, the transfer table house may be desirable."

Mr. Edwin F. Wendt (Pittsburg & Lake Erie):—I move that the conclusions be adopted.

(The motion was carried.)

The Secretary:—"Smoke Jacks—Various Designs and Material, Life, Cost and Recommended Practice. The design and construction of jacks are at the present time in a state of rapid transition from the small diameter, adjustable cast-iron form to a fixed jack of large size, with a large size flue and a damper, made of various materials. These large jacks were at first made of wood, but are now being made more and more of cast-iron, asbestos board and other non-corrosive and non-combustible materials, as fast as the manufacturers are able to adjust the construction to the new designs. The arguments in favor of the large fixed jacks are evident, some of which are:

"The modern large locomotive requires larger jacks to take care of the smoke, particularly from green fires.

"The necessity for quick service in the roundhouse makes the frequent adjustment of the location of the locomotive desirable to facilitate inspection and repairs. These movements frequently result in the separation of the stack from the jack. This difficulty is overcome by the use of the large jack.

"A saving in labor is secured, as there is no work to be done in adjusting the jacks to the stacks each time a locomotive enters the house. This saving, and the general better atmospheric conditions prevailing, offset the loss of the increased draught caused by the small jacks acting as extensions of the stacks.

"The life of the jacks is determined by the kind of material used, and there are no reasons why the same material cannot be used in the large as has been used in the small jacks. The cost will increase with the size, but the advantages in favor of the larger sizes are so great that the cost should not be a determining factor.

"Cast-iron jacks with bottom openings 3½ to 4 ft. wide and from 10 to 12 or more ft. long, tapering gradually upward to a flue of a reasonable length, and 3½ to 4 ft. in diameter, with a damper, will cost from $175.00 to $225.00 each, erected.

"Conclusion.—Your Committee, therefore, has made the following conclusions, and recommends as general principles of practice that—

"The engine house smoke jack should be fixed, the bottom opening should be not less than forty-two (42) in. wide, and long enough to receive the smoke from the stack at its limiting positions, due to the adjustment of the driving wheels to bring the side rods in proper position for repairs. The bottom of the jack should be as low as the engines served will allow, and it should be furnished with a drip trough, the slope upward should be gradual to the flue, the size of the flue for the largest locomotives should be not less than forty-two (42) in. in diameter; a damper shall be provided in the flue—equally adjusted from the floor. And the material used should be non-combustible and non-corrosive."

The President:—You have heard the conclusion of the Committee. Do you desire to take any formal action?

Mr. W. B. Storey, Jr. (Atchison, Topeka & Santa Fe):—I will call attention to the fact that the recommendations call for the bottom openings to be 42 in. in size, and that the size of the flue is also to be 42 in., and yet it speaks of tapering up.

Mr. A. R. Raymer (Pittsburg & Lake Erie):—The tapering is gradual upwards. That point is mentioned for the reason that if the tapering be not made gradual when there is a forced draft, the smoke rebounds from the flat tapering ends, if such were used. Therefore it is desirable to have the taper at quite a steep pitch, gradually up to the flue.

Mr. Storey:—The point I wish to call attention to is that the statement calls for 42 in. at the bottom of the opening; also that the size of the flue be 42 in. Therefore I do not understand how there can be any tapering.

Mr. L. C. Fritch (Illinois Central):—We have been experimenting with the jack question for some time, and our latest development is to use a cast-iron jack on top of the roof and asbestos or transite boards for a hood at the bottom, built practically on the lines of this recommendation. That reduces the weight, and we hope it will give us more satisfaction than any jack we have used up to this time. I think that a jack made entirely of cast-iron of these dimensions would be extremely heavy, and I think some lighter material than cast-iron should be used for the lower part of the jack.

Mr. Raymer:—I wish to call Mr. Fritch's attention to the last sentence of the conclusion: "The material used should be non-combustible and non-corrosive." We have taken into account the proper use of asbestos board, such as you have mentioned. We do not recommend the use of cast-iron.

Mr. L. C. Fritch:—I did not wish to criticise the Committee's report, but simply to give information to the Association.

Mr. A. L. Buck (Canadian Pacific):—The Committee does not recommend or specify the height to which the jack should extend above the roof of the roundhouse.

Mr. Raymer: Your Committee has considered that, but has come to the conclusion that that will depend almost entirely on the construction of the house. In the large jacks the extension feature which causes an increased draft by the use of the jack is lost, so that the object of the large jack is simply to carry the smoke through the roof and the length of the jack is, therefore, determined by the construction of the building. It usually extends four or five feet above the roof.

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis):—I know of a roundhouse with smokestacks at every stall, sixty feet high. I think it is impossible to determine the height above the roof. It depends on local conditions.

Mr. Buck:—I think if the Committee has decided it is impossible to make a recommendation in connection with the general conditions, that ought to be embodied.

Mr. Raymer:—That point is covered in the third paragraph from the bottom on page 15. The full comprehension ot that sentence simply means that the large jacks do not help the draft of the fire. They merely carry the smoke through the roof, so that the length of the jack is not an essential feature other than having it long enough to carry the smoke through the roof.

Mr. Buck:—If it is a fact that the Committee have found that the length of the jack which they recommend is not essential to create a draft, that the jack need only to extend through the roof, then it seems as if it should be embodied in their recommendations, as the practice is largely to build high jacks, and this length is an important factor in the cost of the jacks.

Mr. L. C. Fritch:—This smokejack question is a very live one, and I think that all the information we can get on it is of value. I would like for information to ask the Committee what they would recommend as to the location of the dampers. They say in the flue. Should that be in the body of the flue, or on the sides of the flue? We have lately gone into the practice of taking out the dampers, using an adjustable feature, and we think the less adjustable parts you have in a smokejack the Letter.

Mr. Raymer:—The province of the damper is to prevent the loss or the heat in cold weather. The dampers that we have investigated are hung a little off the center—that is, the supporting bar across the flue opening is off to the center—so that the damper will only open when left to itself, and requires a pull on a rope or a cable to close it. Normally, a damper remains open during mild weather; such jacks as are not in use have their dampers closed. We have discovered it takes about three times as much heat to heat a roundhouse where these large jacks are used, and where there are no dampers furnished, and we have found it desirable to furnish the dampers and put them in place from the point of economy in heating. The dampers are located as low as possible in the flue, above the tapered portion of the jack.

The President:—If there is no further discussion on conclusion No. 2, it will be accepted as approved.

The Secretary:—"Roundhouse Doors—Description and Recommended Practice.—The various designs of roundhouse doors will include the following: Swinging, Rolling, Folding, Lifting and Sliding.

"(a) Swinging Doors.—Have the advantage of being: Comparatively cheap for first cost. Glass can be used in them. Small doors can be built in the larger ones.

"They are, however, exposed to the wind, and liable to be blown against a locomotive and damaged. If struck, they are liable to serious damage.

"(b) Rolling Doors.—Are now made of wood slats or of metal; they cost about sixty cents per square foot erected. Small doors or glass are not placed in the large doors. They are not exposed to damage by wind. If struck, the damaged slats are easily repaired. They fit snugly along the sides and at the bottom.

"(c) Folding Doors.—Are made of wood. Glass and small doors can be used in them. They are not exposed to damage by wind. If struck, they are liable to be seriously damaged.

"(d) Lifting Doors.—Are made of wood. Glass and small doors can be used in them. They are not exposed to damage by wind. If struck, they are liable to be seriously damaged.

"(e) Sliding Doors.—Do not fit tightly; the hangers rust and fail. Glass and small doors can be used in the large ones. One-half of the doors are necessarily closed all the time. They are not exposed to damage by wind. If struck, they are liable to serious damage.

"The tendency to depart from the use of the swinging door, and the introduction of the various kinds of wooden doors of other designs being of such recent date, your Committee has not been able to find a door that has all the virtues and none of the faults of the other doors.

"CONCLUSION.—Your Committee, therefore, has made the following conclusions, and recommends as general principles of practice that—

"Roundhouse doors should be made of non-corrosive material; they should be easily operated, fit snugly, be easily repaired and maintained, and should not be exposed to damage by wind, directly or indirectly, and should admit of the use of small doors.

"The particular kind of door that will suit a given case can be determined only by giving the proper value to the different factors enumerated above."

The President:—If there is no objection, item No. 3 and the conclusion will be considered as being approved. Before relieving the Committee they desire suggestions for work for the coming year.

Mr. J. W. Schaub (Consulting Engineer):—I would like to make a recommendation to the Committee, and that is with reference to the rectangular roundhouse. We have changed that to read "engine house" in every case on our plans, and I think it ought to be adopted by this Committee.

Mr. Wendt:—I would like to offer a motion that the entire report of this Committee, as now presented, be published in the Manual of Recommended Practice.

(The motion was carried.)

Prof. W. D. Pence (Purdue University):—I do not see that the Committee treats of the gradient of the track toward turntable in the circular roundhouse. I should like to ask the Committee what is the practice in that connection. Formerly, with roundhouses having shorter tracks from the turntable outward, it was customary to provide a grade by which engines could be gotten out in case of fire.

Mr. Raymer:—The point raised by Prof. Pence has not been discussed by the Committee. Speaking personally, from my observation and experience, the tracks are usually built with a level grade.

The President:—If there are no further suggestions, the Committee will be relieved with the thanks of the Association.

Mr. Duncan MacPherson (National Trancontinental Railway—by letter):—In item "J," giving the advantages of circular engine sheds, the Committee says that the cubical capacity per stall is comparatively small and therefore heating economical, but in item "K" it tacitly admits the loss of heat from open doors may necessitate roofing over the turntable. This roofing over is very expensive and increases the cubical capacity per stall beyond the rectangular shed, and makes a most difficult building to ventilate. The writer had charge of the roofing of a turntable in this way last year, and after it was done the men in the roundhouse were nearly smothered with gas. All sorts of expedients had to be resorted to to get better ventilation, but with indifferent success. In giving the disadvantages of circular design the Committee surely forgot to say anything about the excessive time required to empty a shed in case of fire, the probable confusion that could ensue, with the usual result of loss of several valuable engines. In the effort to counteract these disadvantages the excessively expensive so-called fireproof sheds have been designed.

Referring to disadvantages which the Committee claims for the through rectangular house, item "A." Suppose, say as an extreme case, that it is necessary to turn all the engines once for a rectangular shed, you practically have to turn them all *twice*, or both coming in and going out, for a circular shed.

(B) Only one "Y" track or turntable is necessary, and engines can run through house on longest diagonal track at all times.

(C) It is not necessary to have doors open at both ends of shed at once, except when two engines are going out or coming in at same time.

(D) Work benches may be put down both side walls and between tracks if necessary.

(E) It is not at all necessary for engines to arrive at one end of shed and depart at the other, which can easily be seen by a study of diagram on page 688 of Proceedings of 1905.

(F) Cost of heating is not so great as with turntable roofed in for circular shed, and ventilation is much easier.

REPORT OF COMMITTEE NO. V.—ON TRACK.

To the Members of the American Railway Engineering and Maintenance of Way Association:

The Committee on Track begs leave to present its annual report as follows:

The general requirements for a standard joint is submitted without change. We did not wish to be specific or undertake to indicate in what particulars the joint should be improved. We think we can all agree on the essential requirements, but differ widely on how best to obtain them. Some members of the Committee believe that with the present pattern of rails a plain heavy angle bar of moderate length used as supported joint will give the best results. We believe that when the idea of anchoring the rail to prevent creeping is divorced from the splice, better results will be obtained.

Two members of the Track Committee met with the Tie Committee in joint session and discussed the subject of spacing and size of ties, as directed by the Board. (For conclusions see Tie Committee report.)

Three members of the Track Committee attended a meeting of the Ballasting Committee October 31, and the result was an agreement on ballast cross-sections that we believe will be very satisfactory. (See Ballasting Committee report.)

At a joint meeting of the Track and Rail Committees in Chicago, August 23, two members of the Rail Committee being present, it was decided that "while the A. S. C. E. section is in the main satisfactory, an improvement upon it might be made by increasing the proportion of metal in the base and reducing that in the head." This conclusion was reached because of frequent breakages starting in the base, and with the heavy sections it was thought the quality of the metal in the head might be improved by slight reduction in depth of head.

This Committee believes that under certain conditions widening the gage on curves is a necessity, not only for safety but for economy, and we recommend the appointment of a committee to confer with a committee of the American Railway Master Mechanics' Association for joint report on necessity and amount to be widened for wheel bases varying by one foot, and curves varying by one degree, and the formula used determining same, to the end that uniformity of practice may be secured.

It is becoming customary to flange all wheels and the wheel bases are being lengthened. Not all roads are fortunate in having light curvature, consequently it frequently happens that with track spiked to standard gage, the flanges impinge against the inner rail of curves, to the detriment of track and engine power. With a given wheel base and wheel gage, one may readily figure what widening the ordinate requires, but it is not always known what variation in wheel gage is allowed nor how much lateral play in the frame. If there is any uniformity followed by locomotive builders in these respects, it should be generally known; if there is none, it should be urged.

In reference to the matter heretofore presented, this Committee urges action on that portion not approved by the Association, viz.: "Maintenance of Gage and Inspection of Track." We beg leave to amend the latter by striking out the second paragraph, namely, "Trackwalker shall be sent over that portion of track not covered by section men," as being superfluous, being covered by preceding paragraph; also in third paragraph strike out "washouts" for same reason. In the fifth paragraph add "telegraph line."

We would like to see a full discussion of standard drilling for rails, feeling that the matter has been passed hastily, more for want of time and opportunity to thoroughly consider it than from a feeling that it is not of sufficient importance.

A highly-esteemed ex-member of this Committee has requested a reconsideration of the formula for elevation of curves on the theory that the centrifugal force of train drawn by a locomotive is not analogous to that of a body moving freely in space. He suggests the method of using the middle ordinate of a chord, whose length equals the speed in feet per second of the fastest passenger train. This gives approximately 20 per cent. less elevation than the formula recommended. The Committee cannot agree with the gentleman for the reason that with the exceedingly high speeds attained the tendency is toward too little elevation instead of too much.

A letter from Mr. H. M. Sternbergh, Vice-President and General Manager of the American Iron & Steel Manufacturing Company, Reading, Pa., calls attention to the fact that with cold-rolled thread the diameter over the thread is a trifle more than $\frac{1}{16}$-in. larger than the body of the bolt; in other words, with bolts called 1-in., the diameter over thread would be slightly more than $1\frac{1}{16}$-in., and suggests that the punching of the round holes in angle bars be $\frac{3}{32}$-in. larger than the diameter of bolt. The Committee distinctly had that fact in mind and the recommendation was that diameter of round hole in splices be 1/16-in. larger than diameter of bolt *over the thread*, and we assume that this will be borne in mind when orders are placed.

*EASEMENT CURVES.

The easement curve recommended is similar to all the transition curves that have been suggested, which are essentially the Froude curve, or cubic parabola. It is reasonably simple to compute and lay out, and is entirely flexible, in that practically any reasonable length of spiral may be used to connect any tangent and curve, or any two adjacent branches of a compound curve.

The spiral is introduced for the purpose of securing gradual change of direction in passing from tangent to curve, or vice versa, and more particularly to secure thereby a uniformly increasing superelevation of the outer rail, which shall be correct at all points. This result is desired for a twofold purpose:

(1) To avoid shock to track and rolling stock;

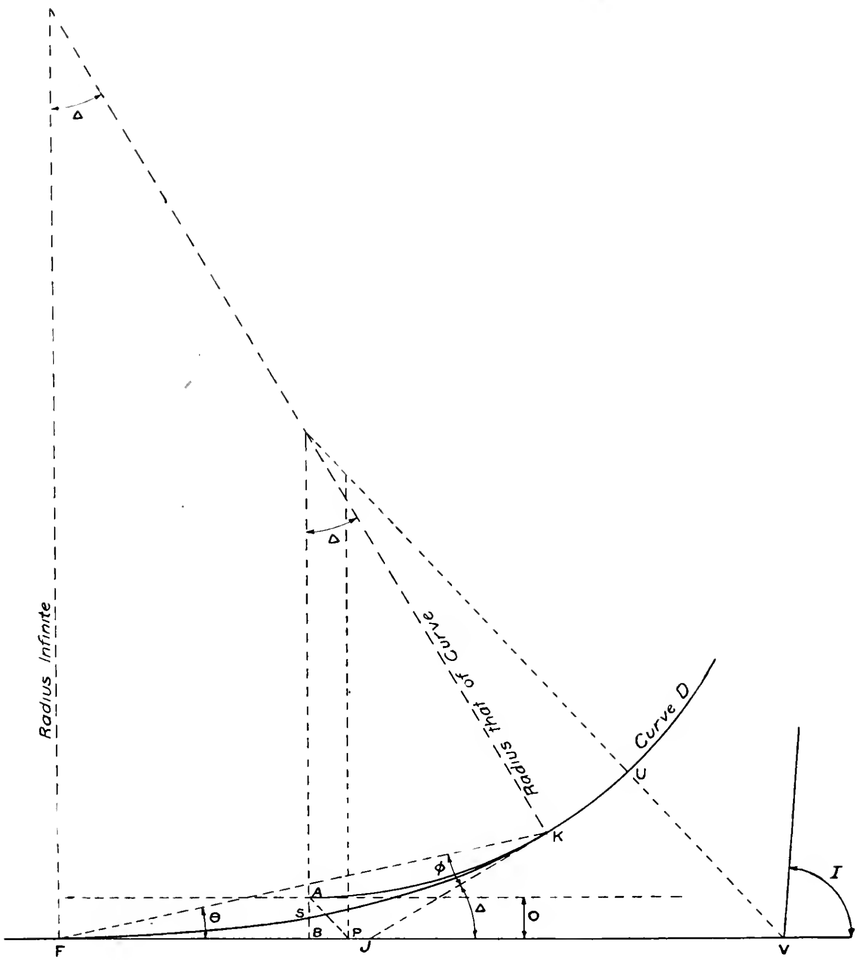
(2) The comfort of passengers.

The conditions of train movement assumed in determining the rate of transition and consequent length of spiral by no means constantly obtain; frequently the length of the spiral will be determined by the practicable track movement.

So far as the comfort of the passenger is concerned, it is unaffected by reasonable changes in the rate of acquiring the elevation of the outer rail, and it is considered that about 1 in 600 will in general give a sufficiently easy transition; that is to say, the length of the spiral should be 600 times the elevation of the outer rail. But any other rate less than this may be assumed, and a rate three or more times as great may be used without serious discomfort of passenger or danger to track or rolling stock. When it is the practicable shifting of track or length of tangent that governs, the rate of transition will be determined accordingly.

In Fig. 1 FSK is the spiral connecting the tangent FV with the simple curve KU of degree D. The radius of the spiral at F is infinite, the degree 0. The radius and degree of the spiral at K are

*The Committee is indebted to Mr. William G. Raymond, dean of the School of Applied Science, State University of Iowa, for assistance in preparing the Easement Curve portion of the report.


Radius Infinite
Radius that of Curve
Curve D
Δ
Δ
Δ
θ
φ
O
I
A
S
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J
F
K
C
V

FIG. 1.

those of the simple curve D. The change in degree being uniform from F to K, the average degree is $\frac{D}{2}$ and the amount of central angle, $\triangle$, required by the spiral, is therefore $\frac{D}{2}$ multiplied by the length FK in stations; or if L be the length in feet of the entire spiral, $\triangle = \frac{LD}{200}$. In minutes $\triangle = 0.3LD$. If d be the degree at any distance l from F, and δ the central angle required for the same length, then $\delta = \frac{l}{100} \times \frac{d}{2}$. But since the change in degree is uniform from F to K, $d = \frac{l}{L} \times D$, and hence, by substitution, $\delta = \frac{l^2D}{200L}$, or, the central angle varies as the square of the length of the spiral.

A theoretical discussion of the curve shows that the deflection angle KFJ = θ always equals one-third the central angle of the spiral. Similarly, the deflection angle Φ at K from the chord FK to the common tangent JK is two-thirds $\triangle$, and the values of the deflection angles for any length of spiral l are respectively one-third δ and two-thirds δ. The error in the foregoing statement of the values of Φ may be as much as one-tenth of a minute when $\triangle = 10°$, four-tenths of a minute when $\triangle = 20°$, a high limit, and one and four-tenths minutes when $\triangle = 30°$, probably never reached.

If the central curve UK be produced till it would end at A in a tangent parallel to FV, the offset AB = O, bisects the spiral and is itself bisected by the spiral, and for locating the curve by offsets it is practically true that the length KA = KS = FS = FB. For a spiral 300 ft. long connecting a tangent and a ten-degree curve the above is true within three-quarters of an inch. In the method of handling the curve by offsets hereinafter described, the assumption that it is exactly true will involve no irregularity in alinement, the most serious result being that the spiral will be about one and one-half inches longer than computed. For a spiral 150 ft. long connecting a tangent and a ten-degree curve, the error will be about one-tenth-inch. A table of corrections is given for use when necessary. The relation between O and L is, $O = \frac{L^2}{24R}$.

The theory of the curve shows that the offsets from the tangent to the spiral at distances l along the spiral are proportional to the cubes of those distances and are equal to $\frac{l^3}{6RL}$.

The offsets between curve KA and spiral KS at various points along the spiral measured from K are the same as the offsets from the tangent FB to the spiral FS measured at corresponding distances along the spiral FS from F.

Since the central angle is proportional to the square of the length of the spiral considered, and since the deflection angle, from tangent to spiral, is always one-third of the central angle, the tangent deflection angle varies also as the square of the length of the spiral.

The foregoing are all the theoretical considerations necessary to the use of the spiral in connecting tangents and simple curves. The method of use is as follows:

(A) New Location.—(1) Selecting the Spiral: In rough country the proper spiral will ordinarily be selected through the value of O, which is determined by fitting the main curve to the ground, the O's at the two ends of the curve not being necessarily equal. When O has been determined within practical limits, L is found from $O = \frac{L^2}{24R}$. If the topography is such that the position of the curve is not fixed, the spiral may be determined by the desirable rate of transition, and for this a length of 600 times the elevation of the outer rail is suggested. A lesser rate may be used for small degree curves, and a higher rate will usually be required for a curve sharper than 10 degrees.

The theoretical length of spirals for one-degree curve, various speeds, and six rates of elevating, are given in Table 1. For central curves of any other than one degree, multiply the tabular quantities by the degree. It will be unnecessary to adopt the precise length thus found. The nearest round number of 25's, 30's or other unit lengths may be assumed. Thus for fifty miles an hour, with a rate of 1 in 600, a six-degree curve requires by the table a spiral 514.8 ft. long; 500 ft. would practically meet the requirement.

By selecting one of the spirals given in Table 2 some computation may be saved.

(2) Location of the Spiral.—(a) By Offsets: If I be the intersection angle of the tangents for the whole curve, the tangent distance VF for the spiral curve may be assumed to be VP (the tangent distance

for an unspiraled curve of degree D), plus PB, (O tan. ½ I), plus BF, (½L). Run the tangent to B; offset O to A; run in the simple curve for the full central angle I; offset O to the following tangent, which may then be produced to the next curve. This will usually be all that is needed at the time of location, though if the ground is very irregular and the offset AB considerable, the levels may require the establishment of points on the spiral. At the time of staking out the work these points should be determined as follows:

Point S established midway between A and B. Quarter points of the spiral may be determined by offsetting from the middle of the tangent length FB and the curve length KA, distances equal to one-sixteenth of O. If other points, as station points, are wanted on spiral, the offsets from tangent to spiral or curve to spiral may be determined if it be remembered that BS is one-half O and that offsets are proportional to the cube of the distances from F or K, respectively. If one of the spirals of Table 2 is assumed, the offsets may be determined by multiplying the tabular quantities of that table by the degree of the central curve.

(b) By Deflection Angles: To find the point of tangency subtract from the tangent distance found under (a) a correction, $c = L^3 \div 128OR^2$, or found from Table 3. Select an aliquot part of the spiral length for a chord and deflect from the tangent at the point F, angles proportional to the squares of the distances measured along the curve, thus: If the chord selected is contained n times in the curve, the first deflection angle will be $\frac{1}{n^2} \times \frac{1}{3} \triangle$. the second will be four times the first, the third nine times the first, and so on, the final deflection angle to K being $\frac{1}{3}\triangle$. Move the transit to K, and from the chord KF deflect an angle equal to $\frac{2}{3}\triangle$ to the tangent at K, from which point run in the simple curve for a central angle equal to I diminished by the central angles of the two spirals. From the tangent at the end of the simple curve deflect to the chord points on the spiral angles found by subtracting from the deflection angles for equal chord lengths of the simple curve the deflection angles already found for corresponding lengths of the spiral measured from F. If one of the spirals given in Table 4 be used, the deflection angles of that table will save some computation. The tabular value should be multiplied by the degree of the central curve.

If a particular station is to be located on the spiral, falling at some plus distance, the deflection to this station may be found if it is remembered that the deflection for the full curve is one-third the central angle, and that deflections are as the squares of the lengths. Since the central angle in minutes is three-tenths LD the deflecting angle is $\frac{1}{10}$ LD.

Example: It is desired to locate a 4° 30′ curve with a spiral. The P. I. is at station 372 + 64; intersection angle 42° 45′, and speed for which track is elevated is 50 miles per hour. Adopting $\frac{1}{600}$ as the rate for elevating Table 1 gives for the length of the spiral $L = 85.8 \times 4\frac{1}{2} = 386.1$ ft., adopt 400 ft.

LOCATION BY OFFSET.

Tangent distance for 4° 30′ curve I = 42° 45′ =		498.46
From Table 2 O for L = 400 = 1.163 × 4½ = 5.234′,	O tan. ½ I =	2.01
From Table 2 △ = 2° × 4½ = 9°.	½ L	= 200.00
		700.47

372 + 64 — 700.47′ =	365 + 63.53 P.S.
	2 + 00.00
Offset point	367 + 63.53
	2 + 00.00
End of spiral	369 + 63.53
	5 + 50.00
End central curve	375 + 13.53
	2 + 00.00
Point of offset	377 + 13.53
	2 + 00.00
End of spiral	379 + 13.53

Length of 4° 30′ curve for 42° 45′ = 9½ stations.

Length deducted for 2 spirals = 4 stations.

Central 4° 30′ curve 5½ stations.

At station 367 + 63.53 offset 5.234′ and run in 4° 30′ curve for 42° 45′ setting sta. 369 + 63.53, 375 + 13.53, and the end of the curve sta. 377 + 13.53, at which offset 5.234′ and proceed with the tangent setting sta. 379 + 13.53 for the end of the spiral. In running in the curve, stakes should be set on the portion to be spiraled as frequently as spiral points are wanted, in this example say each fifty feet, these stakes in addition to be regular station stakes.

To locate points on the spiral, bisect the offset O for the middle point, and at successive 50-ft. points from the point of spiral and end of spiral, respectively, to the middle offset from the tangent and curve point, respectively, the distance taken from Table 2:

$$0.009 \times 4\tfrac{1}{2} = 0.04$$
$$0.073 \times 4\tfrac{1}{2} = 0.33$$
$$0.245 \times 4\tfrac{1}{2} = 1.102$$

The full stations may be set over by eye or omitted altogether. For track centers they will be set over by offset, computed by remembering that the offset for the half spiral is one-half O and that others are proportional to the cubes of the length, or they may again be omitted.

LOCATION BY DEFLECTION ANGLES.

The same computation as before for point of spiral except that the station of P.S. is greater by the correction found from Table 3.

$$0.001523 \times 4.5^2 = 0.03,$$

bringing the point of spiral at station	365 + 63.56
length of spiral	4 + 00.00
End of spiral	369 + 63.56

Deflection computed from Table 4 for 50-ft. points are with the stations corresponding.

End of spiral	=	369 + 63.56
Central curve		5 + 50.00
Beginning of 2d spiral		375 + 13.56
		4 + 00.00
P.T.		379 + 13.56

Angle.	Sta.
$0.625' \times 4\tfrac{1}{2} = 0°\ 03'$	366 + 13.56
$2.5' \times 4\tfrac{1}{2} = 0°\ 11'$	366 + 63.56
$5.625' \times 4\tfrac{1}{2} = 0°\ 25'$	367 + 13.56
$10.000' \times 4\tfrac{1}{2} = 0°\ 45'$	367 + 63.56
$15.625' \times 4\tfrac{1}{2} = 1°\ 10'$	368 + 13.56
$22.5' \times 4\tfrac{1}{2} = 1°\ 41'$	368 + 63.56
$30.625' \times 4\tfrac{1}{2} = 2°\ 18'$	369 + 13.56
$40.0' \times 4\tfrac{1}{2} = 3°\ 00'$	369 + 63.56

At sta. 369 + 63.56, with back sight on P.S., turn 6° 00′ to the tangent and run in the simple curve to sta. 375 + 13.56, where set the transit and from the tangent deflect angles to 50-ft. point on the spiral found by subtracting the angles already found from the deflection for the corresponding distance on the simple curve; the final deflection should be 6° 00′ to the P.T. At the P.T. deflect from the long chord of the spiral 3° 00′ to the tangent. If it is necessary to set on one of the chord points of the spiral, find the degree d of the spiral at that point, knowing its degree is proportional to the length and from the tangent to the spiral at the point occupied, deflect angles to point on the spiral toward the central curve found by adding to the deflection angles for corresponding distance of the simple curve d the tangent deflection angles found for corresponding chord lengths from the P.S. and toward the point of spiral found by subtracting instead of adding these same angles.

(B) The Adjustment of Existing Track: The spiral may in general be selected to fit the required rate of elevating, from which the offset O may be determined. The simple curve should then be shifted and run in with a slightly less radius to secure the offset O with the least shifting of track. Referring to Fig. 2, if the middle point of the curve is retained, the radius to be used is found as follows:

$$E' = E - O \text{ sec. } \tfrac{1}{2} I$$

$$R' = \frac{E'}{\text{ex sec. } \tfrac{1}{2} I}$$

$$\text{or} \qquad D' = \frac{E'}{E \text{ of } 1^\circ \text{ curve}}$$

The point of tangency is moved toward the vertex a distance

$$AA' = (R - R' - O) \text{ tan. } \tfrac{1}{2} I$$
$$= T - (R' + O) \text{ tan. } \tfrac{1}{2} I$$

The greatest movement of track is now somewhat less than ½ O at the new tangent point. Practically it is

$$\tfrac{1}{2} O - \frac{7}{8} \left(\frac{AA'}{100}\right)^2 D$$

The spiral may be run in by deflection angles or offsets from tangent and new curve.

To Connect the Two Branches of a Compound Curve: Consider the difference of the two degrees as the degree of curve in the formula for length and offset O already derived for a spiral between a tangent and a curve; provide the necessary offset O between the two branches at the point of common tangency and locate the spiral by offsets precisely as in locating a spiral from a tangent to a simple curve; the spiral will lie inside the arc of greater radius and outside the arc of smaller radius. If it is desired to locate by deflection angles, those angles, measured at the points of spiral from various chord points on the simple curves are the deflection angles that would be used for the same length of spiral laid out from a tangent. The total central angle consumed will be the average degree times the length in stations.

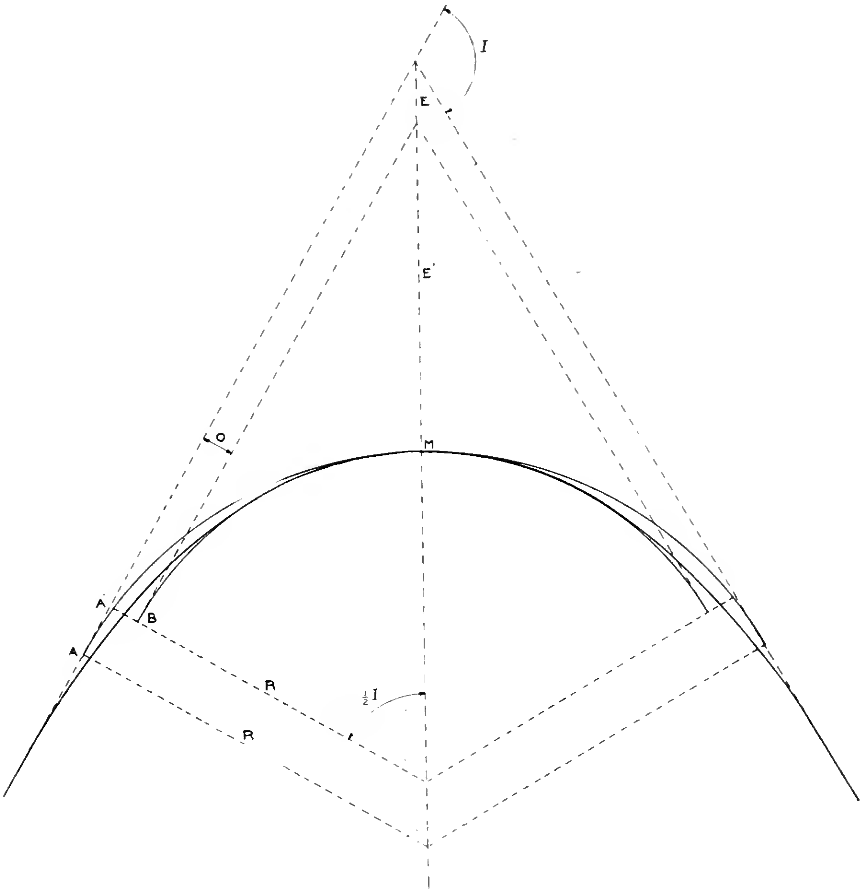

Fig. 2.

TABLE 1.

Rate of Elevating the outer rail	Length of spirals connecting tangent and 1° curve for speeds from 20 to 90 miles per hour and 6 rates of elevating the outer rail. For a D° curve, multiply the tabular value by D.											
	20	25	30	35	40	45	50	55	60	70	80	90
1-100	2.3	3.6	5.1	7.0	9.1	11.6	14.3	17.3	20.6	28.0	36.5	46.1
1-200	4.6	7.2	10.2	14.0	18.2	23.2	28.6	34.6	41.2	56.0	73.0	92.2
1-300	6.9	10.8	15.3	21.0	27.3	34.8	42.9	51.9	61.8	84.0	109.5	138.3
1-400	9.2	14.4	20.4	28.0	36.4	46.4	57.2	69.2	82.4	112.0	134.0	184.4
1-500	11.5	18.0	25.5	35.0	45.5	58.0	71.5	86.5	103.0	140.0	182.5	230.5
1-600	13.8	21.6	30.6	42.0	54.6	69.6	85.8	103.8	123.6	168.0	219.0	276.6

Elevation of outer rail in feet $= \frac{.3273S^2}{R} = e.$ S = speed in miles per hour. R = Radius of curve.

Tabular values = e$\times$ denominator of fraction expressing rate of elevating.

TABLE 3.

Corrections to be subtracted from $\frac{L}{2}$ and L for various spirals connecting tangent and 1° curve to give the half and whole tangent distances of the spirals. For a D° curve multiply the tabular values by D.

	Corrections for half tangent distances	Corrections for whole tangent distances
100	0.000023	0.000736
150	0.000080	0.002560
200	0.000190	0.006080
250	0.000372	0.011904
300	0.000642	0.020544
350	0.001020	0.032646
400	0.001523	0.048732
450	0.002168	0.069385
500	0.002974	0.095179

Formula: $\frac{L^3}{1280\ R^2}$ $\frac{L^3}{40R^2}$

TABLE 2.

L	O	Δ	Values of O, Δ, and tangent offsets to various chord points of spirals of lengths shown in the left column, connecting tangent and 1° curve. For a D° curve, multiply the tabular values by D.																			
			25	50	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500
		° ′																				
100	.073	0—30	.005	.037	.123	.291																
150	.164	0—45	.003	.024	.082	.194	.379	.655														
200	.291	1—00	.002	.018	.061	.145	.284	.491	.781	1.164												
250	.445	1—15	.002	.015	.049	.116	.227	.393	.624	.931	1.326	1.820										
300	.655	1—30	.001	.012	.041	.097	.190	.327	.520	776	1.105	1.517	2.016	2.620								
350	.891	1—45	.001	.010	.035	.083	.162	.280	.445	.665	.946	1.298	1.728	2.243	2.852	3.562						
400	1.163	2—00	.001	.009	.031	.073	.142	.245	.390	.582	.828	1.136	1.512	1.963	2.496	3.117	3.834	4.653				
450	1.472	2—15	.001	.008	.027	.065	.126	.218	.346	.517	.736	1.010	1.344	1.745	2.218	2.771	3.408	4.136	4.961	5.888		
500	1.818	2—30	.001	.007	.025	.058	.114	.196	.312	.465	.662	.909	1.210	1.570	1.996	2.493	3.067	3.722	4.465	5.300	6.233	7.270

Formulas:— $O = \frac{L^2}{24R}$: $\Delta = 0.3LD$ gives Δ in minutes. Tangent offset l feet from P. S. $= \frac{l^3}{6RL}$.

TABLE 4.

L	Δ	Deflection angles in minutes from point of spiral to various chord points on spirals of lengths shown in left column connecting tangent and 1° curve. For a D° curve, multiply the tabular values by D. Formula for deflection angle for length l: $d = \frac{l^2D}{600L}$																			
		25	50	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500
	° ′																				
100	0—30	00.625	02.500	05.625	10.000																
150	0—45	00.417	01.667	03.750	06.667	10.418	15.000														
200	1—00	00.313	01.250	02.813	05.000	07.813	11.250	15.350	20.000												
250	1—15	00.250	01.000	02.250	04.000	06.250	09.000	12.250	16.000	20.250	25.000										
300	1—30	00.208	00.833	01.875	03.333	05.209	07.500	10.210	13.333	16.875	20.833	25.209	30.000								
350	1—45	00.179	00.714	01.607	02.857	04.464	06.428	08.750	11.428	14.463	17.868	21.606	25.712	30.178	35.000						
400	2—00	00.156	00.625	01.406	02.500	03.906	05.625	07.656	10.000	12.658	15.625	18.908	22.500	26.407	30.625	35.158	40.000				
450	2—15	00.139	00.556	01.250	02.222	03.472	05.000	06.805	08.888	11.250	13.890	16.803	20.000	23.470	27.220	31.250	35.555	40.135	45.000		
500	2—30	00.125	00.500	01.125	02.000	03.125	04.500	06.125	08.000	10.125	12.500	15.125	18.000	21.125	24.500	28.125	32.000	36.125	40.500	45.125	50.000

MAINTENANCE OF GAGE.

(a) Proper Method of Spiking:

(1) The gage (tool) used shall be the standard gage recommended.

(2) When track is intended to be spiked to standard gage the rail shall be held against the gage with a bar while the spike is being driven.

*(3) Within proper limits a slight variation of the gage from standard is not seriously objectionable, provided the variation is uniform and constant over long distances. Under ordinary conditions it is not necessary to regage such track when the increase in gage has not amounted to more than three-eighths of an inch.

(4) All spikes shall be started vertically and square, and so driven that face of spike shall come in contact with base of rail; the spike should never have to be straightened while being driven.

(5) Outside spikes of both rails shall be on the same side of the tie, and the inside spikes on the opposite side of the tie. The inside and outside spikes shall be separated as far apart as the face and character of the tie will permit. The ordinary practice shall be to drive the spike 2½ in. from the outer edge of the tie. All old spike holes must be plugged.

INSPECTION OF TRACK.

(1) Except in case of roads of very light traffic, all main track shall be inspected each day by section gang or trackwalker.

(2) Trackwalker or patrol shall be sent out in case of storm, etc., and during the period when slides or falling stone, etc., are to be expected.

(3) The trackwalker shall be provided with spike maul, spikes and proper signals.

(4) His duties shall be to carefully inspect the track, roadway, fences, gates, bridges, culverts and telegraph line, and in general guard against all damage or danger to any railroad property.

(5) In case of trouble he will place torpedoes and other danger signals a sufficient distance to protect trains, and will notify proper officers from the nearest possible point.

(6) Supervisor or Roadmaster shall be required to go over the whole of his district on foot or on handcar at least once every month, making close inspection of all details.

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*See amendment, page 656.

CONCLUSIONS.

Your Committee recommends the adoption of the following conclusions:

(1) That a standard rail joint must fulfill the following general requirements:

(a) It must connect the rails into a uniform continuous girder.

(b) It must be strong enough to resist deformation or taking permanent set.

(c) It must prevent deflection or vertical movement of the ends of the rails and permit movement lengthwise for expansion.

(d) It should be as simple and of as few parts as possible to be effective.

(e) Finally, its cost must not be prohibitive.

(2) That a committee be appointed to confer with a committee of the American Railway Master Mechanics' Association for a joint report on the necessity of widening the gage on curves, and the amount to be widened for wheel bases varying by one foot and for curves varying by one degree, with the formula used in determining the same, to the end that uniformity of practice may be secured.

(3) That the recommendations under Maintenance of Gage and Inspection of Track be approved.

(4) That the Easement Curve formula submitted be approved as being good practice.

Respectfully submitted,

Garrett Davis, District Engineer, Chicago, Rock Island & Pacific Railway, Cedar Rapids, Ia., *Chairman*.

E. H. Lee, Chief Engineer, Chicago & Western Indiana Railroad, Chicago, Ill., *Vice-Chairman*.

Wm. Ashton, Chief Engineer, Oregon Short Line, Salt Lake City, Utah.

J. R. W. Davis, Engineer Maintenance of Way, Great Northern Railway, St. Paul, Minn.

G. E. Drew, Civil Engineer, Los Angeles, Cal.

T. H. Hickey, Roadmaster, Michigan Central Railroad, St. Thomas, Ont.

D. MacPherson, Assistant Chief Engineer, Transcontinental Railway, Ottawa, Canada.

F. L. Nicholson, Engineer Maintenance of Way, Norfolk & Southern Railroad, Norfolk, Va.

O. D. Richards, Chief Engineer, Ann Arbor Railroad, Toledo, O.

L. S. Rose, Engineer Maintenance of Way, Cleveland, Cincinnati, Chicago & St. Louis Railway, Mattoon, Ill.

John C. Sesser, Engineer of Construction, Chicago, Burlington & Quincy Railroad, Centralia, Ill.

F. A. Smith, Editor *Roadmaster and Foreman*, Chicago, Ill.

F. J. Stimson, Engineer Maintenance of Way, Grand Rapids & Indiana Railway, Grand Rapids, Mich.

Committee.

AMENDMENT.

Amend paragraph 3, Maintenance of Gage to read: "Under ordinary conditions it is not necessary to regage track if the increase in gage has not amounted to more than three-eighths-inch, provided such increase is uniform."

DISCUSSION.

The President:—Mr. Garrett Davis, chairman of the Committee on Track, will present the report of the Committee.

Mr. Garrett Davis (Chicago, Rock Island & Pacific):—Gentlemen, the report is before you. The only explanation I care to make now is in reference to the easement formula. The Committee was requested to recommend a formula. The formula presented is not very different from a number of others that have been published. We do not claim it has any new matter in it. The idea of the Committee was not to recommend any particular curve to the exclusion of several others that might be equally good.

The President:—The chairman of the Committee desires that the conclusions be taken up in their order. The Secretary will read them.

The Secretary:—"(1) That a standard rail joint must fulfill the following general requirements:

"(a) It must connect the rails into a uniform continuous girder.

"(b) It must be strong enough to resist deformation or taking permanent set.

"(c) It must prevent deflection or vertical movement of the ends of the rails and permit movement lengthwise for expansion.

"(d) It should be as simple and of as few parts as possible to be effective.

"(e) Finally, its cost must not be prohibitive."

Mr. Edwin F. Wendt (Pittsburg & Lake Erie):—I move the adoption of the conclusion.

Mr. A. L. Buck (Canadian Pacific):—In regard to clause (b), does that mean strong enough to resist cutting by abrasion? Many angle-bars are made too soft and are ruined by abrasion and by binding. We have in use a high carbon bar that is giving excellent results. I mention this as many might think that a high carbon bar would be liable to break.

Mr. Davis:—I take it that there will not be much abrasion if there is no movement, and if the joints are kept tight there is not much movement.

The President:—Are you ready for the question on the adoption of the conclusions?

Mr. Wendt:—My understanding is that the motion merely includes conclusion No. 1. Is that correct?

The President:—The chair did not so understand it. Was that your intention?

Mr. Wendt:—Yes.

(The motion was carried.)

The Secretary:—"(2) That a committee be appointed to confer with a committee of the American Railway Master Mechanics' Association for a joint report on the necessity of widening the gage on curves, and the amount to be widened for wheel bases varying by one foot and for curves varying by one degree, with the formula used in determining the same, to the end that uniformity of practice may be secured."

Mr. Wendt:—I do not mean to say that I am not in favor of that conclusion, but it seems to involve another special committee. Is that desirable, or could the Committee on Track act as such committee?

The President:—It could be a sub-committee formed from the Track Committee.

Mr. Geo. W. Kittredge (Cleveland, Cincinnati, Chicago & St. Louis):—The question brought up in that conclusion is of considerable importance. The question has been up between the mechanical and engineering departments of the system of roads with which I am connected, and it is one which deserves the careful consideration of this Association. It is entirely within the province of the Board of Direction to say whether a sub-committee shall be appointed, or whether that question shall be discussed by this Committee. I would like to urge as a part of the work of the proposed committee this question of widening the gage on curves.

Mr. Wendt:—I am in favor of this conclusion. I think, however, that we have enough committees. I think the Board of Direction should appoint this committee, and if any persons are appointed on the committee outside of the membership of the Track Committee, that they be considered a part of the general committee.

The President:—The tenor of Mr. Wendt's motion is that the Board of Direction appoint this sub-committee; that it preferably be taken from the Track Committee; but if in their opinion a portion of the membership be taken outside of the Track Committee, that those additional members be considered a part of the Committee on Track.

Mr. C. H. Ewing (Philadelphia & Reading):—I would amend that motion and have this same committee include in their report the matter of all flanged drivers, as to their action on track, and as to the necessity for motive power people to space the middle drivers farther apart than the two end drivers. I think they should go into this whole subject and make a report to this Association.

Mr. Kittredge:—The question brought up by Mr. Ewing was the one I had in mind. We have recently received some new engines, and all of the driving wheels have flanges on them. We have had more or less trouble with them on curves that are sharper than six degrees. The leads of some of our shorter turnouts have been affected, and the leads back of the frogs have been so spread by the passage of these engines over them that cars following have been derailed. The question is important, not only from the standpoint of maintenance but from the mechanical standpoint. I recently saw a report from our mechanical department, saying that one of the wheels had been loosened on account of the tightness of the gage of our track, laying the fault entirely on the track. The ties were new and happened to be made of oak and securely spiked, and something had to give.

(The motion, as amended, was carried.)

The President:—The action now reverts to conclusion No. 2. If there is no objection, the conclusion will stand as amended.

The Secretary:—"(3) That the recommendations under Maintenance of Gage and Inspection of Track be approved.

"Maintenance of Gage.—(a) Proper Method of Spiking: (1) The gage (tool) used shall be the standard gage recommended.

"(2) When track is intended to be spiked to standard gage the rail shall be held against the gage with a bar while the spike is being driven.

"(3) Within proper limits a slight variation of the gage from standard is not seriously objectionable, provided the variation is uniform and constant over long distances. Under ordinary conditions it is not necessary to regage such track when the increase in gage has not amounted to more than three-eighths of an inch.

"(4) All spikes shall be started vertically and square, and so driven that face of spike shall come in contact with base of rail; the spike should never have to be straightened while being driven.

"(5) Outside spikes of both rails shall be on the same side of the tie, and the inside spikes on the opposite side of the tie. The inside and outside spikes shall be separated as far apart as the face and character of the tie will permit. The ordinary practice shall be to drive the spike 2½ in. from the outer edge of the tie. All old spike holes must be plugged.

"Inspection of Track.—(1) Except in case of roads of very light traffic, all main track shall be inspected each day by section gang or trackwalker.

"(2) Trackwalker or patrol shall be sent out in case of storm, etc., and during the period when slides or falling stone, etc., are to be expected.

"(3) The trackwalker shall be provided with spike maul, spikes and proper signals.

"(4) His duties shall be to carefully inspect the track, roadway, fences, gates, bridges, culverts and telegraph line, and in general guard against all damage or danger to any railroad property.

"(5) In case of trouble he will place torpedoes and other danger signals a sufficient distance to protect trains, and will notify proper officers from the nearest possible point.

"(6) Supervisor or Roadmaster shall be required to go over the whole of his district on foot or on handcar at least once every month, making close inspection of all details."

Mr. Ewing:—We have always required the trackwalker to see that bolts are tight. I notice that nothing is said about the trackwalker carrying a wrench. Is that purposely omitted?

Mr. Davis:—That was omitted because we did not want to load him down with tools. He is to carry a spike maul so that he can spike a broken rail if he finds one.

Mr. A. R. Raymer (Pittsburg & Lake Erie):—Has the Committee taken up this matter of duties of trackwalker with the Committee on Uniform Rules?

Mr. Wendt:—The Committee on Uniform Rules presented to the Association a series of rules defining the duties of Supervisor of Track. Would it therefore not be proper to refer rule 6, under inspection of track, to that committee? In addition to that it is quite probable that the Committee on Uniform Rules will also formulate rules defining the duties of section foremen.

The President:—Does the chair understand that you make that in the form of a motion, that the rules governing the inspection of track be referred to a joint conference?

Mr. Wendt:—I always think the committees are expert on these things and I like to defer to their judgment.

Mr. Davis:—The Committee agrees with Mr. Wendt. If there is a committee getting up a book of rules, there should not be any dissent. We should defer to them, or they should accept these.

Mr. Ewing:—Before we adopt these rules I would like to make a motion to include the wrench.

The President:—There is now a motion before the house. You can amend it if you wish.

Mr. Ewing:—I would offer an amendment that "wrench" be added to the tools to be carried by the trackwalker.

Mr. Davis:—Before we come to any conclusion, I would like to ask if the trackwalker is to be required to carry additional tools?

Mr. W. M. Camp (Railway and Engineering Review):—If he is walking track at night he ought to have a lantern, and during a snowstorm he ought to carry a broom to keep the switch points clear. I think the rules should be flexible enough to permit the trackwalker to arrange his kit to meet the different conditions which arise. In practice, trackwalkers have an assortment of tools which they are supposed to carry at various times, as requirements may determine. The tool most used is a wrench, to keep joint bolts tight. A spike maul is useful when spread spikes are found on curves, as then the rail can be temporarily spiked to approximate gage, pending the arrival of the section crew to put the track to proper gage, plug the holes where spikes are pulled and put on rail braces, to make things secure. But it should not be necessary to carry a hammer or maul every trip, since if the liability of track to spread were that great the general condition of things would be dangerous for the trackwalkers alone to guard. In almost every case the spreading of spikes is a gradual process, and when the trackwalker observes that spreading has started, or that a tendency to such is developing, he can carry a hammer and spikes on the next trip to double-spike some of the ties and then notify the section foreman of the matter.

As a rule, one tool at a time is all that a trackwalker should be expected to carry, since it is too seldom that the need for any tool at all is urgent. The object in requiring him to carry tools is that he may employ himself while waiting for trains, and, generally, to do occasional work which is of too trifling character to require the attention of the section crew—such, for instance, as to tighten an occasional loose nut at a joint, remove small quantities of mud or debris from ditches (requiring the use of a shovel), nail on a loose fence wire or board, "bleed" the water from the end of a tie after a rainstorm, etc. Theoretically, the trackwalker is supposed to do considerable work with tools, but practically such is not the case. While he is within range of the section foreman's vision he will engage himself briefly, in a perfunctory manner, but for the most of the time he walks along keeping his eyes open for defects in the track and casting side glances to note the condition of things between the right-of-way fences; and these are his really important duties. It helps appearances to have him carry a tool of some kind, and indicates that he is equipped for some kind of work. If he is overburdened with tools he will be obeying the rule if he simply carries them, and that is about all he will do. Under ordinary circumstances a night trackwalker should not be required to carry more than his lantern and signals.

Mr. H. C. Griswold (Illinois Steel Company):—I think it is a good plan to have the trackwalker carry a tamping pick as well.

Mr. Ewing:—Under this rule, the only tools the trackwalker carries are those that permit him to do certain work in case of a broken rail. That happens perhaps once a month or once a year. At other times the trackwalker is a mere figurehead. If he finds loose bolts on the joints, he is powerless to do anything. We have all condemned trackwalkers for not keeping the bolts tight. It seems to me it would be a great mistake to leave this off.

Mr. Camp:—I do not think the rules of any road will allow a trackwalker to run over a broken rail without first being flagged and then to proceed slowly until the break is passed. If a rail is broken over a tie it might be of some service to spike the ends to hold the alinement, if on a curve, but if the break occurs between ties a spike maul is of no account. In any case the most efficient equipment for making safe at a broken rail would be a track drill and a pair of splice bars, but a trackwalker would not be supposed to carry any such load as that. It is only idle to propose that a trackwalker can make repairs of consequence in the case of a broken rail or equivalent dangerous conditions of the track. In all such emergencies he is supposed to stop and warn trains and call out the section crew. The carrying of tools is therefore a matter quite aside from his principal duties.

Mr. L. C. Fritch (Illinois Central):—I would like to suggest that we substitute for the words "spike maul and spikes" the words "necessary tools" and let each railroad company regulate it for itself.

The President:—The question is on the amendment to the original motion.

(The amendment was lost.)

Mr. Wendt:—It is my understanding, when these are referred to the Committee on Uniform Rules, that that committee will bring them in next year, and if they see fit to make modifications in accordance with the discussion, they will have the privilege of doing so, and that we are not now endeavoring to adopt these rules.

The President:—That is the way the chair understands it.

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis):—I will vote in opposition to the proposed amendment on the ground that the Committee on Uniform Rules will from time to time find rules scattered through every committee report, from which they will select those particularly referring to their duties. The Committee on Uniform Rules should have nothing whatever to say in regard to tools the track-walker should carry. It will be impossible for this Association to differentiate between the different committees, where they merge into each other. I think this conclusion ought to stand as it is.

The President:—The motion is on Mr. Wendt's suggestion that the six rules coming under inspection of track be referred to the Committee on Uniform Rules for joint conference with the Track Committee.

(The motion was lost.)

The President:—This leaves the rules before the convention for action. The motion was to refer this to another committee for joint conference. Does the convention desire to take any action upon this conclusion?

Mr. G. B. Woodworth (Chicago, Milwaukee & St. Paul):—I would like to make an amendment to paragraph 3 and substitute one-quarter-inch in place of three-eighths-inch as the limit of increase of gage. I think three-eighths-inch too great.

Mr. A. S. Baldwin (Illinois Central):—I think there is a decided tendency in that paragraph 3 to minimize the importance of accurate gaging, and I would consider a track three-eighths of an inch out of gage as being in very bad gage. I believe there should be a standard gage on every road by which all gages should be tested before being sent out, and any such variation as three-eighths of an inch should be considered quite a serious matter. I think if that rule were revised by the omission of the first three lines, so as to make it read, "Under ordinary conditions it is not necessary to regage track, when the increase in gage does not amount to more than three-eighths." I would put it "three-eighths-inch, provided the track is uniform."

Mr. Buck:—It has not been many years since there were two gages of track—one 4 ft. 8½ in. and one 4 ft. and 9 in.—and in some instances a single railway system employed both gages. It is my recollection that at one time the Pennsylvania Lines East employed one of these gages, while the Pennsylvania Lines West employed the other. The wheel gages being built uniform, the rolling stock was used without any trouble interchangeably over the entire country, so that the last speaker's remarks would be hard to reconcile with such a variation in the gage. I think the Committee's limit of three-eighths of an inch before requiring regaging is about right, as this would apply in good practice only on curves from rails becoming flange-worn. Good practice would rectify a gage one-eighth of an inch wide if this width was the result of the track forcing the spikes back or spreading.

Mr. L. C. Fritch:—I agree with Mr. Baldwin and Mr. Woodworth that we should reach an accurate gage. I will answer the argument of the gentleman who just spoke by saying that when two different gages were in effect we had more trouble with broken flanges than we have now with one gage, and many roads went to considerable expense to change their gage from 4 ft. 9 in. to 4 ft. 8½ in.

Mr. Baldwin:—I worked for a number of years with a company that had a 4-ft. 9-in. gage and handled 4-ft. 8½-in. equipment, and so great was the trouble from chipping of flanges and striking guard rails that that gage was abandoned and that road went to 4 ft. 8½ in. I know that the Committee that has been appointed by the Master Car Builders' thinks a difference of three-eighths-inch will be found to be a very serious matter.

Mr. L. C. Fritch:—There is a question now up before the Master Car Builders' Association of increasing the flange of the wheels one-eighth-inch. The maintenance of way people are opposed to the increase in the size of the flange, but I think the time will come when the flanges will be increased nevertheless; and I think the proposed joint committee would reach that question when they take up the other questions in regard to the widening of gage. If the size of the flange is increased it will make more necessary this refinement of gage, and I think we should reduce that to one-fourth instead of three-eighths of an inch.

Mr. Ewing:—I think the condition that should govern us in this matter is the distance that the guard rail is set from the running side of the opposite rail. In revising our rules recently we have provided that the distance from the running side of the guard rail to the running side of the opposite rail is 4 ft. 6¾ in., if the track is on a curve, and three-eighths-inch around the curve. It does not make any difference if you maintain the 4 ft. 6¾ in. distance, the throat between the guard rail and the main rail should not be the governing feature in this matter. It is the fixed distance as mentioned which conforms to the Master Car Builders' rules.

Mr. Robert Trimble (Pennsylvania Lines):—I think Mr. Baldwin is correct in his remarks about accurate gaging. I do not think we should pass any rule which would allow a great deal of variation in the gage. On the Pennsylvania Lines West we have had both gages, and we are in the transition stage. The probability is that we have a considerable mileage yet of 4 ft. 9 in., but as fast as we lay new rail, we are coming to 4 ft. 8½ in.

Mr. Davis:—The Committee is not indifferent to this matter. I do not think there is a gentleman present who will countenance the laying of track three-eighths of an inch wide. What the Committee had in mind was in curve wear or from the use of imperfect gage, which might occur, it would not be considered unsafe to have one mile or one hundred miles of track uniformly three-eighths-inch wide gage.

Mr. Baldwin:—The point I object to is the tendency of this paragraph to minimize the importance of accurate gaging. I move that the article be revised by omitting the first three lines, making it read, "Under ordinary conditions it is not necessary to regage track, if the increase in gage has not amounted to more than three-eighths of an inch, provided such increase is uniform."

(The motion was carried.)

The President:—If there is no further discussion on conclusion No. 3, it will be considered adopted.

The Secretary:—"(4) That the Easement Curve formula submitted be approved as being good practice."

Mr. G. H. Bremner (Chicago, Burlington & Quincy):—I do not exactly understand what this carries with it. There are several tables here. They are not formulas, but are made from the formula. If this carries with it the idea that these tables are good practice, I would not want to agree to that, especially table 1. If I understand the meaning of the first column—the rate of elevating the outer rail—the minimum rate of elevation in this table is one foot of raise in an elevation of 600 linear feet, and that is the lowest raise that is allowed. The old section man's rule for putting in elevations on the approaches to curves was half an inch in 30 ft.; that is, one in 720, and we have practically been following that on our road on our transition curves, and we find, on the high-speed track, that that does not give us enough room to get our trains over the transition curves without feeling the jar of the raise. In a mountainous country, or on slow-speed track, this would be all right, but in a prairie country where we have high speed and small curvature, I would strongly advocate longer transition curves.

Mr. Davis:—The Committee makes no objection to that. The table can be extended. We thought 1 in 600 was approaching the maximum, and probably would not be exceeded often.

The President:—Does the chair understand, Mr. Bremner, that your remarks are in the nature of an objection to the adoption of the formula?

Mr. Bremner:—Not to the adoption of the formula, but if the adoption of the formula carries with it the adoption of these tables as good practice, I would object to that. Conclusion No. 4 approves it as good practice. It seemingly carries with it that the tables are good practice. I would want about three times as long curves as they have here.

Mr. Davis:—The tables can be extended.

Mr. Bremner:—As long as it is understood, I do not raise any objection.

The President:—If there is no further objection, conclusion No. 4 will be accepted as approved.

Mr. C. D. Purdon (St. Louis & San Francisco—by letter):—Referring to the Manual of Recommended Practice, page 37, in regard to easement of curves, provides that the length of the easement curve should be the same distance in which the elevation is run out. This, of course, is theoretically correct, but our experience is that it does not make smooth riding track. Attached hereto is a lithograph of our rules for curve elevation. This was adopted after experimenting for over two years in putting up curves at the foot of steep hills until we got them to riding as nearly perfect as possible. It will be noticed that we elevate one inch per degree of curve, with one additional inch to the curve. For instance, a 4-degree curve would have a maximum elevation of 5 in., and this extra inch is put in the track outside of the easement curve on two rail lengths of the tangent. The fourth clause on page 39 also applies to this point.

Page 39, under the heading of "Vertical Curves." The first paragraph does not seem correct. The use of vertical curves to connect changes in gradient are so obvious as to require no argument. It would seem that the word "advantage" instead of "use" would be better.

Page 41, "Standard Drilling for Rails." As the standard is for rails only, and no recommendations are made for angle bars or for splices, would it not be well to make the distances from the end of the rail to the center of the first hole 2½ in. instead of $2\frac{13}{32}$? Each person then would design his angle bars to suit his own ideas of the expansion required.

RULES FOR CURVE ELEVATION—FRISCO SYSTEM—MAIN LINE.

On main lines, curves will be elevated one inch per degree of curve with a maximum elevation of 6 in.

When the curve is at, or near the bottom of a grade, where trains run fast, add one inch elevation to each curve; viz., elevate a 3-degree curve, 4 in., 4-degree curve, 5 in., etc. Maximum elevation in this case to be 7 in.

On main lines, ballasted, spiral easement curves will be used at ends of all curves sharper than 2 degrees 30 min.

The spiral curve will be taken one-half from the original curve and will be marked by a round stake opposite each end—a square one, being set opposite the old P.C. or P.T. of original curve. When spirals are used, the elevation should begin on the tangent, two rail lengths before reaching the beginning of the spiral, and be one inch at the beginning of the spiral—then increase one inch in 30 ft. until the full elevation is attained at the end of the spiral.

For instance; a 5-degree curve should be elevated as shown on the diagram.

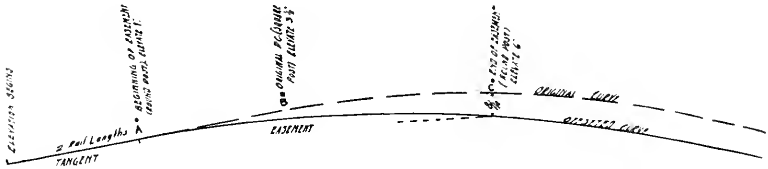

Diagram of easement for 5° curve—offset 0.8 ft.
Length " " A to B 75 ft.
" " " B to C 75 ft.

At top of long grades, where speed is sensibly reduced, elevation to be ¾-in. per degree of curve, maximum 5 in. On Dixon, Hancock, Boston and Winding Stair Hills, elevation to be ½-in. per degree, with maximum of 5 in. This ½-in. elevation should be used within ¼ mile of crossings of other roads, when the crossing is not interlocked.

On branch lines, curves will be given an elevation of ¾-in. per degree of curve, with maximum of 5 in.

The full elevation should be given at the ends of the curves and the easement run out on the tangents at the rate of one rail length for each inch of elevation in the curve. In compound curves, the easement of the sharper curve to be carried back in the flatter curve as far as necessary to reach the elevation of the flatter curve. In special cases, special instructions will be given.

REPORT OF COMMITTEE NO. XIII.—ON WATER SERVICE.

To the Members of the American Railway Engineering and Maintenance of Way Association:

The last two reports of your Committee covered pretty generally the subject of water softening for locomotive boilers.

The report of the Committee for 1904 considered:

(1) The Kinds of Water used in Railroad Boilers.

(2) Character of the Impurities found in Boiler Waters.

(3) The Treatment of Boiler Water.

The report of the Committee for 1905 considered:

(1) Water-Softening Methods and Plants for Various Conditions.

(2) Comparison of the Cost of Installing and Operating Water-Softening Plants.

(3) General Conditions under which the Installation of a Water-Softening Plant would Produce Savings.

The Committee this year has confined its work entirely to the collection of data and statistics from American railroads that have installed water-softening plants. At the request of the Committee the Secretary of the Association wrote to every American railroad that was known to have installed water-softening plants, and asked for certain information. The Committee thinks that the information thus collected should be of value to the Association, as showing the extent to which American railroads have gone into the softening of water for their locomotive boilers, as well as indicating some of the beneficial results that the railroad companies have derived from the use of softened water. The members of the Association will probably note that the information in regard to the water-softening plants on some of the railroads is very meager. The Committee regrets that such is the case, but the information given is all that was furnished by the officers of these railroads. The lack of data in some cases is undoubtedly due to the fact that these railroads have not had their water-softening plants in operation long enough to collect any data.

The Committee begs to submit the following information:

ATCHISON, TOPEKA & SANTA FE RAILWAY SYSTEM.

Nearly all kinds of water are embraced in the general boiler water supply of the Santa Fe.

They have sixty-five plants in operation. The oldest of these has been in service for two years and six months.

The capacity of their plants varies from 40,000 gallons per twenty-four hours for the lowest, to 450,000 gallons per twenty-four hours for the highest. The average capacity is given as 50,000 gallons per twenty-four hours. The cost of softening water at these plants varies from .7 of a cent to 14 cents per 1,000 gallons, the average cost being 3.5 cents per 1,000 gallons.

Among the beneficial results from the use of softened water, they report a very decided decrease in engine failures due to boiler troubles, resulting in reduction in payrolls of boilermakers and helpers; reduction in the number of flues used; increase in time between shoppings (about 100 per cent.), and increased ton mileage of locomotives. Some of the districts where water is softened now show but from one to three engine failures per month from boiler troubles, where before softening the water they had this many failures every twenty-four hours.

BALTIMORE & OHIO RAILROAD.

The character of the boiler water supply of the Baltimore & Ohio Railroad is, generally speaking, good, though in the coal and oil regions the waters contain large amounts of corrosive solids and some free sulphuric acid.

They have two plants in operation. One of these has a capacity of 20,000 gallons, and the other 100,000 gallons per hour. These plants have been in operation about two months.

The cost of softening is .7 of a cent per 1,000 gallons, but the raw water was then in the best condition. The cost will increase in dry seasons.

They report that the scale is falling off of the flues of the boilers that are using the softened water. Also they notice absence of foaming and pitting since the plants were started.

BUFFALO, ROCHESTER & PITTSBURG RAILROAD.

The Buffalo, Rochester & Pittsburg has one water-softening plant. It has been in service two years, and has a capacity of 600,000 gallons per day.

They state that they notice an improvement in the condition of boilers using this water.

CENTRAL RAILROAD OF NEW JERSEY.

The general character of the boiler water supply on this road is reported as poor. They have installed one water-softening plant, which has been in service since September 1, 1904. The capacity of this plant per day is 240,000 gallons.

They find that the use of softened water in their locomotive boilers eliminates a considerable amount of incrusting solids, and improves the operation of their locomotives.

CHESAPEAKE & OHIO RAILWAY.

This company has one water-softening plant in operation. It has been in service one year. Its capacity is 5,000 gallons per hour. The cost of softening water at the plant is 4.19 cents per 1,000 gallons.

They report that the use of softened water has reduced leaky flues and boiler seams to a minimum.

CHICAGO & EASTERN ILLINOIS RAILROAD.

This road has ten water-softening plants in operation and three in process of construction. The character of the boiler water supply of this road is very poor.

The cost of softening runs from one to three cents per 1,000 gallons, with an average of two cents. The capacity of their plants varies from 10,000 gallons per hour to 25,000 gallons per hour, averaging 15,000 gallons. The oldest of the plants has been in operation about two months, so that they have not yet demonstrated the beneficial results of using treated water.

CHICAGO & NORTHWESTERN RAILWAY.

.The water supply along the line of this road varies from very good to very bad. Many of the waters contain a large quantity of scale-forming matter, and some of them, taken from running streams, contain mud and other matter in suspension at certain seasons.

The Northwestern has twenty-five water-softening plants in operation, the oldest of which has been in service three and three-quarters years.

The capacity of the plants varies from 120,000 to 800,000 gallons per twenty-four hours, the average being 300,000.

The cost of softening water at these plants is .8 of a cent for the lowest, to 3.4 cents for the highest—the average being 1.8 cents per 1,000 gallons.

Chemical analyses of the waters, before and after treatment, show that the incrusting solids are reduced so that the quantity left in the softened water is approximately from three to five grains per gallon.

Some of these waters before treatment contain approximately forty to fifty grains per gallon of scale-making material.

The officers of the Mechanical Department, who have charge of the locomotives on the divisions where the water-softening plants are located, as well as the Superintendents of these divisions, say that the use of the softened water has been of great benefit in the economical handling of trains and maintenance of locomotives. Statistics showing the cost of operation in the districts where the plants are installed indicate that they have been the direct cause of saving in the cost of repairs to locomotive boilers.

CHICAGO, BURLINGTON & QUINCY RAILWAY.

The water supply of this railroad varies between wide limits. They have five water-softening plants in operation, the oldest of which has been in service for four years.

The capacity of their plants ranges from 8,000 to 30,000 gallons per hour—averaging 15,000 gallons. The cost of softening is 1.2 cents per 1,000 gallons for the lowest; 2.6 cents per 1,000 gallons for the highest, an average of 1.7 cents per 1,000 gallons.

They report a decrease in boiler failures on road, decrease in flue work, and some decrease in washing, due to the use of softened water.

CHICAGO, MILWAUKEE & ST. PAUL RAILWAY.

The general character of the boiler water supply on the Chicago, Milwaukee & St. Paul Railway varies from very good to very bad, and they have both alkali and incrusting waters.

They have one water-softening plant in operation, which has a capacity of 4,000 gallons per hour, and the cost of treatment is 13.6 cents per 1,000 gallons.

They report benefits derived from the use of softened water, as illustrated in the case of an engine which required work on flues each week before the installation of water-softening plant. This engine was supplied with soft water exclusively after erection of plant, and ran for six weeks without needing any such work.

CHICAGO, ROCK ISLAND & PACIFIC RAILWAY.

The character of the boiler water supply of the Chicago, Rock Island & Pacific Railway is variable, the solid matter dissolved in the waters ranging from six to one hundred and fifty grains per gallon.

They have installed fifteen water-softening plants, the oldest of which has been in service twenty-one months. The capacity of these plants varies from 4,200 gallons per hour for the lowest, to 15,000 gallons per hour for the highest, with an average of 8,400 gallons per hour.

The cost of softening varies from 3.1 to 14.9 cents per 1,000 gallons, the average being 12.2 cents per 1,000 gallons.

They report that the use of softened water has increased the engine miles between washings, reduced engine failures on account of leaky flues and staybolts, and materially reduced the cost of repairs to locomotives.

CHICAGO, ST. PAUL, MINNEAPOLIS & OMAHA RAILWAY.

The general character of the water on this road ranges from very good to very bad.

They have nine water-softening plants in operation, the oldest of which has been in service four years. The cost of softening water varies from 1.3 cents per 1,000 gallons to 3.9 cents, the average being 2.1 cents per 1,000 gallons.

They report a decrease in repairs to boilers, and a marked improvement in the handling of trains in the district where the plants are in operation.

DELAWARE, LACKAWANNA & WESTERN RAILROAD.

This road has five water-softening plants, the oldest of which has been in operation three years. The average capacity of these plants is 286,000 gallons per 24 hours. The lowest is 240,000 gallons and the highest 350,000 gallons per twenty-four hours. The cost of softening is: lowest, .9 of a cent; highest, 1.1 cents; average, 1 cent per 1,000 gallons.

They report a reduction in scale-forming matter in locomotive boilers, resulting in greater measure of efficiency of engines, as evidenced by greater mileage for every tube reset. Previous to using treated water, boilers needed more frequent washing out, and scale-forming sediment made it necessary to repair boiler tubes often.

DETROIT, TOLEDO & IRONTON RAILWAY.

The general character of the boiler water supply on the Detroit, Toledo & Ironton Railway is poor. They have two water-softening plants in operation and one under construction. The oldest plant has been in operation nine months.

They report cost of softening: lowest, 1 cent; highest, 2.7 cents, with an average of 1.8 cents per 1,000 gallons. The capacity of their plants are 100,000 and 160,000 gallons per twenty-four hours—averaging 130,000 gallons.

They experience considerable benefit in the direction of less boiler work and maintenance, and find that locomotives using treated water give less trouble in way of flue and firebox leakage. They estimate roundhouse boiler work to be 50 per cent. less since the installation of their water-softening plants, and 20 per cent. reduction in fuel expense.

ERIE RAILROAD COMPANY.

The Erie Railroad has one water-softening plant. It has been in operation for six months.

The capacity of this plant is 12,000 gallons per hour.

EL PASO & SOUTHWESTERN SYSTEM—EASTERN DIVISION.

This road has installed eight water-softening plants, the oldest of which has been in operation a little over two years. The general character of their water supply is poor. The water from several of their wells contains 170 or more grains per gallon of incrusting solids.

The capacity of their plants varies from 2,000 gallons to 10,000 gallons per hour—averaging 5,000 gallons per hour. The cost for softening water on this road is 7 cents at the lowest, and 28.5 cents at the highest, with an average of 18 cents per 1,000 gallons.

They found that before they commenced to soften water that it was almost impossible to get an engine over the division between Alamogordo and Santa Rosa without boiler trouble. Since the plants were started, the use of softened water has lessened their trouble.

HOCKING VALLEY AND TOLEDO & OHIO CENTRAL RAILWAYS.

The general character of the boiler water supply of the Hocking Valley Railway and the Toledo & Ohio Central Railway is poor. They have three water-softening plants in service, the oldest of which has been in operation three years.

Their plants have a capacity of from 100,000 to 650,000 gallons per twenty-four hours. Their cost for softening is two cents per 1,000 gallons.

They report that the use of softened water results in the removal of scale-forming matter, prolongs the life of the boiler, and saves fuel.

ILLINOIS CENTRAL RAILROAD.

The character of their boiler water supply varies on different parts of their line. They have six water-softening plants in operation. The oldest has been in operation sixteen months. Each plant has a capacity of 10,000 gallons per hour. They report a great reduction in cost of repairs to locomotives, as well as doing away with engine failures on account of hard water.

LAKE ERIE & WESTERN RAILROAD.

The character of the boiler water supply found on this road is variable. At two of the stations where softening plants are located the waters contain about twenty-five grains of incrusting matter per gallon. At the other two stations the waters sometimes contain sixty grains of incrusting matter per gallon, with also a large amount of alkali during a part of the time. Four plants are in service on this road.

One of these has been operating for twenty-one months, and the other three for eight months. They have a capacity of from 175,000 to 275,000 gallons per 24 hours—averaging 206,000 gallons.

The cost of chemicals used for softening water is 2.1 cents per 1,000 gallons for the lowest, 3 cents per 1,000 gallons for the highest, with an average of 2.5 cents per 1,000 gallons.

The benefits they have derived from the use of softened water in their locomotive boilers have been removal of incrusting solids (part of which were also corrosive), large reduction in engine failures due to leaking boilers, and decreasing running repairs to boilers.

LEHIGH VALLEY RAILROAD.

The Lehigh Valley Railroad has four water-softening plants. The oldest has been in operation for two years. The capacity of these plants are: lowest, 100,000 gallons per twenty-four hours; highest, 300,000 gallons per twenty-four hours, averaging 225,000 gallons.

Three of these plants have been in operation for only nine months, and figures showing the benefits due to the use of softened water in their boilers have not yet been ascertained.

MISSOURI PACIFIC RAILWAY.

The general character of the boiler water supply on the Missouri Pacific Railway is poor. They have at the present time three water-softening plants in service. All have been in operation for nine months. The capacity of each plant is 250,000 gallons per twenty-four hours.

The average cost of softening water on this road is 2.4 cents per 1,000 gallons, ranging from 1.2 cents per 1,000 gallons for the lowest, to 4.3 cents per 1,000 gallons for the highest.

The Missouri Pacific Railway reports that the number of engine failures due to water troubles has been greatly reduced by softening the water. The Master Mechanic states that a saving of several hundred dollars per month has been effected through the use of softened water.

NEW YORK, ONTARIO & WESTERN RAILWAY.

The New York, Ontario & Western Railway has one water-softening plant in operation. It was installed in 1901. The cost of softening water at this plant averages 2.5 cents per 1,000 gallons, the capacity of which is 5,000 gallons per hour.

They find that their engines are out of service less time on account of boiler washings and flue repairs than they were before commencing to soften water; also longer life of flues.

NORFOLK & WESTERN RAILWAY.

The general character of their boiler water supply varies. On about one-half of their line the water supply is fair. On about one-fourth it needs filtering to remove mud and suspended matter. On about one-fourth the water contains much scale-forming material.

They have one water-softening plant in service, which has been in operation one year. They also have five more plants in course of construction. The cost of treatment at their plant is three cents per 1,000 gallons. The capacity of their plants ranges from 100,000 to 250,000 gallons per twenty-four hours.

They report that one plant that has been in operation for the past year has proved to be a great success. The water untreated contains thirty-six grains per gallon of incrusting solids. After treatment it contains only four grains. After thirty days' use of the treated water in a stationary boiler, no scale was deposited in it.

PENNSYLVANIA LINES—SOUTHWEST SYSTEM.

The general character of the boiler water supply of this railroad varies—part of it being good and part very bad. There are four water-softening plants in operation on this road, the oldest of which has been in service for one and a half years. The cost for treatment varies from two cents to three cents per 1,000 gallons, with an average of two and a quarter cents per 1,000 gallons. The capacity of the plants varies from 10,000 to 20,000 gallons per hour—averaging 15,000 gallons per hour.

As a result of the installation of these water-softening plants they report that they now have no cracked firebox sheets; reduced number of leaky flues, less boiler work; no trains given up on account of leaky engines; less roundhouse labor; less fuel consumed, and engines are gotten ready more quickly for trains.

PITTSBURG & LAKE ERIE RAILROAD.

The general character of the boiler water supply on the Pittsburg & Lake Erie Railroad is poor, the water containing carbonates and sulphates of lime, also sulphuric acid at times.

They have ten water-softening plants in operation, the oldest of which has been installed two and one-half years. The capacity of these plants is from 15,000 to 60,000 gallons per hour—averaging 25,000 gallons.

The cost for softening is: lowest, .5 of a cent; highest, 2.5 cents; average, 1 cent per 1,000 gallons.

The benefits they have derived from the use of softened water, are: increased life of fireboxes and tubes; absence of scale, collapsed tubes and corrosion; greater amount of service from locomotives, and great reduction in number of engine failures.

RIO GRANDE & EAGLE PASS RAILWAY.

The general character of the boiler water supply on this railroad is poor. There are two water-softening plants in operation, the oldest of which has been in service four years and seven months.

The capacity of their plants is 1,000 gallons per hour.

As a result of the use of softened water, they report a saving of 40 per cent. in boiler repairs, 20 per cent. in fuel, and 50 per cent. for labor and water used for washing out locomotives.

RIO GRANDE WESTERN RAILROAD.

This road has three water-softening plants. The oldest has been in service five years. The capacity of the lowest is 50,000 gallons per twenty-four hours; highest, 120,000 gallons, and average 70,000 gallons per twenty-four hours.

They report that the plants reduce the incrusting solids to three or four grains per gallon, eliminating the matter in suspension and improving the water treated.

SOUTHERN PACIFIC COMPANY (PACIFIC SYSTEM).

The boiler water supply of the Southern Pacific (Pacific System) includes both scale-forming and corrosive waters. They have sixteen water-softening plants in operation, the oldest of which has been in operation for six and a half years. The capacity of their plants varies from 12,500 to 175,000 gallons per twenty-four hours, with an average of 51,000 gallons per twenty-four hours. They also have seven more plants in course of construction.

The average cost for softening water on this road is 4.2 cents per 1,000 gallons. This varies from 1.9 cents in the lowest to 6.5 cents per 1,000 gallons in the highest.

The beneficial results of the operation of their water-softening plants is shown in an average decrease in scale-forming matter and prevention of corrosion due to action of unstable salts naturally contained in the waters before treatment.

TEXAS & PACIFIC RAILWAY.

The Texas & Pacific Railway report that they have all kinds of water on their line. They have one water-softening plant that has been in service eight months. It has a capacity of 80,000 gallons per twenty-four hours. The cost of softening water is three cents per 1,000 gallons. They report that this plant has been beneficial, but to what extent has not yet been determined. They also state that this water was so bad that it was necessary to replace the boiler used in the pumping plant every four months, but that the boiler used since plant was installed is still in use.

UNION PACIFIC RAILROAD.

The general character of the boiler water supply found along the lines of the Union Pacific Railroad is poor—carrying a considerable amount of both the carbonates and sulphates of lime and magnesia, to which is attributable hard scale.

They have thirty-six plants in operation, the oldest of which has been in operation for four years. The capacity of these plants varies from 8,000 to 20,000 gallons, averaging 11,600 gallons per hour.

The cost of softening water on this road per 1,000 gallons varies from .8 of a cent at the lowest, to 3.9 cents at the highest, with an average cost of 1.9 cents per 1,000 gallons.

The benefits derived from the use of softened water are a very marked decrease in boiler repairs and in fuel consumption, decrease in number of boiler washings, and increase in mileage of locomotives owing to less frequent shoppings.

WABASH RAILROAD.

The Wabash Railroad has one softening plant, with a capacity of 175,000 gallons per twenty-four hours.

They report the cost of softening water to be 3.1 cents per 1,000 gallons.

Respectfully submitted,

G. M. Davidson, Chemist and Engineer of Tests, Chicago & Northwestern Railway, Chicago, *Chairman.*

Anthony McGill, Assistant Analyst, Inland Revenue, Canadian Government, Ottawa, Canada. *Vice-Chairman.*

Geo. Crocker, Chief Engineer, Detroit Southern Railroad, Springfield, Ohio.

C. A. Morse, Acting Chief Engineer, Atchison, Topeka & Santa Fe Railway, Los Angeles, Cal.

R. S. Parsons, Engineer Maintenance of Way, Erie Railroad, Cleveland, Ohio.

J. P. Ramsey, General Manager, Chicago, Peoria & St. Louis Railway, St. Louis, Mo.

E. J. Randall, Principal Assistant Engineer, Bessemer & Lake Erie Railroad, Greenville, Pa.

H. S. Waterman, Chief Engineer, Detroit & Mackinac Railway, East Tawas, Mich.

M. H. Wickhorst, Engineer of Tests, Chicago, Burlington & Quincy Railroad, Aurora, Ill.

K. J. C. Zinck, Assistant Engineer, Grand Trunk Railway, Montreal, Canada.

Committee.

DISCUSSION.

Mr. G. M. Davidson (Chicago & Northwestern):—The subject of water-softening for locomotive boilers became a live one in this country about five years ago. The last three reports of this Committee have taken up the subject and discussed it in its various phases. The subject is an important one to the mechanical department of railroads, and they are especially interested in it. There is a good chance to save considerable money for the railroads by improving the quality of the water used in the locomotive boilers. It was not very many years ago, when, in locating the water supply, the chief aim was to get plenty of water—quantity—and for that reason a great many wells were put down close to running streams, because at certain seasons of the year the water from the running stream was muddy and gave trouble. In many cases the water from these wells has caused more trouble than water from the streams would have caused. The water from the wells appeared to be all right, but often it contained so much lime and other incrusting matter dissolved in it that its use was the cause of much trouble and expense. The problem in America to-day is largely a mechanical one. The chemistry of water-softening is pretty well understood; there is nothing specially new in it. The present method of water-softening was discovered by Dr. Clark, of Scotland, in the early forties. Various attempts were made to treat water, and some of them were successful, and some of them were not successful. The improvements that have been made in this country in recent years have largely been on mechanical lines. The chemistry of the subject is practically the same with all systems. The only difference is in the machine which is used for mixing the proper amount of chemicals with the proper amount of water to produce proper results. Up to the present time, lime and soda ash have been the only two available chemicals. There have been a great many interested people who have been working along other lines, but they have not been able to produce the results at a cost as low as they could be produced with lime and soda ash. One of the members of the Committee has been giving the subject of barium hydrate considerable thought. The report this year is simply a compilation of data and statistics which we have gathered through correspondence with various American railroads that were known to have installed water-softening plants. This report, therefore, is simply supplemental to the preceding ones, as rounding out the subject and bringing it up to date.

Dr. Anthony McGill (Inland Revenue Department, Canadian Government):—Supplementing the remarks of the chairman of the Committee just made, I would say that I am of the opinion that there are two directions in which this Committee may be of particular service for the next year. There are two points upon which the Association could advantageously concentrate its attention during the coming year. I mention the Association, because without the sympathetic co-operation of the whole Association your Committee cannot be expected to make much headway with the special subjects to which I would ask attention. These are:

First—The minimum amount of scaling matter which will justify the cost of treatment. I am aware that a consideration of quantity of scaling matter alone cannot satisfactorily meet the question. The nature of the scaling matter must be taken into account. But it should be possible to say whether or not an amount of scaling matter consisting chiefly of carbonates of lime or magnesia, and reaching fifteen grains per gallon, would justify the cost of treatment under ordinary conditions of railroad practice. It is just such definite information that railroad men appreciate and desire. It would be of great value to have reports from superintendents of motive power, stating the nature and extent of difficulties actually found with this class of waters.

Second—The advantage of using barium hydrate in treatment of waters containing soda salts, along with sulphate of lime and magnesia, is generally acknowledged. The practical objection is the present cost of the re-agent. It should be possible to figure out a maximum price which the railroads could profitably pay for the barium hydrate. This established, it would remain to endeavor to introduce cheaper methods for its manufacture; and I am justified in saying that there is reasonable ground for expecting success in this direction.

The cheapest materials at present available for softening water are undoubtedly carbonate of soda and lime. The advantage, however, of using barium hydrate in the treatment of water where sulphate of lime and magnesia are present, is universally acknowledged. I have been for some years now in close contact with the manufacturers of barium hydrate, both in America and in Europe, and I am in a position to say that I am very far from hopeless in the matter of its being brought down to a cost which will make it profitable for the railroads to use it on a pretty large scale. Without going into chemical details, I may simply say that barium hydrate has two qualities of permanently high importance in the softening of water not possessed by carbonate of soda or lime. In the first place, the sulphates are completely thrown out of solution, and they are really the worst scaling feature of a water. The second is that barium hydrate renders available for actual softening of the water the lime which is present in the water; that is to say, the lime which is an objectionable quality in the water is made, by the chemical reaction with barium hydrate, to itself become valuable for the further softening of the water. The point to be made is this—can the railways arrive at some maximum price which they can afford to pay for the barium hydrate? It seems to me that a careful inquiry along the line I have suggested would enable railway men to come to some conclusion as to the maximum price which can be afforded, and then it would rest with the chemists and manufacturers to try and bring down the cost of hydrate to that limit. I have in mind three or four different suggestions, some made to manufacturers, and others by manufacturers, by means of which barium hydrate might be much cheapened, provided a fixed and large demand for it was known to exist. There are at least two cases in which barium hydrate might be turned out as a by-product in the course of other manufactures, which would greatly reduce its cost.

Mr. A. S. Baldwin (Illinois Central):—By way of getting at the actual value that railroad companies could pay for barium hydrate—I have not had any experience with it—I would ask if it is used in the tender of the engine, or just as the soda ash is used?

Dr. McGill:—The economical use of barium hydrate would involve its use in mechanical purifiers. It could not be otherwise economically used.

Mr. Baldwin:—Would it be possible to give a comparison between the cost of that method and the ordinary treatment used in water-softening plants?

Dr. McGill:—Any comparison made, which took into consideration the present price of barium hydrate, would make the use of it quite out of the question. That is what I want to get at. I want to obtain from railway men an idea of what it would be worth their while to pay for barium hydrate as a substitute for the present treatment methods. Part of the answer depends on what satisfaction you find in the present treatment. I have learned, informally, that the practical limit possible now is the reduction of the scale matter to something like four or five grains. If that four or five grains contains sulphates of lime, in any quantity, even to the amount of a single grain, the water would continue to form scale.

Mr. M. H. Wickhorst (Chicago, Burlington & Quincy):—In discussion, it has generally been assumed that the value of water treatment is determined by the reduction in the amount of hardness. For instance, the effort is generally to get the water which has only four, five or six grains, possibly only three grains per gallon, and that considered as showing the value of water-softening, and the value of that water for the boiler. The point I call particular attention to is that water, to be thoroughly satisfactory, as far as the scaling condition of the boiler is concerned, must have, in all cases, a little excess of soda ash, and that, as Dr. McGill mentions, even if the water is left with a little sulphate of lime—it does not make much difference how little—the water will still scale, and the trouble from scale will continue. I have in mind a case that has been strongly brought to our notice in the last year or so, of the waters along the LaCrosse Division of the Chicago, Burlington & Quincy Railroad. The water is largely from the Upper Mississippi, and the average hardness does not run more than eight grains to the gallon, and yet it was a fact that the boilers were giving as much or even more trouble with this water which was considered soft water, than the general average on the rest of the system, That was due to the fact that the water had about one grain or so of the sulphate of lime, and such troubles as were caused by the sulphate of lime were overcome by simply treating the water with one or two grains of carbonate of soda or soda ash. In water treatment, to get results, it is always necessary to have a little excess of soda ash. That applies whether we introduce the soda ash directly into the tender of the locomotive, into the water treating plant, or inject it into the water as the water is pumped into the supply tank. Of course, the soda ash required depends upon the sulphate of lime present, whether the water is given plain soda treatment or additional lime treatment in a softening plant. The disadvantage of the soda ash is that it enormously increases the foaming tendency of the water, and for that reason if barium hydrate could be made commercially available, we could get the advantage of soft water without the use of soda ash, and at the same time do away with the foaming trouble attendant upon the use of soda ash.

The President:—Are there any other suggestions to be made for the work of this Committee for the coming year? Their work is important, and any suggestions made will be appreciated by the Board of Direction and also by the Committee. The duty devolves upon the Board of Direction to assign the subjects to be considered by the Committee for its next report, and any suggestions made will be appreciated. If there are no suggestions, the Committee will be excused, with the thanks of the Association.

REPORT OF COMMITTEE NO. VII.—ON WOODEN BRIDGES AND TRESTLES.

To the Members of the American Railway Engineering and Maintenance of Way Association:

Under the instructions of the Board of Direction, transmitted by the Secretary by letter, dated May 19, 1905, your Committee respectfully submits the following report:

(1) Compiled definitions adopted by the Association, March, 1905.

(2) Revised specifications for bridge and trestle timber and piles.

(3) Specifications for workmanship for trestles to be built by contract.

(4) Specifications for metallic details used in wooden bridges and trestles.

(5) Recommended safe unit working stresses for trestle timber.

In the appendix are recorded the following:

Table of safe unit working stresses for timbers, recommended by the Association of Railway Superintendents of Bridges and Buildings.

Table of safe unit working stresses for timber trestles and bridges, by A. L. Johnson, published by United States Division of Forestry.

Safe unit working stresses for timber railroad bridges, used by the Baltimore & Ohio Railroad.

Abstracts from bulletins issued by the United States Bureau of Forestry, showing tests on several kinds of timber made by that department.

Typical plans of ballasted deck trestles in use on the Atchison, Topeka & Santa Fe Railway, the Oregon Short Line Railroad and the Louisville & Nashville Railroad.

CONCLUSIONS.

Your Committee makes the following recommendations:

(1) The adoption of the revised specifications for bridge and trestle timber.

(2) The adoption of the specifications for workmanship for trestles to be built by contract.

(3) The adoption of specifications for metallic details used in wooden bridges and trestles.

(4) The adoption of the allowable safe unit working stresses.

The various tables of safe unit stresses and tests of timber shown in the appendix are for information and guidance in designing wooden structures; also to show that, while considerable progress has been made by the United States Bureau of Forestry in making tests of timbers, and much valuable information has been obtained on the subject, it will require considerable more work, investigating and testing the various kinds of timber used in structures, to enable the Committee to recommend a list of unit stresses for a greater number of kinds of timber used in railroad structures than those submitted for adoption in this report.

The three plans of ballasted deck trestles are appended for the information of the members of the Association, showing the design of such structures on several railroads, and for the purpose of discussing the subject and the framing of instructions to the Committee, if it is desirable to have the Committee prepare and present a plan of such structure for recommendation by the Association.

Respectfully submitted,

F. E. SCHALL, Bridge Engineer, Lehigh Valley Railroad, South Bethlehem, Pa., *Chairman.*

H. S. JACOBY, Professor of Bridge Engineering, Cornell University, Ithaca, N. Y., *Vice-Chairman.*

F. H. BAINBRIDGE, Assistant Chief Engineer, Chicago & Northwestern Railway, Chicago, Ill.

A. L. BOWMAN, Consulting Engineer, New York, N. Y.

D. B. DUNN, Assistant Engineer, Tidewater Railway, Eggleston, Va.

H. G. FLEMING, President and Chief Engineer, Union Belt Railway, Memphis, Tenn.

JAMES KEYS, Assistant Engineer, Union Pacific Railroad, Omaha, Neb.

H. B. MERRIAM, Assistant Engineer, Oregon Short Line, Salt Lake, Utah.

WM. MICHEL, Engineer Maintenance of Way, Hocking Valley Railroad, Columbus, O.

Committee.

DEFINITIONS.

ADOPTED AT CONVENTION, MARCH, 1905.

WOODEN TRESTLE.—A structure composed of upright members, supporting simple horizontal members or beams, the whole forming a support for loads applied to the horizontal members.

FRAME TRESTLE.—A structure in which the upright members or supports are framed timbers.

PILE TRESTLE.—A structure in which the upright members or supports are piles.

BENT.—The group of members forming a single vertical support of a trestle, designated as pile bent where the principal members are piles, and as framed bent where of framed timbers.

POSTS.—The vertical and battered members of the bent of a framed trestle.

PILES.—Timbers driven in the ground, and intended generally to support a structure.

BATTER.—The deviation from the vertical in upright members of a bent.

CAP.—The horizontal member upon the top of piles or posts, connecting them in the form of a bent.

SILL.—The lower horizontal member of a framed bent.

SUB-SILLS.—Timbers bedded in the ground to support framed bents.

INTERMEDIATE SILL.—A horizontal member in the plane of the bent between the cap and sill to which the posts are framed.

SWAY BRACES.—Members bolted or spiked to the bent and extending diagonally across its face.

LONGITUDINAL STRUTS OR GIRTS.—Stiff members running horizontally, or nearly so, from bent to bent.

LONGITUDINAL X BRACES.—Members extending diagonally from bent to bent in vertical or battered planes.

SASH BRACES.—Horizontal members secured to the posts or piles of a bent.

STRINGERS.—The longitudinal members extending from bent to bent and supporting the ties.

JACK STRINGERS.—A single line of stringers placed outside of the main stringers.

TIES.—Transverse timbers resting on the stringers and supporting the rails.

GUARD RAILS.—Longitudinal members, either iron or wood, secured on top of ties.

PACKING BLOCKS.—Small members, usually wood, used to secure the parts of a composite member in their proper relative positions.

PACKING SPOOLS OR SEPARATORS.—Small castings used in connection with packing bolts to secure the several parts of a composite member in their proper relative position.

DRIFT BOLT.—A piece of round or square iron of specified length, with or without head or point, driven as a spike.

DOWEL.—An iron or wood pin, extending into, but not through, two members of the structure to connect them.

SHIM.—A small piece of wood or metal placed between two members of a structure to bring them to a desired relative position.

FISH-PLATE.—A short piece lapping a joint, secured to the side of several members, which are butt-jointed.

BULKHEAD.—Timber placed against the side of an end bent for the purpose of retaining the embankment.

SPECIFICATIONS FOR BRIDGE AND TRESTLE TIMBER AND PILING.

BRIDGE AND TRESTLE TIMBER.

General Requirements. *All timber shall be cut from sound live trees of slow growth, firm grain, sawed to full size, rectangular in section and out of wind; it shall be free from wind shakes, unsound knots or sound knots over two (2) in. in diameter, knots in groups, pitch seams, decay or defects that will impair its strength or durability.

Guard Rail. LONG-LEAF YELLOW PINE.—One face shall show all heart, the other face and both sides shall show not less than 75 per cent. heart, measured across the sides anywhere on the piece.

Guard Rail. *DOUGLAS FIR.—One face shall show all heart, the other face and both edges shall show not less than 75 per cent. heart, measured across the surface anywhere on the piece. It shall not show less than an average of 12 rings to the inch.

Bridge Ties. LONG-LEAF YELLOW PINE, WHITE, POST AND BURR OAK.—Shall show not less than 75 per cent. heart on each of the four sides, measured across the side anywhere in the length of the piece.

Bridge Ties. *DOUGLAS FIR.—Shall show not less than 85 per cent. heart at any point in the length of the tie; it shall show not less than an average of 12 rings to the inch.

Stringers. *LONG-LEAF YELLOW PINE.—Shall show not less than 85 per cent. heart on each of the four sides, measured across the side anywhere in the length of the piece.

Stringers. *DOUGLAS FIR.—Shall show not less than 85 per cent. heart on any face and not less than 70 per cent. on any edge; sound sapwood will be permitted on two corners of the stringer; it shall show not less than an average of 12 rings to the inch. Sound knots less than two (2) in. in diameter will be permitted if not less than four (4) in. from the edge of the piece.

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*See amendment, page 703.

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LONG-LEAF YELLOW PINE, WHITE, POST AND BURR OAK.—The opposite or bearing faces shall show not less than 85 per cent. heart, and the other two sides shall show not less than 75 per cent. heart, measured across the face anywhere in the length of the piece.

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*DOUGLAS FIR.—Shall show not less than 75 per cent. heart on each face, measured across the face anywhere in the length of the piece; sound sapwood will be permitted, not exceeding two (2) in. in width at any corner. Knots must be sound and not over three (3) in. in diameter, measured on the surface of the timber, and must not be in groups. It shall show not less than an average of 12 rings to the inch.

sts.

LONG-LEAF YELLOW PINE, WHITE, POST AND BURR OAK.—Shall show not less than 66 per cent. heart, measured across the face anywhere in the length of the piece. No knots will be permitted in the corners of the post. One inch wane will be allowed on two corners half the length of the piece.

*DOUGLAS FIR.—Shall show not less than 66 per cent. heart, measured across the face anywhere in the length of the piece. No knots will be permitted in the corners of the post; it shall show not less than an average of 12 rings to the inch. One inch wane will be allowed on two corners half the length of the piece.

ngitu- al Struts Girts.

LONG-LEAF YELLOW PINE.—Shall show one side all heart; the other three sides shall show not less than 85 per cent. heart, measured across the face anywhere in the length of the piece.

ngitu- ial Struts Girts.

*DOUGLAS FIR.—Shall show one side all heart; the other three sides shall show not less than 85 per cent. heart, measured across the face anywhere on the piece; it shall show not less than an average of 12 rings per inch.

ngitu- ial X- aces, Sash aces and ray aces.

*LONG-LEAF YELLOW PINE, DOUGLAS FIR, WHITE, BURR AND POST OAK.—Shall show not less than 66 per cent. heart anywhere in the length of the piece; no restrictions as to sap on edges.

ing. neral quire- ɔnts.

*PILING.—All piling shall be cut from sound live trees of slow growth, firm grain, free from wind shakes, decay, large, unsound knots, or other defects that will impair their strength and durability. They shall be butt cuts, above the ground swell, and be uniformly tapering from the butt to the tip. They shall be so straight that a line stretched from the center of the pile at the butt to the center of the pile at the tip will not leave the center of the pile at any point more than two (2)

* See amendment, pp. 703, 704.

in. for piles 20 ft., four (4) in. for piles 30 ft., six (6) in. for piles 40 ft., and eight (8) in. for piles 50 ft. in length. No short bends will be allowed. Piling.

All knots shall be trimmed close to the body of the pile, and the bark peeled.

WHITE, POST, OR BURR OAK.—Round piles shall not be less than 12 in. diameter, 6 ft. from the butt, and not less than 10 in. diameter at the tip for piles under 30 ft. long, not less than 9 in. diameter for piles 30 to 39 ft. long, and not less than 8 in. diameter for piles over 40 ft. long. They shall show not less than 75 per cent. heart. Piling.

Square piles shall be of timber squared throughout their entire length, smoothly hewed; they shall not be less than 14 in. nor more than 16 in. square at the butt and not less than 10 in. square at the tip for piles 30 ft. long and under, 9 in. square for piles 30 to 39 ft. long, and not less than 8 in. square for piles 40 ft. long and over. They shall show not less than 75 per cent. heart.

NORWAY PINE AND TAMARACK.—Piles shall not be less than 14 in. nor more than 18 in in diameter at the butt, and not less than 10 in. at the tip for piles under 36 ft. long and not less than 9 in. diameter for piles over 36 ft. long. Piling.

SOUTHERN LONG-LEAF YELLOW PINE.—Round piles shall not be less than 14 in., nor more than 16 in. in diameter at the butt, and not less than 10 in. at the tip. They shall show not less than 80 per cent. heart on the ends. Piling.

Square piles shall not be less than 12 in. nor over 14 in. square at the butt, and not less than 8 in. square at the tip. Piles shall be hewed square, except that one inch wane will be allowed on two corners for half the length of pile. They shall show not less than 75 per cent. heart on any side for full length of pile.

WHITE CEDAR.—Piles shall not be less than 14 in. in diameter at the butt and not less than 9 in. diameter at the tip when under 30 ft. in length, and not less than 8 in. diameter at the tip when over 30 ft. in length. Unsound butts will be accepted if the defect is not more than 4 in. in diameter. There must be 5 in. of sound close-grained wood all around the defect. Piling.

RED CEDAR.—Piles shall not be less than 12 in. in diameter at the butt, and not less than 9 in. diameter at the tip when under 30 ft. in length, and not less than 8 in. diameter at the tip when over 30 ft. in length. Unsound butts will be accepted if the defect is not more Piling.

than 3 in. in diameter. There must be 5 in. of sound close-grained wood all around the defect.

Piling.

*Douglas Fir.—Piles shall be of either red or yellow Oregon Fir. They shall not be less than 14 in. nor more than 18 in. in diameter at the butt, and not less than 10 in. diameter at the tip. Piles over 40 ft. in length shall not be less than 16 in. nor more than 22 in. diameter at the butt, and not less than 8 in. diameter at the tip; they shall show not less than 75 per cent. heart at the tip.

Piling.

Cypress.—Piles shall be red or swamp cypress They shall be squared throughout their entire length, smoothly hewed. They shall not be less than 14 in. nor more than 16 in. square at the butt, and not less than 10 in. square at the tip for piles under 30 ft. long, not less than 9 in. square for piles 40 ft. long, and not less than 8 in. square for piles 50 ft. long. Piles shall show all heart.

Foundation Piling.

Foundation Piling.—Piles for foundations that will always be completely submerged and piles for cofferdams, false-work and sundry temporary work may be of red oak, hickory, elm, gum or any sound timber that will stand driving and need not be peeled. Foundation piles shall not be less than 12 in. nor more than 16 in. diameter at the butt, and not less than 9 in. at the tip.

*See amendment, page 704.

RECOMMENDED SPECIFICATIONS FOR WORKMANSHIP FOR PILE AND TIMBER TRESTLES TO BE BUILT UNDER CONTRACT.

SITE.

The trestle to be built under these specifications is located on the line of .... Railroad, at ...., County of ...., State of ....

GENERAL DESCRIPTION.

The work to be done under these specifications covers the driving, framing and erection of a .... track wooden trestle about ...... ft. long and an average of ...... ft. high.

The contractor is to furnish all the necessary labor, tools, machinery, supplies, temporary staging and outfit to build the trestle complete ready for the rails of track in a workmanlike manner, in strict accordance with the plans and the true intent of these specifications to the satisfaction and acceptance of the engineer of the Railroad Company.

GENERAL CLAUSES.

The workmanship to be of the best quality in the several lines of work; all details, fastenings and connections to be of the best method in general use on first-class work.

Holes must be bored for all spikes and drift bolts for at least two-thirds the length of the spike or drift bolt to be used; the auger to be the same diameter as the thickness of the spike.

All timber must be cut at the ends with a saw and not with an axe.

On the completion of the work, all refuse material and rubbish that may have accumulated on top or under and near the trestle, by reason of its construction, shall be removed by the contractor.

The engineer or his authorized agents shall have full power to cause any inferior work to be condemned and taken down or altered at the expense of the contractor. Any material destroyed by the contractor on account of inferior workmanship or carelessness of his men to be replaced by the contractor at his expense.

Figures shown on the plans are to govern in preference to scale measurements; if any discrepancies should arise or irregularities be discovered in the plans, the contractor shall call on the engineer for instructions. These specifications and the plans are intended to co-operate, and, should any question arise as to the proper interpretation of the plans or these specifications, it shall be referred to the engineer for a ruling.

The contractor shall, when required by the engineer, furnish a satisfactory watchman to guard the work.

DETAIL SPECIFICATIONS.

Piles. All piles shall be carefully selected to suit the place and ground where they are to be driven. When required by the engineer, pile butts shall be provided with iron or steel rings, and the tips with suitable iron or steel shoes; such rings and shoes will be furnished by the Railroad Company. All piles to be driven to a firm bearing, satisfactory to the engineer, or until five blows of a hammer weighing 3,000 lbs., falling 15 ft. (or a hammer and fall producing the same mechanical effect), are required to drive the pile one-half (½) in. per blow, except in soft bottom, when special instructions will be given.

Batter piles shall be driven to the inclination shown by the plans and shall require but slight bending before framing.

Piles. The butts of the piles in a bent to be sawed off to one plane and to be trimmed so as not to leave any horizontal projection outside of the cap.

Piles to be slightly flattened at intersection of braces, to give them a fair bearing.

Piles injured in driving, or driven out of place, shall either be pulled or cut off and replaced by new piles.

Caps. Caps shall be sized over the piles or posts to a uniform thickness and even bearing on piles or posts. They shall be drift-bolted to piles or posts.

The side with most sap shall be placed downward.

Posts. Posts shall be sawed to proper length for their position (vertical or batter) to an even bearing on cap and sill. They shall be drift-bolted to cap and doweled or toe-nailed to sill.

Sills shall be sized at the bearing of posts to one plane. They shall be doweled to posts and drift-bolted to sub-sills. **Sills.**

All sway bracing shall be properly framed and securely bolted to piles or posts, when necessary for pile bents; filling pieces shall be used between the braces and the piles on account of the variation in size of piles, to obtain a bearing against all piles. **Sway Braces.**

Longitudinal struts and X-braces shall be properly framed and securely bolted to piles or posts. **Longitudinal Braces.**

Girts shall be properly framed and drift-bolted to caps, sub-sills, posts or piles, as the plans may require. **Girts.**

Stringers shall be sized to a uniform height. They shall be laid with alternating joints, provided with packing spools or separators, and the several lines under each rail bolted together. All continuous stringers over cap shall be drift-bolted to cap. **Stringers.**

The edges with most sap shall be placed downward.

Jack stringers, when used, shall be neatly framed on caps and drift-bolted to cap. **Jack Stringers.**

Ties shall be notched over the stringers to a close fit, firm bearing, and uniform top surface. They shall be spaced regularly, cut to even length and a line as called for on the plans. **Ties.**

Every sixth tie shall be spiked at each end to outside stringers, the spikes to be in the same tie in which the guard rail bolts occur. When ties are planed to uniform thickness, the rough side shall be placed upward.

Guard rails shall be neatly notched over every tie, spliced at joints by half and half splice over a tie. **Guard Rails.**

They shall be bolted to every third tie, the bolt to be placed in the same tie for each guard rail. The splices of guard rail shall be bolted to the tie underlying the splice.

The work to be completed in all its parts on or before the .... A. D., 19.. **Time of Completion.**

Payments will be made under the usual regulations of the Railroad Company. **Payments.**

SPECIFICATIONS FOR METALLIC DETAILS USED IN WOODEN BRIDGES AND TRESTLES.

GENERAL REQUIREMENTS.

ought- i.

Wrought-iron shall be tough, fibrous and uniform in character. It shall be thoroughly welded in rolling and be free from surface defects. When tested in specimens of the form of Fig. 1 or in full-sized pieces of the same length, it shall show an ultimate strength of at least 50,000 lbs. per sq. in., an elongation of 18 per cent. in 8 in., with fracture wholly fibrous. Specimens shall bend cold, with the fiber, through 135 degrees, without sign of fracture, around a pin the diameter of which is not over twice the thickness of the piece tested. When nicked and bent, the fracture shall show at least 90 per cent. fibrous.

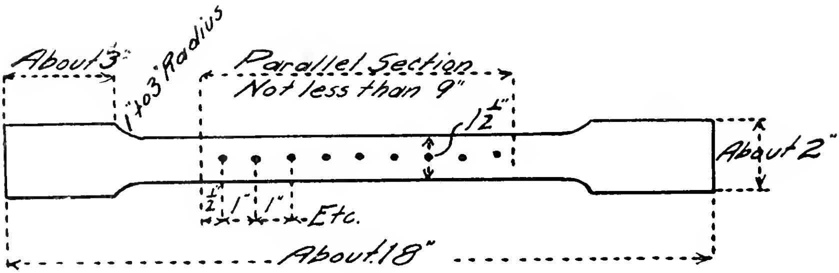


FIG. 1.

eel.

Steel shall be made by the open-hearth process. It shall contain not over 0.04 per cent. phosphorus and not over 0.04 per cent. sulphur, when tested in specimens of the form Fig. 1 or full-sized pieces of same length. It shall have a desired ultimate strength of 50,000 lbs. per sq. in.; tensile tests of steel showing an ultimate strength within 5,000 lbs. per sq. in. of that desired will be considered satisfactory, except that, if the ultimate strength varies more than 4,000 lbs. from that desired, a retest shall be made on the same, which, to be acceptable, shall be within 5,000 lbs. of the desired ultimate; it shall have an elongation of $\frac{1,500,000}{\text{ult. tens. strength}}$ in 8 in.; it shall bend cold without fracture 180 degrees flat. The fracture of tensile test shall be silky.

Cast-Iron. Cast-iron shall be made of tough gray iron, with sulphur not over 0.10 per cent. If tested on the "Arbitration Bar" of the American Society for Testing Materials, which is a round bar 1¼ in. in diameter and 15 in. in length, the transverse test shall be made on a supported length of 12 in. with load at the middle. The minimum breaking load so applied shall be 2,900 lbs. with a deflection of at least $\frac{1}{10}$-in. before rupture.

DETAIL SPECIFICATIONS.

Bolts. Bolts shall be of wrought-iron or steel, made with square heads, standard size, the length of thread to be 2½ times the diameter of bolt. The nuts shall be made square, standard size, with thread fitting closely the thread of bolt. All threads shall be cut according to U. S. standards.

Drift Bolts. Drift bolts shall be of wrought-iron or steel, with or without square head, pointed or without point, as may be called for on the plans.

Spikes. Spikes shall be of wrought-iron or steel, square or round, as called for on the plans; steel wire spikes, when used for spiking planking, shall not be used in lengths more than 6 in.; if greater lengths are required, wrought or steel spikes shall be used.

Packing Spools or Separator. Packing spools or separators shall be of cast-iron, made to size and shape called for on plans; the diameter of hole shall be ⅛-in. larger than diameter of packing bolts.

Cast Washers. *Cast washers shall be of cast-iron. The diameter shall be not less than 3½ times the diameter of bolt for which it is used, and not less than ⅝-in. thick; the diameter of hole shall be ⅛-in. larger than the diameter of the bolt.

Wrought Washers. Wrought washers shall be of wrought-iron or steel; the diameter shall be not less than 3½ times the diameter of bolt for which it is used, and not less than ¼-in. thick. The hole shall be ⅛-in. larger than the diameter of the bolt.

Special Castings. *Special castings shall be of cast-iron, made true to pattern, without wind, free from flaws, and excessive shrinkage; size and shape to be as called for by the plans.

*See amendment, page 704.

SAFE UNIT STRESSES.

The following allowable unit stresses are recommended, their values being chosen so as to include the allowance for impact:

*STRINGERS.—For long-leaf yellow pine and Pacific Coast red fir: 1,200 lbs. per sq. in on the extreme fibers in bending, and 120 lbs. per sq. in. for shear parallel to the fibers.

*CAPS AND SILLS.—For long-leaf yellow pine and Pacific Coast red fir: 300 lbs. per sq. in. for bearing on the side of the fibers.

For white, post and burr oak: 500 lbs. per sq. in.

*POSTS AND PILES.—For long-leaf yellow pine and Pacific Coast red fir: $1{,}200 - 18\frac{l}{d}$ lbs. per sq. in. for the average compression on the cross-section, in which "l" is the length and "d" the least diameter of the column, both expressed in inches.

For white, post and burr oak: $1{,}000 - 15\frac{l}{d}$ lbs. per sq. in.

For Norway pine, cypress and cedar: $800 - 12\frac{l}{d}$ lbs. per sq. in.

AVERAGE SAFE UNIT STRESSES IN POUNDS PER SQUARE INCH.

Recommended by the Committee on "Strength of Bridge and Trestle Timbers," American Association of Railway Superintendents of Bridges and Buildings. Fifth Annual Convention, New Orleans, October, 1895.

	Factor of Safety	White Oak	Long Leaf Yellow Pine	Douglas, Oregon and Yellow Fir	Norway Pine	Cypress	Cedar
Compression with the grain......	5	1,400	1,600	1,600	1,200	1,200	1,200
For columns under 15 diameters.	5	900	1,000	1,200	800	800	800
Compression across the grain....	4	500	350	300	200	200	200
Extreme fiber stress in bending..	6	1,000	1,200	1,100	700	800	800
Modulus of Elasticity	2	550,000	850,000	700,000	600,000	450,000	350,000
Shearing with the grain	4	200	150	150		.	

NOTE:—The above unit stresses are intended to be used without increasing the live load stresses by an allowance for impact.

*See amendment, page 704.

SAFE UNIT STRESSES AT 18 PER CENT. MOISTURE.

From Bulletin No. 12 of Division of Forestry in "Economical Designing of Timber Trestle Bridges by A. L. Johnson, 1896."
All values are expressed in pounds per square inch.

	Factor of Safety	Long Leaf Yellow Pine	Norway Pine	Douglas Fir	Red Cedar	Bald Cypress	White Oak
Modulus of Rupture	5	1,550	1,090	1,320	1,000	1,000	1,200
Modulus of Elasticity	2	720,000	566,000	690,000	335,000	450,000	550,000
Compression Strength, endwise	5	1,000	760	880	700	675	800
Compression Strength, across the grain	3	215	143	167	250	120	400
Shearing Strength parallel to fibers	4	125	....	....	....	60	200

The values for long-leaf yellow pine, bald cypress and white oak were obtained from tests made by the Forestry Division and are considered quite reliable, especially those for long-leaf pine. These are, as indicated above, for a moisture of 18 per cent., representing a half dry condition, and were taken from a minimum moisture curve in Bulletin No. 8, which represented the average strength of the lowest 10 per cent. of the non-defective pieces tested. This curve gives values from 15 to 20 per cent. less than the mean values obtained for the species and material of this strength can readily be obtained even for full-sized beams and columns by an inspector of average intelligence. The other values were obtained from various sources, chief of which was the Tenth Census report, but so modified as to give results comparable with the Forestry Division values.

THE BALTIMORE & OHIO RAILROAD COMPANY.

GENERAL SPECIFICATIONS FOR TIMBER RAILROAD BRIDGES.

(Part III of General Specifications for Railroad and Highway Bridges.)
1901.

	Long Leaf Yellow Pine	White Oak
Bending or direct tension	1200	1000
Columns under 17 diameters	900	750
Columns over 17 diameters	$1200-18\frac{l}{d}$	$1000-15\frac{l}{d}$
Shearing along grain	150	200
Bearing in direction of grain	1500	1250
Bearing perpendicular to grain	350	500

l = length and d = least thickness, all in inches.

NOTE:—The above unit stresses are to be used without increasing the live load stresses by an allowance for impact, except for Howe trusses used for temporary purposes, in which an allowance of 25 per cent. is made to cover impact or possible increase of live load.

TESTS OF LONG LEAF YELLOW PINE.

Abstracted from Circular No. 32 of the U. S. Bureau of Forestry, 1904.
Progress Report by W. K. Hatt, Civil Engineer in Bureau.
All values are expressed in pounds per square inch.

	Flexure			Compression		Shear Parallel to Fiber from Flexural Tests
	Fiber Stress at Elastic Limit	Modulus of Rupture	Modulus of Elasticity	Parallel to Fiber* Ultimate	Perpendicular to Fiber Elastic Limit	
Number of tests	20	20	20	41	22	3
Size	10"x12"x 16' 0"	10"x12"x 16' 0"	10"x12"x 16' 0"	4"x6"	4"x4"x16'	10"x12"x 16' 0"
Grade	......	Georgia Merchantable				....
Number of rings per inch	18	18	18	....	....	18
Percentage of moisture, average	28.2	28.2	28.2	26.9	25.1	28.2
Weight per cubic foot dry	42.9	42.9	42.9	35.7	36.0	42.9
Maximum strength	7890	10080	2,408,000	5950	875	291
Average of all tests	5530	8280	1,807,000	4862	616	268†
Minimum strength	3660	6010	1,356,000	3290	375	247

(*) Compressive strength at elastic limit equals about 75 per cent. of ultimate strength.

(†) Nineteen beams that did not fail by longitudinal shear gave an average value of 243 lbs. per sq. in.

The above tests all relate to actual market products.

TESTS OF PACIFIC COAST RED FIR (OR DOUGLAS FIR).

Abstracted from Circular No. 32 of the U. S. Bureau of Forestry, 1904.
Progress Report by W. K. Hatt, Civil Engineer in Bureau.

All values are expressed in pounds per square inch.

	Flexure			Compression		Shear Parallel to Fiber from Flexural Tests
	Fiber Stress at Elastic Limit	Modulus of Rupture	Modulus of Elasticity	Parallel to Fiber* Ultimate	Perpendicular to Fiber Elastic Limit	
Number of tests	6	6	6	143	142	6
Size	8"x16"x 16' 0"	8"x16"x 16' 0"	8"x16"x 16' 0"	5"x5"	4"x4"x16'0"	8"x16"x 16' 0"
Grade	Merchantable			All Grades		Merchantable
Number of rings per inch	29.4-6.2	29.4-6.2	29.4-6.2	36.0-4.0	....	29.4-6.2
Average number	18.1	18.1	18.1	17.2	....	18.1
Percentage of moisture	25.6-19.0	25.6-19.0	25.6-19.0	28.3-15.7	22.4-17.5	25.6-19.0
Average percentage	22.1	22.1	22.1	20.7	19.5	22.1
Weight per cu. ft., dry	....	....	....	36.2-22.9	35.9-23.0	....
Average weight	28.5	28.5	28.5	28.7	28.8	28.5
Maximum strength	5270	7190	1,880,000	7070	1300	287
Average of all tests	4800	6610†	1,577,000†	4825	597	272
Minimum strength	4440	5710	1,365,000	2780	402	228

(*) At the elastic limit the corresponding values are: Maximum, 5,280; average, 3,700; minimum, 1,970.

(†) Twenty-nine sticks, most of which were 6 x 8 in. x 16 ft. 0 in. in size, gave an average modulus of rupture of 7,730, and modulus of elasticity, 1,825,000.

The above tests all relate to actual market products.

PACIFIC COAST RED FIR.

Notes abstracted from Circular No. 32 of the U. S. Bureau of Forestry, 1904.

The tests relate to actual market products.

Sticks 24 x 24 in. x 100 ft. are regularly listed and obtainable in Merchantable grade.

This timber has exceptionable strength and stiffness compared with its weight. It is almost entirely heartwood, hence durable on exposure to the weather.

In green logs the sapwood is not more than 2 in. beneath the bark, a light-colored ring.

In seasoned timber, sapwood that is distinguishable is seldom encountered.

It is used on the Pacific Coast exclusive of other species for piling for docks and foundations in soft ground. Standard piles are 12 in. in diameter, 60 to 70 ft. long.

The color is light yellow to pronounced red.

The grain varies from 4 to 40 (or even more) rings per inch.

The wide ringed wood is somewhat spongy.

The wood splits easily when dry.

There is no marked difference between the strength of fir of red and of yellow color, provided the sticks have the same rate of growth and are equally free from defects.

The greatest density and strength is found in sticks with 21 rings per inch.

SUMMARY OF TESTS FROM CIRCULAR NO. 15, DIVISION OF FORESTRY (1897).

All values are expressed in pounds per square inch.

	Long-leaf Yellow Pine	Bald Cypress	White Cedar	Douglas Spruce	White Oak
Modulus of Rupture; Moisture	15 per cent	12 per cent	12 per cent	12 per cent	12 per cent
Number of tests............	1,160	655	87	41	218
Highest single test.........	17,800	14,800	9,100	13.000	20.300
Average highest 10 per cent of tests....	14,200	11.700	8,400	12.000	18,500
Average of all tests.........	10,900	7,900	6.300	7,900	13,100
Average lowest 10 per cent of tests.....................	8,800	5,000	4,000	4,100	7,600
Lowest single test........ ...	3.300	2.300	3.500	3,800	5,700
Proportion of tests within 10 per cent of average....	41 per cent	25 per cent	32 per cent	22 per cent	39 per cent
Proportion of tests within 25 per cent of average....	84 per cent	69 per cent	78 per cent	58 per cent	75 per cent
Stress in outer fiber at Relative Elastic Limit:* Moisture and number of tests same as above.					
Highest single test...... ...	13,500	12,000	8,200	13,700	15,700
Average highest 10 per cent of tests.....................	11.100	9,900	7,390	9,600	14.100
Average of all tests.........	8.500	6,600	5,800	6.400	9.600
Average lowest 10 per cent of tests.....................	5,400	4.200	4,000	3.400	6.100
Lowest single test........	2,400	2.200	3,400	2,800	4,400
Proportion of tests within 10 per cent of average....	43 per cent	25 per cent	44 per cent	32 per cent	37 per cent
Proportion of tests within 25 per cent of average....	81 per cent	66 per cent	86 per cent	56 per cent	73 per cent
Modulus of Elasticity, average of all tests.........	1,890,000	1,290,000	910,000	1,680,000	2,090.000
Compression endwise; No. of tests..................	1,230	655	87	41	218
Moisture.........	15 per cent	12 per cent	12 per cent	12 per cent	12 per cent
Highest single test.........	11,900	9,900	6,200	8,900	12,500
Average of highest 10 per cent.......................	8,600	8,500	6,000	8,100	11.300
Average of all tests.........	6,900	6,000	5,200	5,700	8,500
Average of lowest 10 per cent.......................	5,700	4,200	4,400	4,200	6,300
Lowest single test......	3.400	2.900	3.200	4.100	5,100
Proportion of results within 10 per cent of average.	53 per cent	31 per cent	79 per cent	28 per cent	40 per cent
Proportion of results within 25 per cent of average.	90 per cent	74 per cent	99 per cent	65 per cent	81 per cent
Compression endwise: No. of tests......................	86	280	34	....	25
On green wood (not reduced)	....	over 40	per cent	moisture	....
Highest single test.........	7,300	8,200	3,400	....	7,000
Average of all tests.........	4,300	4,200	2,900	....	5,300
Lowest single test..........	2,800	1,800	2,300	....	3,200
Compression across the grain; Moisture....................	15 per cent	12 per cent	12 per cent	12 per cent	12 per cent
No. of tests	1,210	650	87	41	218
Average of all tests	1,000	800	700	800	2,200
Shearing with the grain, not reduced for moisture (same number of tests as for compression across the grain)................					
Average of all tests.........	700	500	400	500	1,000

*The unit stress for which the relative distortion is 50 per cent greater than for the initial load applied in the test.

ABSTRACTED FROM "TABLES OF SAFE LOADS FOR WOODEN BEAMS AND COLUMNS" BY KIDWELL AND MOORE, NEW YORK, 1899.

Safe working unit stresses due to flexure:	*Pounds per Square Inch.*
Douglas, Oregon and Washington Red Fir	800
White Oak	1,000
Douglas, Oregon and Washington Yellow Fir	1,100
Long Leaf Yellow Pine	1,200

Column Formulas:

	$\frac{l}{d}$ = 25 or less	$\frac{l}{d}$ = over 25
Oak	$900 - 9\frac{l}{d}$	$900 - 11\frac{l}{d}$
Long-leaf Yellow Pine	$1000 - 8.5\frac{l}{d}$	$1000 - 11\frac{l}{d}$
Oregon, Washington and Douglas Yellow Fir	$1200 - 9\frac{l}{d}$	$1200 - 12\frac{l}{d}$
Norway Pine, Red Pine	$800 - 6.5\frac{l}{d}$	$800 - 8\frac{l}{d}$
Cypress	$800 - 7.6\frac{l}{d}$	$800 - 9.5\frac{l}{d}$
Cedar	$800 - 8.6\frac{l}{d}$	$800 - 11\frac{l}{d}$

l=length of column in inches.

d=least dimension of cross-section in inches.

NOTE.—The above unit stresses are intended for use without the addition of stresses due to impact.

ABSTRACT OF COMPARATIVE TESTS OF DOUGLAS FIR AND LONG-LEAF YELLOW PINE BY FRANK W. HIBBS, NAVAL CONSTRUCTOR, 1901.

From Proceedings of Pacific Northwest Society of Engineers, Vol. 1, page 1, November, 1902.
All values are expressed in pounds per square inch.

	Douglas Fir		Long Leaf Yellow Pine
	Green	Air dried	Air dried
Compression on End of Fibers:			
Number of tests	4	6	8
Maximum	8,386	10,233	9,440
Average	8,273	8,669	8,502
Minimum	8,031	7,268	7 800
Column Test: length=16 diameters:			
Number of tests	3	6	6
Maximum	6,844	6,742	6,435
Average	6,148	5,896	5,669
Minimum	5,760	5,106	4,973
Compression on Side of Fibers (Ultimate):			
Number of tests	6	11	9
Maximum	3,392	2,495	2,895
Average	2,223	2,112	2,133
Minimum	1,444	1,696	1,643
Transverse Test (Modulus of Rupture):			
Number of tests	10	17	10
Maximum	12,756	13,992	12,853
Average	9,598	10,001*	10,156
Minimum	7,267	8,065	7,585
Shear Parallel to the Fibers:			
Number of tests	......	6	4
Maximum	....	1,744	1,600
Average	....	1,532	1,297
Minimum	....	1,452	1,023
verage Specific Gravity	0.597	0.56	0.653

* Elastic Limit=6000; modulus of elasticity=1,500,000.

NOTES ON COMPARATIVE TESTS OF DOUGLAS FIR AND LONG-LEAF YELLOW PINE.

BY FRANK W. HIBBS.

TRANSVERSE TESTS.—Yellow pine was stiffer than Douglas fir, even when its strength was less. The yellow pine broke very short, while the Douglas fir generally had a long fibrous fracture.

COMPRESSION ACROSS THE GRAIN.—The side of the long stick was compressed by a short block $3 \times 3\frac{1}{2}$ in., as wide as the stick. The wood was compressed to destruction, and the values recorded are the maximum stress recorded before ultimate failure. The green specimens gave the best results for Douglas fir. The best results were given when the rings were vertical and the timber fine-grained.

The ultimate stress is about double that at which failure began, which may be spoken of as the elastic limit, and which may be taken as the basis of any compression calculations. The deformation of Douglas fir is noticeably less than for yellow pine, particularly when the rings are vertical.

COMPRESSION ON END OF GRAIN.—The difference in the fractures is particularly noticeable; the fir crushed from end to end fairly square across the piece, or bulged symmetrically at the sides and split, while the yellow pine gave way in diagonal lines from top to bottom, and in two cases in double diagonals, showing as four triangles laid together.

NOTES ON COMPARATIVE TESTS OF DOUGLAS FIR AND LONG-LEAF YELLOW PINE.

BY FRANK W. HIBBS.

The tests were all made on small pieces of selected stock from principal dealers on Puget Sound.

CONCLUSIONS.

(1) Strength. Douglas Fir is generally equal to Yellow Pine, and superior to it in some essential particulars.

(2) Elasticity. Douglas Fir is decidedly more elastic than Yellow Pine.

(3) Toughness. Douglas Fir is far superior to Yellow Pine as regards toughness.

(4) Wearing Qualities. Yellow Pine is superior to Douglas Fir on account of the greater pitch that it contains.

(5) Lasting Qualities. Yellow Pine is superior to Douglas Fir on account of the greater amount of pitch that it contains.

(6) Weight. Douglas Fir is 14 per cent. lighter than Yellow Pine.

Fine grained lumber is stronger than coarse grained, except as against splitting.

Horizontal rings gives the strongest beams.

TESTS OF PACIFIC COAST RED FIR.

BY L. E. HUNT, IN CHARGE OF U. S. PACIFIC COAST LABORATORY.

	Static Test, Flexure, Load at Mid-Span			Static Test Compression, parallel to Fiber		Static Test Compression perpendicular to Fiber	Shear parallel to Fiber from Flexure Tests	
	Fiber Stress at Elastic Limit pounds per sq. inch	Fiber Stress at Rupture pounds per sq. inch	Modulus of Elasticity 1000 pounds per sq. inch	Fiber Stress at Elastic Limit pounds per sq. inch	Fiber Stress at Rupture pounds per sq. inch	Fiber Stress at Elastic Limit pounds per sq. inch	Sticks failing by Shear pounds per sq. inch	All sticks tested pounds per sq. inch
Size	8"x16"x16'0"			6"x6" x30" to 4"x4" x20"		8"x16" x30" to 4"x4" x30"		8"x16"x 16'0"
Grade	Merchantable			All grades		All grades		Merchantable
Number of rings:								Of the 21 Merchantable sticks 8" x 16" x 16' 15 failed by shear 6 by comp &tension
Per in., average	13.8			15.0		11.6		
" " maximum	29.0			36.0		44.0		
" " minimum	4.0			2.0		3.0		
Percentage of:								
Moisture, average	22.4%			21.9%		21.8%		
" maximum	25.7			35.3		39.5		
" minimum	18.1			15.6		14.2		
Dry weight:								
Per cu. ft., average	27.0 lbs			28.8 lbs.		28.0 lbs.		
" " " maximum	30.2 "			42.6 "		36.7 "		
" " " minimum	23.6 "			22.1 "		22.2 "		
Average stress per sq. inch	4115	6418	1576	3309	4354	611	271	266
Maximum stress per sq. inch	5680	7820	1930	5540	7700	1290	334	334
Minimum stress per sq inch	3080	4350	1379	1405	1620	312	173	173
Number of Tests	21	21	21	301	301	306	15	21
Number of tests between average and aver. + 10% aver.	7	11	4	45	51	60	9	10
do — 10% aver.	5	4	11	35	55	46	2	4
do within 25% of average	17	19	21	204	226	231	14	19

TESTS OF PACIFIC COAST RED FIR.

See tables giving Classified Summary of Tests with respect to method of failure for each grade, and also with respect to the rate of growth; also the accompanying discussion, Proceedings American Railway Engineering and Maintenance of Way Association. Vol. 6, pp. 101-117 (1905).

AMENDMENTS.

General Requirements.—All timber shall be cut from sound trees, grain to show a large proportion of hard summer wood, sawed to full size, rectangular in section and out of wind; it shall be free from ring shakes, unsound knots or sound knots over one and one-half (1½) in. in diameter, knots in groups, pitch seams, decay or defects that will impair its strength or durability.

Guard Rail. Douglas Fir.—One face shall show all heart, the other face and both edges shall show not less than 75 per cent. heart, measured across the surface anywhere on the piece. It shall not show less than an average of 12 annual rings to the inch.

Bridge Ties. Douglas Fir.—Shall show not less than 85 per cent. heart at any point in the length of the tie; it shall show not less than an average of 12 annual rings to the inch.

Stringers. Long-Leaf Yellow Pine.—Shall show not less than 85 per cent. heart on each of the four sides, measured across the side anywhere in the length of the piece. Sound knots, less than three (3) in. in diameter, will be permitted in the vertical faces of the stringer at points not less than one-quarter the depth from the edge of the piece.

Stringers. Douglas Fir.—Shall show not less than 85 per cent. heart on any face and not less than 70 per cent. on any edge; it shall show not less than an average of 12 annual rings to the inch. Sound knots less than one and one-half (1½) in. in diameter will be permitted if not less than four (4) in. from the edge of the piece. Sound knots less than three (3) in. in diameter will be permitted in the vertical faces of the stringer at points not less than one-quarter the depth from the edge of the piece.

Caps and Sills. Douglas Fir.—Shall show not less than 75 per cent. heart on each face, measured across the face anywhere in the length of the piece; sound sapwood will be permitted, not exceeding two (2) in. in width at any corner. Knots must be sound and not over three (3) in. in diameter, measured on the surface of the timber, and must not be in groups. It shall show not less than an average of 12 annual rings to the inch.

Posts. Douglas Fir.—Shall show not less than 66 per cent. heart, measured across the face anywhere in the length of the piece. No knots will be permitted in the corners of the post; it shall show not less than an average of 12 annual rings to the inch. One inch wane will be allowed on two corners half the length of the piece.

Longitudinal Struts or Girts. Douglas Fir.—Shall show one side all heart; the other three sides shall show not less than 85 per cent. heart, measured across the face anywhere on the piece; it shall show not less than an average of 12 annual rings per inch.

Longitudinal X-Braces, Sash Braces and Sway Braces.—Long-Leaf Yellow Pine, Douglas Fir, White, Burr and Post Oak.—Shall show not less than 66 per cent. heart on each of the four sides anywhere in the length of the piece; no restrictions as to sap on edges.

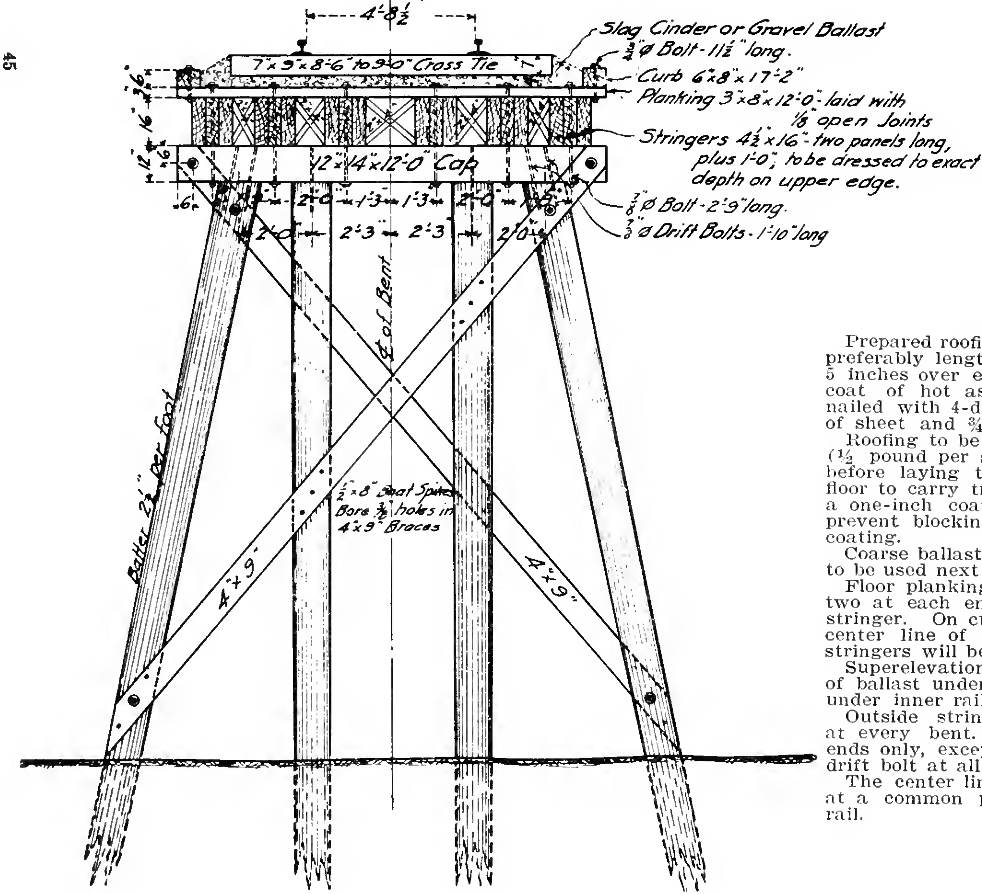
Piling. General Requirements.—All piling shall be cut from sound live trees of slow growth, firm grain, free from ring shakes, decay, large, unsound knots, or other defects that will impair their strength and durability. They shall be butt cuts, above the ground swell, and be uniformly tapering from the butt to the tip. They shall be so straight that a line stretched from the center of the pile at the butt to the center of the pile at the tip will not leave the center of the pile at any point more than two (2) in. for piles 20 ft., four (4) in. for piles 30 ft., six (6) in. for piles 40 ft., and eight (8) in. for piles 50 ft. in length. No short bends will be allowed.

Piling. Douglas Fir.—Piles shall be of either red or yellow Douglas Fir. They shall not be less than 14 in. nor more than 18 in. in diameter at the butt, and not less than 10 in. diameter at the tip. Piles over 40 ft. in length shall not be less than 16 in. nor more than 22 in. diameter at the butt, and not less than 8 in. diameter at the tip; they shall show not less than 75 per cent. heart at the tip.

Cast Washers.—Cast washers shall be of cast-iron. The diameter shall be not less than 3½ times the diameter of bolt for which it is used, and its thickness equal to the diameter of bolt; the diameter of hole shall be ⅛-in. larger than the diameter of the bolt.

Special Castings.—Special castings shall be made true to pattern, without wind, free from flaws, and excessive shrinkage; size and shape to be as called for by the plans.

Safe Unit Stresses.—Change the words "Pacific Coast" to read "Douglas," in the third, sixth and ninth lines.



Elevation of Bent, Single Track Ballasted Wooden Trestle—Oregon Short Line Railroad.

GENERAL NOTES.

For trestles more than one story in height, longitudinal girts to occur at vertical intervals of 12 feet, measured from top of cap, and at every sixth bent; towers to be framed as per plan.

For heights less than 16 feet from ground surface to top of cap, longitudinal girts to be omitted.

For heights less than 7 feet from ground surface to top of cap, sway bracing to be omitted.

Piles and caps to be creosoted. All other material to be untreated pine.

Prepared roofing to be laid with 3-inch lap joints, preferably lengthwise of trestle and turned down 5 inches over ends of planking. Joints to have a coat of hot asphalt applied between laps and nailed with 4-d. nails, 2½ inches apart lengthwise of sheet and ¾ inch from edge of sheet.

Roofing to be reinforced with extra asphalt coat (½ pound per sq. ft.) to make ¼ inch thick and before laying temporary blocking or stringers on floor to carry traffic previous to ballasting, spread a one-inch coat of coarse sand or pea gravel to prevent blocking sticking to or injuring asphalt coating.

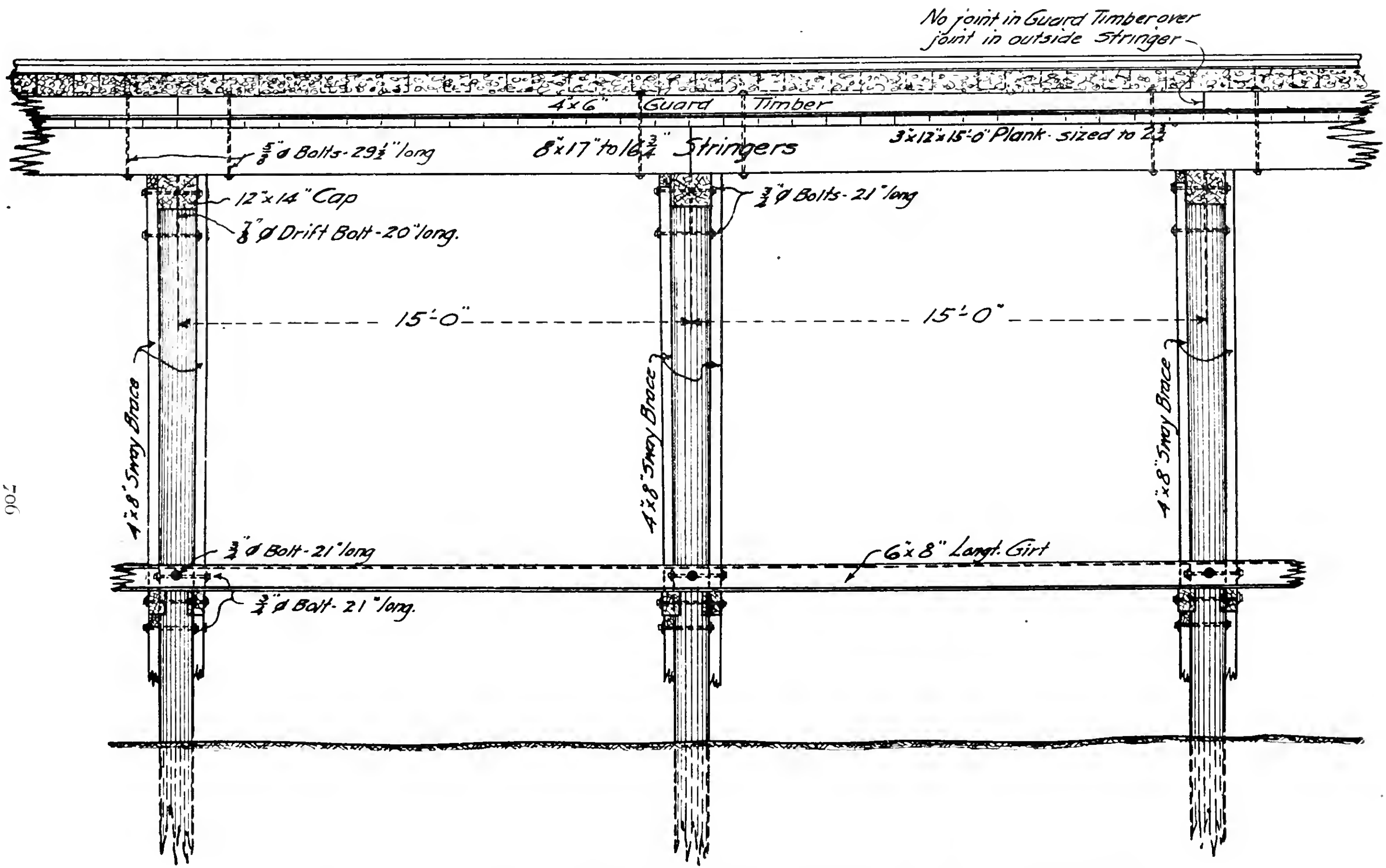
Coarse ballast (no dimension less than one inch) to be used next to guard timbers.

Floor planking will be spiked with 6-inch spikes, two at each end, and one at each intermediate stringer. On curves, bents to be placed radial to center line of track and spaced so that outside stringers will be 30 feet long.

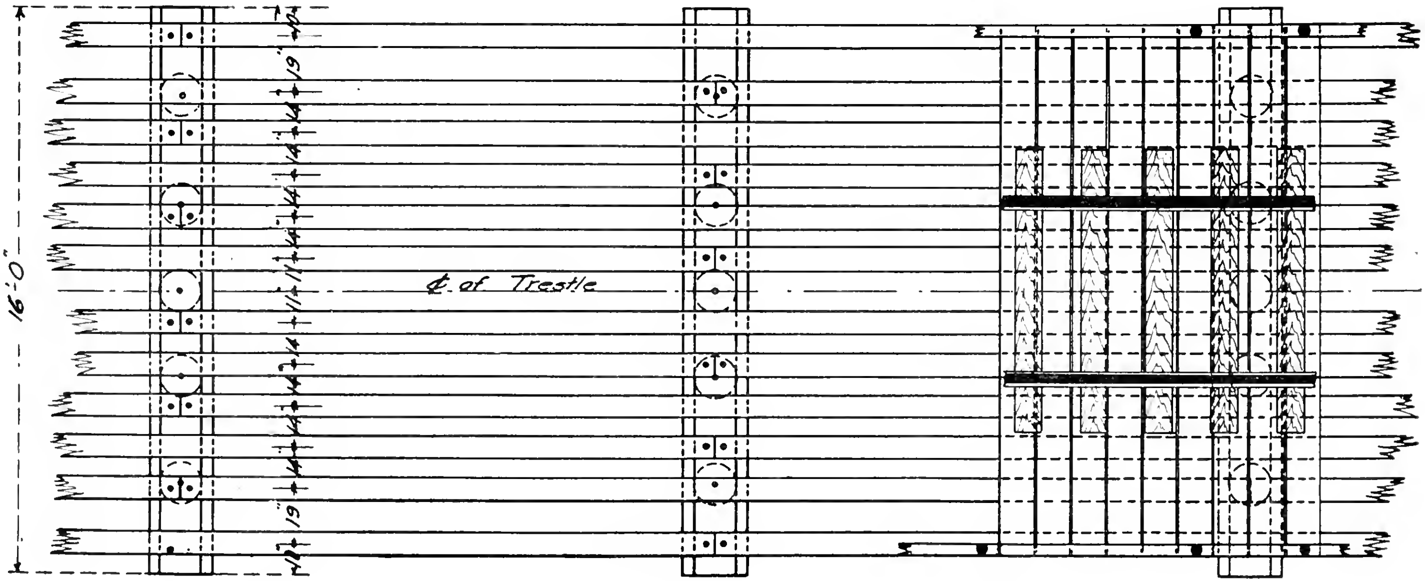
Superelevation to be effected by increasing depth of ballast under outer rail, the depth of ballast under inner rail being constant.

Outside stringers to be drift bolted to caps at every bent. Inside stringers drift bolted at ends only, except on openings 30 feet long, when drift bolt at all bents.

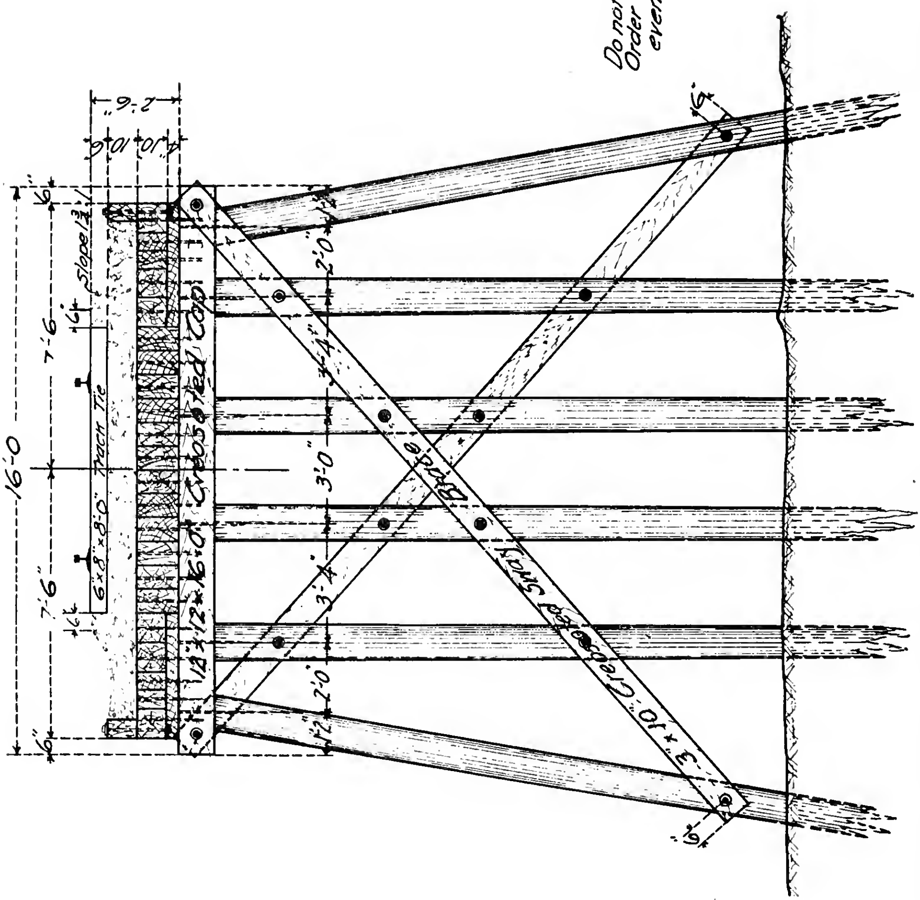
The center lines of piles prolonged should meet at a common point about 26 feet above base of rail.



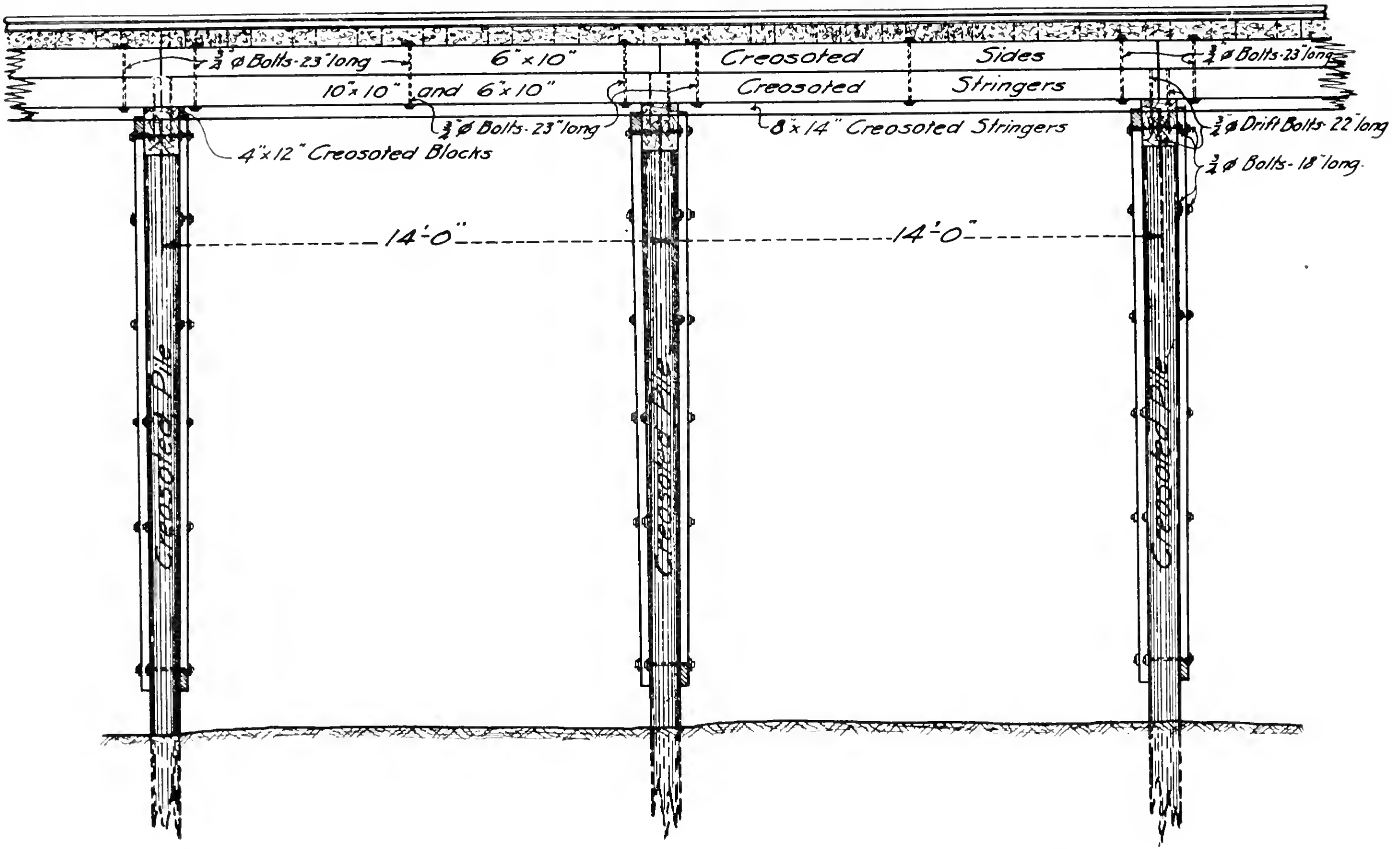
Side Elevation, Single Track Ballasted Wooden Trestle—Oregon Short Line Railroad.



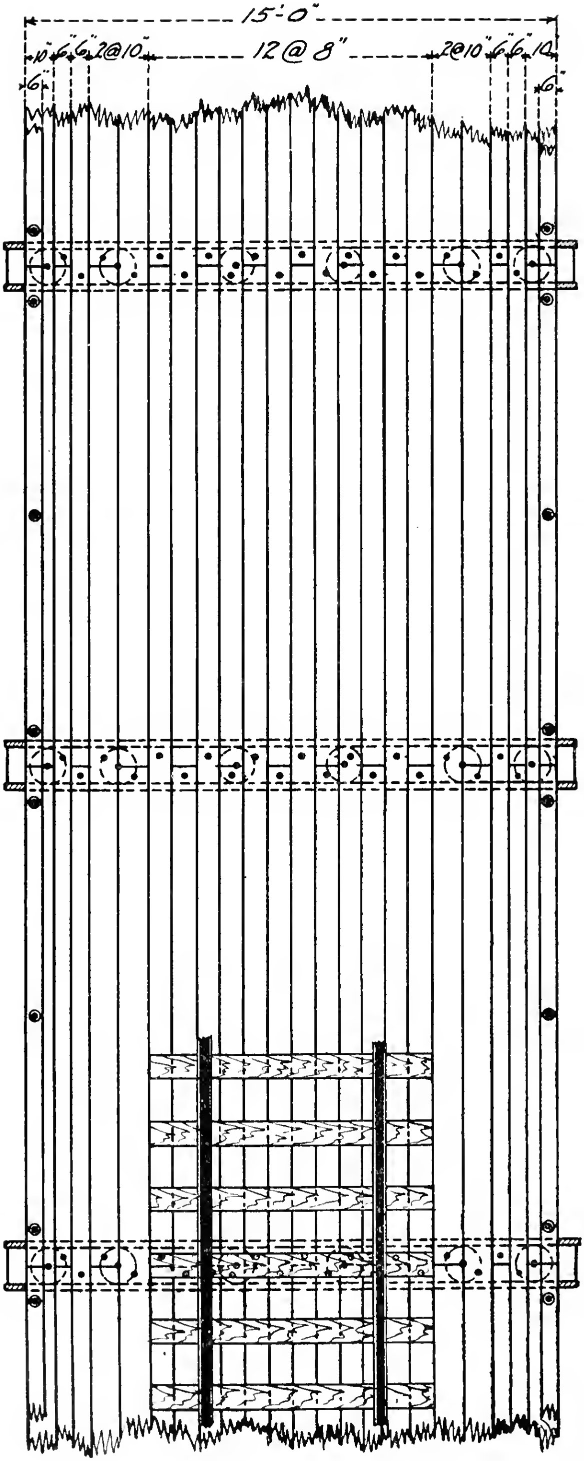
Floor Plan, Single Track Ballasted Wooden Trestle—Oregon Short Line Railroad.



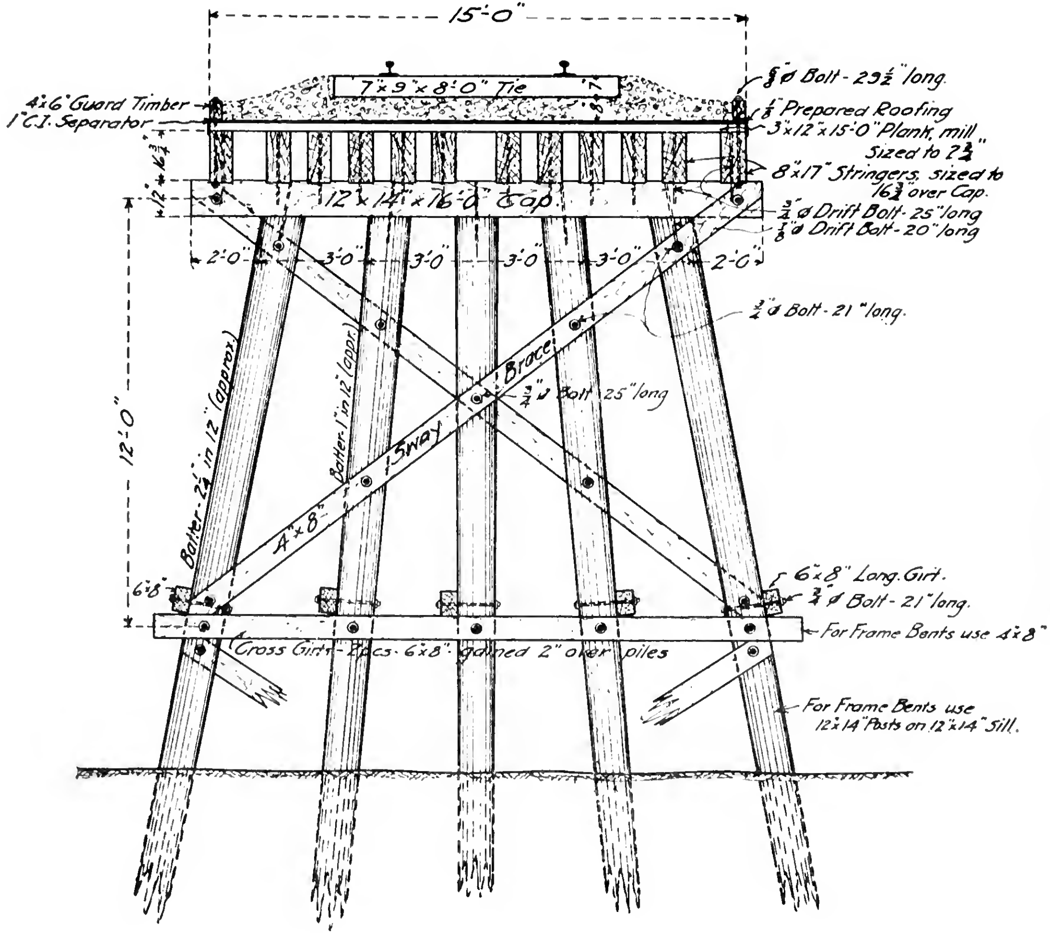
ELEVATION OF BENT, SINGLE TRACK BALLASTED WOODEN TRESTLE—ATCHISON, TOPEKA & SANTA FE RAILWAY.



Side Elevation, Single Track Ballasted Wooden Trestle—Atchison, Topeka & Santa Fe Railway.



Floor Plan, Single Track Ballasted Wooden Trestle—Atchison, Topeka & Santa Fe Railway.

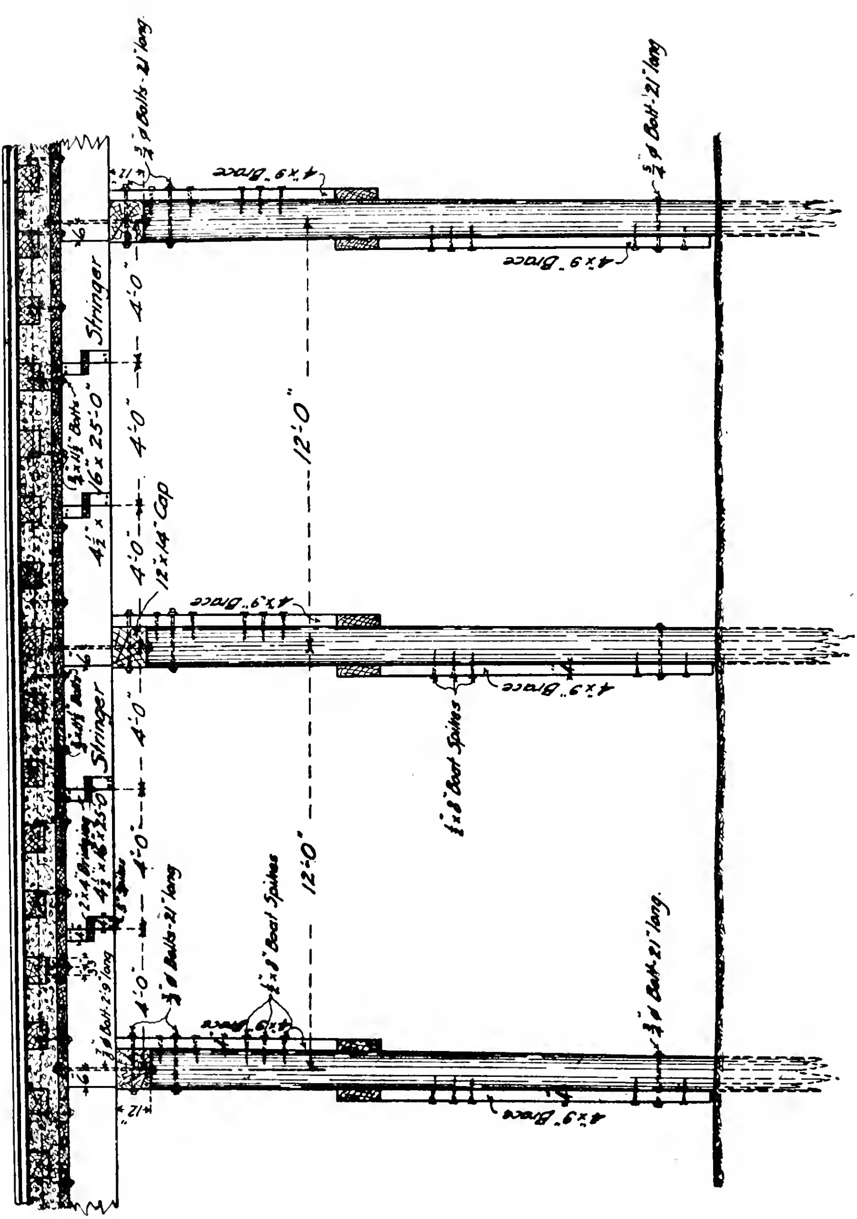


GENERAL NOTES.

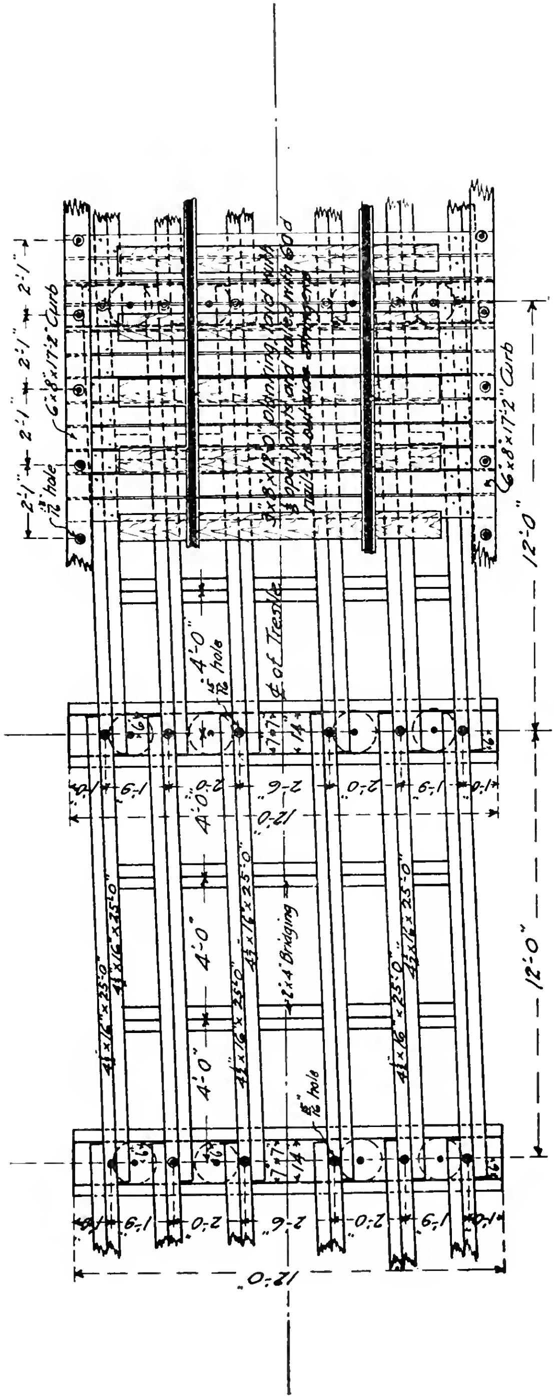
All timbers, including piles, to be creosoted.

Creosoted timber not to be cut if it can possibly be avoided; should it become absolutely necessary to cut any of the creosoted timbers, then the ends of the timber shall be painted with creosote oil and pitched.

Elevation of Bent, Single Track Ballasted Wooden Trestle— Louisville & Nashville Railroad.



SECTION ALONG CENTER LINE, SINGLE TRACK BALLASTED WOODEN TRESTLE—LOUISVILLE & NASHVILLE RAILROAD.



FLOOR PLAN, SINGLE TRACK BALLASTED WOODEN TRESTLE—LOUISVILLE & NASHVILLE RAILROAD.

DISCUSSION.

The President:—We will now consider the report of the Committee on Wooden Bridges and Trestles. Prof. H. S. Jacoby, vice-chairman of the Committee, will present the report in the absence of the chairman.

Prof. H. S. Jacoby (Cornell University):—The work of the Committee, so far as the specifications for bridge and trestle timber and piles are concerned, is mainly a rearrangement of material. As presented last year, there was considerable repetition, with a view of having the various sections practically complete, so that any part could be taken out and used separately. It was felt, as shown by the discussion last year, that there was too much repetition in the specifications and that it would be better to have general requirements, and afterwards only to give the details in which they differed from one another, as relating to stringers, caps and sills and posts, without repeating such requirements in every single case. The specifications as presented, beginning on page 106, of Bulletin No. 71, were practically adopted at the last annual meeting and are now presented in a different form.

We were also asked to prepare specifications for the metallic details used in wooden bridges and trestles, and to prepare specifications for workmanship for trestles to be built by contract.

There are a few suggestions made in the recently printed discussions which the Committee is willing to accept, and which will not be regarded as material changes. Wherever the word "rings" is employed, it is to be replaced by "annual rings." In the paragraph at the bottom of page 106, second and third lines from the bottom, the clause "sound sapwood will be permitted on two corners of the stringer" is to be stricken out as superfluous, because it is already covered in the preceding part of the paragraph, which says, "shall show not less than 85 per cent. heart on any face," etc.

On page 107, next to the last paragraph, where it says, "shall show not less than 66 per cent. heart," insert between the words "heart" and "anywhere" the expression "on each of the four sides."

On the top of page 109, change the word "Oregon" to "Douglas."

It has been suggested that for the general requirements on page 106 a slight modification be made, which the Committee is willing to accept, so as to read as follows: "All timber shall be cut from sound trees, grain to show a large proportion of hard summer wood," the idea being that it is more important, according to the great body of tests recently made by the Bureau of Forestry, to have a large proportion of summer wood than it is that the tree shall simply have slow growth, and that in a period of fairly rapid growth, when the proportion of hard summer wood is relatively large, really gives a better tree. The term "ring shake" is to be substituted for "wind shake." It indicates the observed fact without reference to the cause. Reduce the size of knots from 2 inches to 1½ inches.

In the paragraph on "Longleaf yellow pine for stringers" add another sentence: "Sound knots, less than three inches in diameter, will be permitted in the vertical faces of the stringer at points not less than one-quarter the depth from the edge of the piece." Tests show that if a knot be not less than 25 per cent. of the depth of the piece from the edge, it is not injurious. This change gives a more satisfactory specification than the one printed. Under Douglas fir for stringers, the same addition should be made.

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis):—For the purpose of hastening the consideration of this report I wish to ask the Committee if the report as presented modifies the meaning of the specifications which were adopted last year? There is no comparison between the old and the new. These specifications were thoroughly threshed over last year and they were referred back to the Committee simply for readjustment and condensation. As I understand it, this report as printed shows that readjustment and condensation only. No essential features have been altered?

Prof. Jacoby:—As printed in Bulletin No. 71, the changes relate mainly to rearrangement of material. No essential changes were made in regard to percentages of heart wood or other data.

The Secretary:—The following communication has been received from Prof. W. K. Hatt:

"The American Society for Testing Materials has appointed a Committee to draw up specifications for structural timber. This committee includes not only engineers but consumers and producers. As timber must be used as it is found in the forest, it is necessary that specifications shall reflect the condition of supply.

"The present specifications are an advance, but further consideration seems necessary.

"It is therefore moved that the specifications for bridge and trestle timbers and piling be referred back to the Committee with the instruction that they co-operate with the committee of the American Society for Testing Materials for Structural Timber, with a view to the preparation of joint specifications."

Mr. L. C. Fritch (Illinois Central):—I move the adoption of the motion.

Mr. McDonald:—I second it.

(The motion was lost.)

The President:—If there is no objection, the specifications for bridge and trestle timber and piling, as now presented, with the changes mentioned by Prof. Jacoby, will stand approved. We will next consider the recommended specifications for workmanship for pile and timber trestles to be built under contract.

The Secretary:—"RECOMMENDED SPECIFICATIONS FOR WORKMANSHIP FOR PILE AND TIMBER TRESTLES TO BE BUILT UNDER CONTRACT.—Site.—The trestle to be built under these specifications is located on the line of .... Railroad, at ...., County of ...., State of ....

"GENERAL DESCRIPTION.—The work to be done under these specifications covers the driving, framing and erection of a .... track wooden trestle about ...... ft. long and an average of ...... ft. high.

"The contractor is to furnish all the necessary labor, tools, machinery, supplies, temporary staging and outfit to build the trestle complete ready for the rails of track in a workmanlike manner, in strict accordance with the plans and the true intent of these specifications to the satisfaction and acceptance of the engineer of the Railroad Company.

"GENERAL CLAUSES.—The workmanship to be of the best quality in the several lines of work; all details, fastenings and connections to be of the best method in general use on first-class work.

"Holes must be bored for all spikes and drift bolts for at least two-thirds the length of the spike or drift bolt to be used; the auger to be the same diameter as the thickness of the spike.

"All timber must be cut at the ends with a saw and not with an axe.

"On the completion of the work, all refuse material and rubbish that may have accumulated on top or under and near the trestle, by reason of its construction, shall be removed by the contractor.

"The engineer or his authorized agents shall have full power to cause any inferior work to be condemned and taken down or altered at the expense of the contractor. Any material destroyed by the contractor on account of inferior workmanship or carelessness of his men to be replaced by the contractor at his expense.

"Figures shown on the plans are to govern in preference to scale measurements; if any discrepancies should arise or irregularities be discovered in the plans, the contractor shall call on the engineer for instructions. These specifications and the plans are intended to cooperate, and, should any question arise as to the proper interpretation of the plans or these specifications, it shall be referred to the engineer for a ruling.

"The contractor shall, when required by the engineer, furnish a satisfactory watchman to guard the work.

"DETAIL SPECIFICATIONS.—Piles.—All piles shall be carefully selected to suit the place and ground where they are to be driven. When required by the engineer, pile butts shall be provided with iron or steel rings, and the tips with suitable iron or steel shoes; such rings and shoes will be furnished by the Railroad Company. All piles to be driven to a firm bearing, satisfactory to the engineer, or until five blows of a hammer weighing 3,000 lbs., falling 15 ft. (or a hammer and fall producing the same mechanical effect), are required to drive the pile one-half (½) in. per blow, except in soft bottom, when special instructions will be given.

"Batter piles shall be driven to the inclination shown by the plans and shall require but slight bending before framing.

"Piles.—The butts of the piles in a bent to be sawed off to one plane and to be trimmed so as not to leave any horizontal projection outside of the cap.

"Piles to be slightly flattened at intersection of braces, to give them a fair bearing.

"Piles injured in driving, or driven out of place, shall either be pulled or cut off and replaced by new piles.

"Caps.—Caps shall be sized over the piles or posts to a uniform thickness and even bearing on piles or posts. They shall be drift-bolted to piles or posts.

"The side with most sap shall be placed downward.

"Posts.—Posts shall be sawed to proper length for their position (vertical or batter) to an even bearing on cap and sill. They shall be drift-bolted to cap and doweled or toe-nailed to sill.

"Sills.—Sills shall be sized at the bearing of posts to one plane. They shall be doweled to posts and drift-bolted to sub-sills.

"Sway Braces.—All sway bracing shall be properly framed and securely bolted to piles or posts, when necessary, for pile bents; filling pieces shall be used between the braces and the piles on account of the variation in size of piles, to obtain a bearing against all piles.

"Longitudinal Braces.—Longitudinal struts and X-braces shall be properly framed and securely bolted to piles or posts.

"Girts.—Girts shall be properly framed and drift-bolted to caps, sub-sills, posts or piles, as the plans may require.

"Stringers.—Stringers shall be sized to a uniform height. They shall be laid with alternating joints, provided with packing spools or separators, and the several lines under each rail bolted together. All continuous stringers over cap shall be drift-bolted to cap.

"The edges with most sap shall be placed downward.

"Jack Stringers.—Jack stringers, when used, shall be neatly framed on caps and drift-bolted to cap.

"Ties.—Ties shall be notched over the stringers to a close fit, firm bearing, and uniform top surface. They shall be spaced regularly, cut to even length and a line as called for on the plans.

"Every sixth tie shall be spiked at each end to outside stringers, the spikes to be in the same tie in which the guard rail bolts occur. When ties are planed to uniform thickness, the rough side shall be placed upward.

"Guard Rails.—Guard rails shall be neatly notched over every tie, spliced at joints by half and half splice over a tie.

"They shall be bolted to every third tie, the bolt to be placed in the same tie for each guard rail. The splices of guard rail shall be bolted to the tie underlying the splice.

"Time of Completion.—The work to be completed in all its parts on or before the .... A. D., 19....

"Payments.—Payments will be made under the usual regulations of the Railroad Company."

Mr. C. H. Cartlidge (Chicago, Burlington & Quincy):—It seems to me where the specification says, "Ties shall be notched over the stringers to a close fit," is wrong and out-of-date. Any repairs to a wooden stringer bridge generally involve the replacing of a portion of the stringer chord, and if the ties are notched down to a close fit over the stringers, that adds materially to the labor, and I move that it be amended to read, "sized to a uniform surface," or any wording meaning the same thing.

Mr. C. S. Churchill (Norfolk & Western):—I hardly think that we will get a good floor system with ties not fastened over the stringers. We follow the same practice of notching ties over the steel stringers of steel bridges, and I see no argument for not following this course in wooden structures, whatever form of trestle they may be.

Mr. Cartlidge:—I think the question is different in regard to wooden and iron stringers. In the case of a wooden stringer, we need very often four sticks, and each one, under these specifications, has to be closely fitted. They will vary, within a quarter of an inch, and each stringer must have its own dap in the tie, and each must be fitted. If the stringer is taken out, the floor must be jacked up to a greater height than would be necessary if the tie was simply sized on the stringer, as recommended. As far as fastening the floor of the tie on the stringer is concerned, the practice on the road with which I am connected is to lag-screw the deck to the stringer, and we have no difficulty. We have abandoned the notching of the ties over stringers over the whole system, and content ourselves with bolting the deck in the case of iron stringers and lag-screwing them in the case of wooden stringers.

Mr. A. S. Markley (Chicago & Eastern Illinois):—I cannot agree with Mr. Cartlidge that it is good practice to secure ties to wooden stringers with lag-screws for the purpose of holding track in line and only sizing the ties instead of dapping. Trains passing over bridges cause ties to vibrate more or less. In doing so, lag-screws are likely to break off, leaving the track unprotected in this direction. The Committee's recommendation of dapping ties over stringers is certainly the proper method for practical purposes.

Mr. Cartlidge:—There is nothing in the amendment that I propose which would prevent notching ties if it is desired to do so. The point that I make is that those who do not want to notch them should not be compelled under this specification to do so. There should be a certain amount of latitude left in such cases.

Mr. I. O. Walker (Nashville, Chattanooga & St. Louis):—In the two paragraphs relating to ties the Committee have attempted to inject a bridge design into these specifications, and that being the case, I should say that these paragraphs were out of place.

(The motion was carried.)

Mr. McDonald:—The point has been raised that the specifications carry with them not only workmanship, but design, and I think it is well taken. I wish to refer back to the place where it says that stringers shall be drift-bolted to the caps. I do not consider that good practice, and I think it is unnecessary. We do not do it at all. If you expect to protect your timber by means of galvanized iron, it will be fatal to it. I do not think the specifications can be adopted in their present form—all through them they treat of design rather than the quality of workmanship, and I move therefore that they be referred back to the Committee for further consideration with regard to workmanship only.

(The motion was carried.)

The President:—The next item in the report is the "Specifications for Metallic Details Used in Wooden Bridges and Trestles." The Secretary will read the specifications.

The Secretary:—"SPECIFICATIONS FOR METALLIC DETAILS USED IN WOODEN BRIDGES AND TRESTLES.—GENERAL REQUIREMENTS.—Wrought-Iron.—Wrought-iron shall be tough, fibrous and uniform in character. It shall be thoroughly welded in rolling and be free from surface defects. When tested in specimens of the form of Fig. 1 (see page 692) or in full-sized pieces of the same length, it shall show an ultimate strength of at least 50,000 lbs. per sq. in., an elongation of 18 per cent. in 8 in., with fracture wholly fibrous. Specimens shall bend cold, with the fiber, through 135 degrees, without sign of fracture, around a pin the diameter of which is not over twice the thickness of the piece tested. When nicked and bent, the fracture shall show at least 90 per cent. fibrous.

"Steel.—Steel shall be made by the open-hearth process. It shall contain not over 0.04 per cent. phosphorus and not over 0.04 per cent. sulphur, when tested in specimens of the form Fig. 1 (see page 692) or full-sized pieces of same length. It shall have a desired ultimate strength of 50,000 lbs. per sq. in.; tensile tests of steel showing an ultimate strength within 5,000 lbs. per sq. in. of that desired will be considered satisfactory, except that, if the ultimate strength varies more than 4,000 lbs. from that desired, a retest shall be made on the same, which, to be acceptable, shall be within 5,000 lbs. of the desired ultimate; it shall have an elongation of $\frac{1,500,000}{\text{ult. tens. strength}}$ in 8 in.; it shall bend cold without fracture 180 degrees flat. The fracture of tensile test shall be silky.

"Cast-Iron.—Cast-iron shall be made of tough gray iron, with sulphur not over 0.10 per cent. If tested on the 'Arbitration Bar' of the American Society for Testing Materials, which is a round bar $1\frac{1}{4}$ in. in diameter and 15 in. in length, the transverse test shall be made on a supported length of 12 in. with load at the middle. The minimum breaking load so applied shall be 2,900 lbs. with a deflection of at least $\frac{1}{16}$-in. before rupture.

"DETAIL SPECIFICATIONS.—Bolts.—Bolts shall be of wrought-iron or steel, made with square heads, standard size, the length of thread to be 2½ times the diameter of bolt. The nuts shall be made square, standard size, with thread fitting closely the thread of bolt. All threads shall be cut according to U. S. standards.

"Drift Bolts.—Drift bolts shall be of wrought-iron or steel, with or without square head, pointed or without point, as may be called for on the plans.

"Spikes.—Spikes shall be of wrought-iron or steel, square or round, as called for on the plans; steel wire spikes, when used for spiking planking, shall not be used in lengths more than 6 in.; if greater lengths are required, wrought or steel spikes shall be used.

"Packing Spools or Separators.—Packing spools or separators shall be of cast-iron, made to size and shape called for on plans; the diameter of hole shall be ⅛-in. larger than diameter of packing bolts.

"Cast Washers.—Cast washers shall be of cast-iron. The diameter shall be not less than 3½ times the diameter of bolt for which it is used, and not less than ⅝-in. thick; the diameter of hole shall be ⅛-in. larger than the diameter of the bolt.

"Wrought Washers.—Wrought washers shall be of wrought-iron or steel; the diameter shall be not less than 3½ times the diameter of bolt for which it is used, and not less than ¼-in. thick. The hole shall be ⅛-in. larger than the diameter of the bolt.

"Special Castings.—Special castings shall be of cast-iron, made true to pattern, without wind, free from flaws, and excessive shrinkage; size and shape to be as called for by the plans.

"SAFE UNIT STRESSES.—The following allowable unit stresses are recommended, their values being chosen so as to include the allowance for impact:

"STRINGERS.—For long-leaf yellow pine and Pacific Coast red fir: 1,200 lbs. per sq. in. on the extreme fibers in bending, and 120 lbs. per sq. in. for shear parallel to the fibers.

"CAPS AND SILLS.—For long-leaf yellow pine and Pacific Coast red fir: 300 lbs. per sq. in. for bearing on the side of the fibers.

"For white, post and burr oak: 500 lbs. per sq. in.

"POSTS AND PILES.—For long-leaf yellow pine and Pacific Coast red fir: $1{,}200 - 18\frac{l}{d}$ lbs. per sq. in. for the average compression on the cross-section, in which "l" is the length and "d" the least diameter of the column, both expressed in inches.

"For white, post and burr oak: $1{,}000 - 15\frac{l}{d}$ lbs. per sq. in.

"For Norway pine, cypress and cedar: $800 - 12\frac{l}{d}$ lbs. per sq. in."

Prof. Jacoby:—At the bottom of page 113, and at the top of page 114, where the words "Pacific Coast red fir" are used, they should be replaced by the words "Douglas fir" as that term is used by the Association in former reports.

Mr. Cartlidge:—I would ask the Committee if in their opinion it would be necessary in letting contracts for timber trestles to have tests made of the structural material. It does not seem as if a lot of bolts, spikes and lag-screws should require testing in the same manner as structural steel. It would seem as if, having the bolts, it would be an easy matter to determine whether they would do the work or not. They are not called upon to stand high stresses or bending stresses, except perhaps in the case of washers; and to bring it before the convention, I would move that the specifications for metallic details be referred back to the Committee with instructions to simplify them so that they might read rather more as covering surface and workmanship than the quality of material of which they are composed.

Mr. A. J. Himes (New York, Chicago & St. Louis):—As to the necessity of testing material for bolts to be used in wooden trestles, I will say that at one time I purchased a considerable quantity of bolts without a specification, and found them very bad indeed—they were hardly fit to use.

Mr. McDonald:—I think the gentleman who made the motion has overlooked the fact that the material is intended to be used in wooden bridges.

Mr. Cartlidge:—I understood these details to apply to trestle bridges, and not to apply to Howe truss bridges.

Mr. C. F. Loweth (Chicago, Milwaukee & St. Paul):—I notice that in the paragraph referring to cast washers, that the cast washer is to be ⅝-inch thick. That is proper for a ⅝-inch bolt, but for a Howe truss bridge washer it would be out of the way. I think we should revise it so as to make the thickness of the washer equal to the diameter of the bolt with which it is to be used.

The President:—The Committee accepts that alteration.

Mr. Loweth:—I also suggest that the next to the last clause on page 113, "Special castings shall be of cast-iron," etc., be appended to the requirement for castings, near the top of the same page. I make a motion to that effect.

Mr. L. C. Fritch:—It seems to me that the Committee's report as it stands is proper. In "Special Castings" it refers to the details, while the paragraph above on "Cast-iron" is a general clause.

(The motion was lost.)

Prof. Jacoby:—It might be better in this case to omit the words "shall be of cast-iron" and say, "Special castings shall be made true to pattern," etc.

The President:—If there is no objection, the Committee will be allowed to make that change.

Prof. W. D. Pence (Purdue University):—I suggest that the paragraphs be numbered when printed.

Mr. Loweth:—I would call attention to the fact that when the report of the Committee on Iron and Steel Structures was under consideration it was decided by the convention that the safe unit stress in a bridge floor was two thousand pounds, with an allowance for impact, and we should certainly change the twelve hundred pounds at the top of page 114 to two thousand pounds.

Prof. Jacoby:—I call attention to the statement in the opening sentence on the lower part of page 113: "The following allowable unit stresses are recommended, their values being chosen so as to include the allowance for impact." It will be remembered, in reference to the report to which Mr. Loweth has called attention, a separate computation for impact is made, so that uniform unit stresses may be adopted. The idea here is that the unit stresses are taken so low that no separate addition is made to allow for impact or the effect of moving loads. If it is desired to change the method of dealing with the unit stresses in timber structures, or making a separate computation, that might be done by raising all the stresses. Is it not the general practice in designing timber structures not to make separate computations for the dynamic effect of moving loads?

The President:—The chair would ask Mr. Loweth whether the specification of the Committee on Iron and Steel Structures, where they give the allowable extreme fiber stress, did not apply to ties only and not to stringers? This item, as the chair understands it, applies to stringers.

Mr. Loweth:—That is true. In the specifications for steel structures we give the unit stresses for ties, and the Committee recommended two thousand pounds, adding an allowance for impact, as being a safe and proper stress in the tie. If that is true, then certainly twelve hundred pounds, without making the same allowance for impact in proportion to the length of span, is altogether too low a unit stress. I think in any impact formula the difference between the impact on the tie and on the stringer would not be very great.

Mr. J. W. Schaub (Consulting Engineer):—I think Mr. Loweth is laboring under a misapprehension. Prof. Jacoby included that allowance—included all impact necessary—and he is perfectly correct. According to Mr. Loweth, you could not add anything for impact. and two thousand pounds for fiber stress would be ridiculous. To allow two thousand pounds fiber stress for a static load would be absurd.

Prof. A. N. Talbot (University of Illinois):—I desire to ask whether the Committee, in selecting unit stresses, intended to include the allowance for impact in the stress recommended for shear parallel to the fibers (longitudinal shear) in the case of timber stringers, as they evidently did in the unit stress of twelve hundred pounds per square inch given for the maximum bending fiber stress. If so, it is evident that the factor of safety for longitudinal shear is considerably less than for fiber stress. It should be recognized that for ordinary timber stringers of the length and depth generally used, the longitudinal shearing resistance of the wood is the controlling consideration, rather than the tensile or compression strength. Many values given for longitudinal shearing resistance are not applicable to the longitudinal shear of timber stringers, and their application to beams gives results far beyond the strength of the pieces. The values given for long-leaf yellow pine in two of the tables included in the Committee's report are of this kind, and engineers should be warned against using these values in calculating the strength of beams. The value given for "shearing with the grain" in the table of the American Railway Superintendents of Bridges and Buildings indicates an ultimate shearing resistance of six hundred pounds per square inch, and that in the table from Bulletin No. 12 of the Division of Forestry a resistance of five hundred pounds per square inch. Values as high as eight hundred pounds per square inch have been quoted. However, the value given in the table abstracted from Circular No. 32 of the United States Bureau of Forestry and credited to Prof. W. K. Hatt is two hundred and sixty-eight pounds per square inch as the average of all beams failing by longitudinal shear. Tests made at the University of Illinois on 7x16x14 feet yellow pine stringers give an average of three hundred and twenty pounds per square inch shearing resistance developed in the beams which failed by longitudinal shear. Nearly all of these stringers failed by longitudinal shear, those failing otherwise having visible defects which would have insured rejection. Evidently the resistance to longitudinal shear is a more important quality than is generally recognized. It would seem that the values recommended by the Committee give a so-called factor of safety for longitudinal shear of 2¼ to 2¾, while for fiber stress the factor is 6 or 6½. It is to be presumed that the Committee has given this matter consideration.

Prof. Jacoby:—Referring to the remarks made by Prof. Talbot, the Committee realizes that the amount of experimental knowledge in regard to horizontal shear on full-size pieces is not as voluminous or satisfactory as is desirable, and in general I think the practice has been to use a somewhat lower factor of safety for horizontal shear than for stresses in the outer fibers due to bending. It should be noted that the value of the unit stress here inserted is less than has been generally used in other specifications. As a rule, the lowest one to be found in any specification is one hundred and fifty pounds; but it was felt that our present knowledge based on experimental investigation was such that it should be reduced to one hundred and twenty pounds per square inch, with probably a further reduction to be made later.

The President:—If there is no objection, this portion of the Committee's report will be accepted as approved.

Prof. Jacoby:—The table on page 116 should be omitted, and the table on page 121 should take its place. The note at the bottom of the table on page 121 should be placed on page 116, under the section relating to "Pacific Coast red fir," this term being replaced by "Douglas fir" in all cases.

The President:—If there are no suggestions for the work of the Committee for the coming year, they will be excused with the thanks of the Association.

W. K. Hatt (Purdue University—by letter):—There are a few minor matters in the report which, in the opinion of the writer, can be improved.

In the specifications for bridge and trestle timbers, under the heading, "General Requirements," the term "wind shakes" should be replaced by the term "ring shakes." The size of pitch seams should be stated, because small pitch seams are very minor defects. The limitation to slow growth possesses but little significance. What is wanted is a wood that shows a large proportion of large summer growth. The wood next to the bark of a large tree, which is put on during the post-mature period of its growth, is of slow growth, but has little strength and durability. The best wood in the conifers is usually found about two-thirds of the distance from the center to the bark. This is wood usually of a vigorous growth, but containing a large proportion of hard summer wood. I would suggest the following substitution for the paragraph under the heading, "General Requirements:"

"All timber shall be cut from sound trees, grain to show a large proportion of hard summer wood; to be sawed to full size, rectangular in section and out of wind. It should be free from wind shakes, unsound knots, or sound knots over 1½ in. in diameter except as specified, knots in groups, large pitch seams, decay or defects that would impair its strength or durability."

I would suggest using the word "annual" in conjunction with the word "rings" in all cases.

With reference to the allowance of knots in stringers, I believe the following specifications will lead to the selection of good stringers:

"Longleaf Pine.—Shall show not less than 85 per cent. of heart on each of the four sides measured across the side anywhere in the length of the piece. Sound knots less than 3 in. in diameter will be permitted in the vertical faces of the stringer at points not less than one-quarter the depth from the edge of the piece.

"Douglas Fir.—Shall show not less than 85 per cent. of heart on any face, and not less than 70 per cent. on any edge; shall show not less than an average of 12 annual rings per inch. Sound knots less than 3 in. in diameter will be permitted in the vertical faces of the stringer at points not less than one-quarter the depth from the edge of the piece."

It is found as the result of tests of a large number of stringers that knots occurring in the vertical face of a beam not less than one-quarter the depth from the edge of the piece do not diminish the strength compared with that of a clear stick. Knots occurring anywhere outside of the middle two-thirds of the length of a stick do not diminish its strength.

The clause "sound sapwood will be permitted on two corners of the stringer," seems to be contained in the first clause of the specification for Douglas fir stringers, and, therefore, is unnecessary.

Longitudinal X-Braces, etc.—The intended meaning of the limitation of heart is not clear to the writer.

Douglas Fir Piling.—The sense of the specification only allows fir grown in Oregon. The word "Oregon" should be cut out before the word "fir."

Safe Unit Stresses.—Taking 1,200 lbs. per sq. in. on the extreme fibers in bending, and 120 lbs. per sq in. for shear parallel to the fibers, it will be found that for 8x16 stringers 12 ft. long these fiber stresses correspond to the same total load on the beam. Under this load, however, the factor of safety in bending is about 5½, and in shear is about 2.3.

Under "Caps, Sills, Posts and Piles," the words "Pacific Coast red fir" should be changed to read "Douglas fir."

Since, at times, the design of stringers is governed by the amount of deflection allowed, some recommendation for the modulus of elasticity should be made by the Committee. A modulus of elasticity of 750,000 lbs. per sq. in. in bending will yield a factor of safety of 2 against quickly-applied loads, and will give very nearly the actual deflection for dead loads.

In the tables showing the strength of timber, following the Committee report, it will be found that the table on page 121 includes the values given in the table on page 116. The latter should be omitted and replaced by the table on page 121.

I regard the average safe unit stresses recommended by the Committee of the American Association of Railway Superintendents of Bridges and Buildings as satisfactory. The factor of safety, however, for shear with the grain will not be as large as given in the table.

There is a large amount of loblolly pine and short-leaf pine grown under conditions which produce heavy, strong wood, with a considerable percentage of heart. This wood is equally strong with longleaf pine and Douglas fir, although, being sapwood, it is not so durable. However, for temporary trestle work it is equally available with these woods.

APPENDIX

OFFICERS OF PRELIMINARY ORGANIZATION.

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Secretary.

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Committee on Constitution and By-Laws.

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Thos. Rodd, Pennsylvania Lines, Pittsburg, Pa.
W. G. Curtis, Southern Pacific Company, San Francisco, Cal.
C. H. Hudson, Southern Railway, Washington, D. C.
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Editor.

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W. C. Cushing, Chief Engineer M. of Way, S. W. System, Pennsylvania Lines, Pittsburg, Pa.

J. P. Snow, Bridge Engineer, Boston & Maine Railroad, Boston, Mass.

Editor of Publications.

W. D. Pence, Professor of Railway Engineering, University of Wisconsin, Madison, Wis.

CONSTITUTION.

REVISED AT THE FIFTH ANNUAL CONVENTION.

ARTICLE I.

SECTION 1. Name: The name of this Association shall be "THE AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION."

SECTION 2. Location: The offices of the Association shall be located in Chicago, Ill.

SECTION 3. Object: The object of this Association shall be the advancement of knowledge pertaining to the scientific and economical location, construction, operation and maintenance of railroads.

SECTION 4. Means: The means to be employed for this purpose shall be as follows:

(a) Meetings for the reading and discussion of papers and for social intercourse.

(b) The investigation of matters pertaining to the objects of this Association through Standing and Special Committees.

(c) The publication of papers, reports and discussions.

(d) The maintenance of a library.

ARTICLE II.

MEMBERSHIP.

SECTION 1. The membership of this Association shall be divided into two classes, viz., Active and Honorary.

SECTION 2. Any Civil, Mechanical or Electrical Engineer who has had five (5) years' experience in the location, construction or maintenance of railroads, or a Professor of Engineering in a College of recognized standing, and any railroad official who is responsible for or has supervision of Maintenance of Way (embracing all grades of officials from General Managers to Engineers of Maintenance of Way in charge of Divisions, inclusive), or railroad men bearing other titles but performing similar duties, shall be eligible for Active membership; provided, however, that an applicant, to be eligible for membership, shall be not less than twenty-five (25) years of age.

SECTION 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. Honorary members shall have all the rights of Active members, except those of voting and holding office.

SECTION 4. Persons who are exclusively engaged in the sale or promotion of railroad patents or appliances shall not be eligible for nor retain Active membership in this Association.

ARTICLE III.

ADMISSIONS AND EXPULSIONS.

SECTION 1. The Charter membership shall consist of all persons who are eligible for membership under the provisions of Article II, and who may make application to the Secretary of the Preliminary Organization and receive a majority of the votes of the Organization Committee (composed of the Chairman and Secretary of the Preliminary Organization and the five persons constituting the Committee to prepare a Constitution and By-Laws), and pay the entrance fee, hereinafter provided for, within thirty days from the date of the adoption of this Constitution.

SECTION 2. After the expiration of said thirty days 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 the candidate's name, age, residence and technical 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 in the Association. An application shall not be considered by the Board which has not been formally endorsed by three members of the Association.

Upon receipt of an application properly endorsed, the Board of Direction, through its Secretary, or a Committee on Applications to be appointed by the Board of Direction from among its own members, shall make such investigation of the candidate's fitness as may be deemed necessary. The Secretary of the Association will furnish copies of the information obtained, together with a copy of the application, to each member of the Board of Direction. At any time, not less than thirty days after the filing of the application, the admission of the applicant shall be voted on by letter-ballot by each member of the Board of Direction. Affirmative votes by two-thirds of the Board of Direction 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 territory of the United States as precludes him from a sufficient acquaintance with members of the Association, he may refer to well-known men engaged in railroad 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 of Direction.

SECTION 3. All candidates, after due notice from the Secretary of their election, shall subscribe to the Constitution and By-Laws on forms 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.

SECTION 4. Any person having once been an Active member of the Association, and having, while in good standing, resigned from such membership, may at a subsequent date be restored to Active membership without the payment of a second entrance fee; provided his application for reinstatement is signed by five members, certifying to his fitness for re-election, and such application is favorably passed upon by the Board of Direction by a two-thirds majority vote of the entire Board.

SECTION 5. Honorary members shall be proposed by at least ten Active members to the Secretary. Each member of the Board of Direction shall be furnished with a copy of the proposal, and after thirty days votes by ballot shall be taken by the Board of Direction thereon. If a candidate shall receive the unanimous vote of said Board, he shall be declared elected an Honorary member.

SECTION 6. Expulsions: On written charges preferred by ten or more members, addressed to the Secretary of the Association, the member complained of shall be served with a copy of said charges, and shall be called upon to show cause to the Board of Direction why he should not be expelled from the Association. Thirty days after said member has been properly notified of the charge preferred against him, a vote shall be taken on his expulsion, and he may be expelled upon a two-thirds vote of the Board of Direction.

SECTION 7. Resignations: It shall be the duty of the Board of Direction to accept the resignation, tendered in writing, of any member whose dues are fully paid up.

ARTICLE IV.

DUES.

SECTION 1. An initiation fee of $10.00 shall be payable to the Secretary with each application for membership; this sum is to be returned to the applicant, however, who is not elected.

SECTION 2. The annual dues of this Association shall be $10.00, payable annually, during the first three months of each calendar year for the current year.

SECTION 3. Any person whose dues remain three months in arrears shall be notified of same by the Secretary. Should the dues in arrears not be paid prior to July 1st of each year, the delinquent member shall lose his right to vote, but shall continue to receive the publications of the Association. Should his dues become nine months in arrears 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 delinquent dues are not paid by the first of the following year, he shall forfeit his membership with the Association without further action or notice.

SECTION 4. The Board of Direction may, however, extend the time of payment of dues and for the application of these penalties. The Board of Direction may also, for sufficient cause, excuse from payment the annual dues of any member who, from ill-health, advanced age or other good reason, is unable to pay his dues.

ARTICLE V.

OFFICERS.

SECTION 1. The officers of this Association shall consist of a President, a First Vice-President, a Second Vice-President, six Directors, a Secretary and a Treasurer, who, together with the four latest living Past-Presidents who are Active 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. The offices of First and Second Vice-President shall be determined by the priority of the respective dates of election of the two Vice-Presidents.

SECTION 2. The term of office of the President shall be one year; that of the Vice-Presidents two years; that of the Directors three years, and of the Secretary and the Treasurer one year, with the exception, however, that at the first election of officers after the adoption of this Constitution one Vice-President and two Directors shall be elected to serve one year; one Vice-President and two Directors for two years, and two Directors for three years; provided, also, that after the first annual election, one Vice-President and two Directors shall be elected each year, in addition to the President, Secretary and Treasurer.

SECTION 3. The President shall not be eligible for re-election to that office until the period of eight years shall have elapsed after the expiration of his previous term of office. The Vice-Presidents and Directors shall not be eligible for re-election to the same office until at least one full term shall have elapsed after the expiration of their previous term of office.

SECTION 4. The first election of officers under this Constitution shall be held by the Preliminary Organization of Charter members immediately after the adoption of this Constitution, and the officers so elected shall at once assume office. The term of each officer shall begin at the close of each election and shall continue until his successor shall be elected.

SECTION 5. Any vacancy in the office of President shall be filled by the First Vice-President. A vacancy in the office of either of the Vice-Presidents shall be filled by election from among the Directors. In case of the disability or neglect in the performance of his duty of any officers of this Association, the Board of Direction, by a two-thirds majority of the entire Board, shall have power to declare the office vacant. Vacancies in any office for the unexpired term shall be filled by the Board of Direction, except vacancy in the office of President, as provided above.

SECTION 6. At least thirty days before each annual meeting, the Board of Direction, who shall act as a Nominating Committee, shall nominate to the Association a list of officers for the next ensuing year. At any time prior to the thirty days before the annual meeting any ten members of the Association shall have the right to nominate officers for the ensuing year. Thirty days prior to each annual meeting the Secretary shall issue ballots to each member of record in good standing, with a list of the several candidates to be voted upon, whose names shall be placed in alphabetical order if more than one person is nominated for any position. Ballots shall be placed in a sealed envelope, with the name of the member voting endorsed thereon, and deposited with the Secretary at any time previous to the annual meeting. At the annual meeting three tellers shall be appointed, who shall open and count the ballots and report the result thereof. The majority of votes cast for any nominee shall determine his election.

ARTICLE VI.

COMMITTEES.

SECTION 1. The Board of Direction shall meet within thirty days after each annual meeting, and shall appoint from among its members a Finance Committee of three, a Library Committee of three and a Committee on Publications of three. These Committees shall report to the Board of Direction and perform their duties under its supervision.

SECTION 2. 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.

SECTION 3. The Library Committee shall have general supervision of the library of the Association and property therein.

SECTION 4. The Committee on Publications shall have general supervision of the publications of the Association.

SECTION 5. The Board of Direction may appoint such Standing Committees as it may deem best, to investigate, consider and report upon methods or appliances pertaining to the general question of railroad location, construction or maintenance.

It shall be within the province of the Board of Direction to invite discussions of reports from sources outside of the Association from those who are especially qualified by their learning and experience to add to the value of the report under consideration; and such discussions may be printed in the Bulletins prior to the regular annual meeting, and, if approved by the vote of the Association, shall be included in the published Proceedings of the Association.

SECTION 6. Special Committees to examine into and report upon any subject connected with the purposes of this Association may be appointed in the following manner:

A resolution to appoint such Committee, setting forth its objects and the number of its members, may be presented by letter at any time to the Secretary of the Association, if signed by ten Active members, and shall be referred by him to the Board of Direction, which, if it sees fit, may appoint such Committee. If the Board of Direction should not deem it expedient to appoint such a Committee, the members requesting the appointment of such Committee shall be notified, and the matter will then be referred to the Association at its next annual meeting and decided upon by ballot. If two-thirds of the members present vote in favor of such Committee it shall be appointed by the President.

ARTICLE VII.

MANAGEMENT.

SECTION 1. The President shall have a general supervision of the affairs of the Association. He shall preside at all meetings of the Association and at all meetings of the Board of Direction, and shall be ex-officio member of all Committees.

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.

SECTION 2. The Board of Direction shall manage the affairs of the Association and shall have full power to control and regulate all matters not otherwise provided for in the Constitution.

SECTION 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.

SECTION 4. The Secretary shall be, under the direction of the President and Board of Direction, the Executive officer of the Association. He shall attend all meetings of the Association and of the Board of Direction, prepare the business therefor, and duly record the proceedings thereof. He shall see that all moneys due the Association are carefully 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 may be assigned to him from time to time by the Board of Direction.

ARTICLE VIII.

MEETINGS.

SECTION 1. The regular annual meeting of the Association shall be held in the City of Chicago, commencing upon the third Tuesday in March of each year, and at such place in said city as may be selected by the Board of Direction. Twenty-five Active members shall constitute a quorum. Other meetings of the Association may be held at such times and at such places, either within or without the City of Chicago, as the Board of Direction may select. The Secretary shall notify all members of the time and place of all meetings of the Association at least thirty days in advance thereof.

SECTION 2. The Board of Direction shall meet at such times and at such places as the President may direct. Five members of the Board of Direction shall constitute a quorum.

SECTION 3. The order of business at meetings of the Association shall be as follows:

1. Reading of Minutes of last meeting.
2. Address of the President.
3. Reports of the Secretary and Treasurer.
4. Reports of Standing Committees.
5. Reports of Special Committees.
6. Unfinished business.
7. New business.
8. Election of officers.
9. Adjournment.

This order of business, however, may be varied from on a majority vote of members present at any meeting.

SECTION 4. Discussions shall be limited to members and to those invited to speak by the Presiding Officer.

ARTICLE IX.

AMENDMENTS.

SECTION 1. Proposed amendments to this Constitution must be made in writing and signed by not less than ten Active 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 Board are in favor of considering the proposed amendments, the matter shall then be submitted by letter to each Active member of the Association for voting by ballot, and the result announced by the Secretary at the next annual meeting of the Association. In case two-thirds of the votes received are affirmative, the amendments shall be declared adopted. Amendments so adopted shall take effect thirty days thereafter.

GENERAL RULES FOR THE PREPARATION OF COMMITTEE REPORTS.

(1) Submit condensed statement of meetings held and names of members in attendance; also personnel of sub-committees appointed for special subjects.

(2) Review briefly last report, describing action taken by the Association thereon, enumerating in their order all conclusions adopted, referring to volume and page of Proceedings. Submit recommendations for changes in previously adopted reports when deemed advisable, and include specifications or standards adopted at the last convention.

(3) Make special effort, by personal request and letters, to secure written discussion of past reports as a guide for future action.

(4) Frame reports to conform as far as possible to the following general plan:

First—Historical.—A brief account of the history of the subject-matter of the report, giving an outline of the origin and development of the same.

Second—Analytical.—An analysis of the subject-matter of the report, especially of the most important elements thereof.

Third—Argument.—A statement giving the advantages in favor of the recommended practices and the disadvantages of the old or present practices.

Fourth—Conclusions.—The final recommendations for the adoption of the various elements of the report in the order of sequence, expressing in succinct language the action which it is desired the convention is to take.

Fifth—Definitions.—Submit definitions of technical terms used in the report, the meaning of which is not clearly established, defining them only from a professional standpoint. Group or tabulate definitions according to their analytical sequence or for convenience of discussion and reference.

Sixth—Plans.—The title of the drawings or plans submitted with reports to be placed in the upper right-hand corner, together with the following lettering:

Am. Ry. Eng. & M. W. Assn.
Convention of 190..
Committee on ....
(Title of drawing.)

(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 all committee work, but the ultimate aim of all the Association's efforts should be to produce permanent results. This can be best accomplished by having all committee work tend toward the presentation to the Association of concise conclusions, recommendations, specifications, standards, plans, etc., suitable for adoption and recommendation as good practice.

GENERAL RULES FOR CONSIDERATION AND PUBLICATION OF COMMITTEE REPORTS.

(1) No report shall come before the convention for discussion unless it has been published in the Bulletin.

(2) Written discussions on published reports will appear in subsequent Bulletins. The last Bulletin before the convention will appear about February 1st. Discussions received between December 31st and February 15th which do not appear in the last Bulletin will be published in leaflet form. The convention will be held about the middle of March of each year. Discussions received after February 15th will not be published prior to the convention, but will be transmitted to the respective committees as soon as received. Reports for which no definite date for publication has been fixed by the Board of Direction must be presented not later than December 31st. Reports received after December 31st will not come before the following convention for discussion; will be withheld from the public press, published in a Bulletin after the convention, and considered at the next convention.

(3) Reports will be considered by the convention in the order of their publication in the Bulletin, unless the convention by a two-thirds majority may decide to give precedence to one or more particular reports.

(4) No report shall be published in the Proceedings unless it shall have been acted upon by the convention. Reports coming before the convention and not being acted upon for lack of time will be published in subsequent Bulletins, together with all written discussions presented to the Secretary thereon, at times fixed by the Board of Direction.

(5) The method of consideration of reports will be as follows:

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

(6) Action by the convention on reports will be one of the following after discussion is closed:

(a) Receiving as information.
(b) Receiving as a progress report and referring back to committee.
(c) Adoption of a portion and referring remainder back to committee.
(d) Adoption as amended.
(c) Adoption as submitted.

(7) Reports will be published in the Proceedings in their original form, as presented by the committee; but the Secretary will prepare for convenience of reference a summary of the alterations ordered by the Association and insert the same immediately after the signature of the committee and preceding the discussion.

(8) All discussions, both oral and written, will be published in the Proceedings. Each speaker's remarks will be submitted to him in writing before publication in the Proceedings for correction of diction and errors of reporting, but not for the elimination of remarks.

(9) All committee organizations are to be considered permanent unless changes are made by the Board of Direction.

(10) As soon as possible after each annual convention the Board of Direction will announce the outline of committee work for the next convention, with list of committeemen.

(11) Reports as finally adopted by the Association will be published from time to time in a volume to be entitled "*Manual of Recommended Practice for Railway Engineering and Maintenance of Way*, containing the Definitions, Specifications and Principles of Practice adopted and recommended by the American Railway Engineering and Maintenance of Way Association."

GENERAL RULES FOR PUBLICATION OF "MANUAL OF RECOMMENDED PRACTICE."

(1) The title of the volume will be "*Manual of Recommended Practice for Railway Engineering and Maintenance of Way*, containing the Definitions, Specifications and Principles of Practice adopted and recommended by the American Railway Engineering and Maintenance of Way Association," edited under the direction of the Committee on Publications and publication approved by the Board of Direction.

(2) The adoption by the Association and subsequent publication of any matter in the Manual shall be considered in the nature of *recommended practice* and shall not be binding on the members.

(3) The Manual shall only include resolutions, conclusions, recommendations, plans, etc., relating to definitions, specifications or principles of practice of such questions connected with railway engineering and maintenance of way work which have been made the subject of a special study by a standing or special committee and embodied in a committee report, published not less than thirty days prior to the annual convention, and submitted by the committee at the annual convention, and which, after due consideration and discussion, shall have been voted on and formally adopted by the Association.

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

(5) All resolutions, conclusions, recommendations, specifications, standards, etc., in order to be included in the Manual must be in concise

and proper final shape for publication, as the Manual will consist only of a summary record of the definitions, principles of practice, specifications and standards recommended by the Association, with a brief reference to the published Proceedings of the Association for the context of the committee report and subsequent discussions and the final action of the Association.

(6) The Board of Direction shall have authority to exclude from the Manual any matter which, in its judgment, it shall consider as not desirable to publish, or as not being in proper shape, or as not having received proper study and consideration.

(7) The Manual will be revised annually and kept up-to-date by publishing a new edition or a supplemental pamphlet as promptly as possible after each convention.

INSTRUCTIONS TO COMMITTEES—OUTLINE FOR 1905-1906.

GENERAL FOR ALL COMMITTEES.

Review, revise and supplement, if thought desirable, all matter published in the "Manual of Recommended Practice," and give the necessary notice of any recommended changes in accordance with Clause "a," Article 4, of the General Rules for the Publication of the Manual of Recommended Practice.

In presenting new matter for consideration of the Association, with a view to having same subsequently appear in the Manual, aim to have all conclusions, recommendations, specifications, standards, etc., in concise and proper final shape, suitable for publication in the Manual.

Descriptive and argumentative matter will not be published in the Manual unless brief and absolutely essential to a proper understanding of the context or plans.

Resubmit any matter presented in previous reports on which the Association has not acted, and which the Committee desires to have considered, and state concisely what sections are to be so considered and what action the Committee desires. It will not be necessary to include such matter in the Committee report, but refer to the previous publication of same in the Proceedings, unless the changes in the previously published version are extensive. Minor changes can be explained in the text of the Committee report.

At the end of the Committee report, state concisely what action the Committee desires to have taken on the various parts of the report, and especially the sections recommended for publication in the Manual.

I. COMMITTEE ON ROADWAY.

(1) Submit general specifications for a modern steam shovel for roadway construction.

(2) Submit a blank form that can be recommended to show the results of steam shovel work, including quantity of material moved and itemized cost of same.

(3) Consider the question of grade and curve improvement work, as it applies to conditions inside cities, such as track elevation and depression, confining these investigations to the consideration of practical methods and organization, and omitting the economic features.

(4) Tabulate and prepare information bearing upon the subject of the general practical work of grade and curve improvement work, confining these investigations to the consideration of practical methods and organization, and omitting the economic features.

(5) Report on the best method of determining the size of waterways.

(6) Report on the result of the letter-ballot upon the overhaul clause presented by the Committee at the annual convention.

II. COMMITTEE ON BALLASTING.

(1) Prepare ballast cross-sections for single and double track in line with the action of the Association at the annual convention and for the three classes of track presented in the report of the Special Committee on Classification of Track, giving special consideration to the necessary depth of ballast under the ties. A careful study of special literature upon the subject of ballasting should be made.

(2) A review of the customary recommended practice for preparation and delivery of various classes of ballast, with cost of handling same, if practicable.

(3) A review of the advantages and disadvantages of the various types of ballast, including rock, slag and gravel, and the different qualities of gravel with reference to the amount of sand or clay contained.

(4) A review of the customary practice and practicability of treating rock ballast which has become foul under the ties.

(5) Confer with the Committee on Ties and upon Track relative to the size of ties, and how ballast cross-sections would be affected by the same.

III. COMMITTEE ON TIES.

(1) Continue the compilation of statistics upon the life of ties, both treated and untreated, and the causes of failure, whether from decay, wear or spike cutting; and confer with the Committee on Track upon the latter conditions.

(2) Recommendations for size of ties to be used with the three classes of track, conferring with the Track and Ballasting Committees.

(3) A review of the specifications now in use for the treatment of tie timber.

(4) Recommendations or a review of the proper methods of analysis for creosote oils.

(5) Information upon the subject of the design and use of concrete and steel ties.

(6) A review of the sources of tie supply and their conservation and probable results of forest planting for future supplies.

IV. COMMITTEE ON RAIL.

(1) Confer with the Committee on Rail of the American Society of Civil Engineers and report on any recommended changes in specifications.

(2) Continue the investigation of the breakage and failure of rails and report upon the apparent causes for such failures.

(3) Report, if possible, upon the results of the use of open-hearth steel rail and the chemical composition of such rails.

(4) Recommendation as to limiting the number of standard rail sections.

V. COMMITTEE ON TRACK.

(1) Review the subject of turnouts and turnout material, including the best types of switchstands, switch points, frogs, guard-rails and throat clearance, bearing in mind the possibility of an increase of the thickness of wheel flanges and the effect of worn tires and wheels upon the various parts of turnouts, frogs and crossings.

(2) Report upon the tiling of wet cuts and the curing of slides.

(3) Report upon whether the recommendations for drilling of rails be reconsidered, and reasons for such recommendation, if advised.

(4) Confer through a sub-committee with the American Railway Master Mechanics' Association upon the subject of widening the gage on curves as affected by the different lengths of engine wheel base and arrangement of flanged wheels.

(5) Confer with Committee on Ties relative to causes of destruction of ties and size of tie.

(6) Confer with Ballasting Committee relative to ballast cross-sections and their effect upon track maintenance.

VI. COMMITTEE ON BUILDINGS.

(1) Report on the current practice and designs for locomotive coaling stations, showing typical plans, with discussion of salient features of each.

(2) Review the report upon roundhouses presented to the convention of 1906, making such additions or changes as may be considered advisable; also recommend the proper grade from stalls to turntable for circular roundhouses.

(3) Review the current practice with results of placing sheds over freight-car repair tracks.

VII. COMMITTEE ON WOODEN BRIDGES AND TRESTLES.

(1) Review and prepare specifications for workmanship for pile and timber trestles to be built by contract.

(2) Co-operate with the Committee on Structural Materials of the American Society for Testing Materials with a view, if possible, to the preparation of a joint specification for structural timber.

(3) Continue the compilation of data upon the cost of construction, maintenance and life of ballast floor trestles of the different types now in use, with designs explanatory of the types considered.

(4) Extend list of recommended safe unit stresses for timber, if considered desirable.

(5) Report on classification of the Washington or Northwest timbers and recommended standard names for principal varieties in use for railroad structural work.

VIII. COMMITTEE ON MASONRY.

(1) Appoint a sub-committee to co-operate with the Joint Committee on Concrete and Reinforced Concrete.

(2) Review and edit the specifications for stone masonry presented in Bulletin No. 72, bearing in mind the suggestions offered at the annual convention in March.

(3) Investigate and report upon the most economical size or combination of sizes for stone to be used in stone concrete as applied to the different classes of work. This may be a portion of the work of the sub-committee.

(4) Collect data upon the reported failures of concrete structures and the probable causes of same. This may be assigned to the subcommittee, if thought desirable.

(5) Investigate and report upon the waterproofing of masonry—methods, results, cost and recommended practice.

(6) Present typical standard designs now in use for masonry culverts, both stone and concrete.

IX. COMMITTEE ON SIGNS, FENCES, CROSSINGS AND CATTLE-GUARDS.

(1) Report upon the styles of gates for right-of-way fences, with typical designs actually in use, bearing in mind the width of opening required by law or custom, and the probable increase of such width in grain-producing States.

(2) Present data upon the various kinds of fence posts in use, with comparative results obtained.

(3) Report upon the best form of public highway and private grade crossings, with especial reference to flangeway; also, the most effective types of safety signals or crossing gates for public highway crossings in thickly-settled communities.

(4) Report upon the comparative cost and economy of metal and wooden signs.

X. COMMITTEE ON SIGNALING AND INTERLOCKING.

(1) Revise and amend, where necessary, the various features of the report presented at the annual convention in March.

(2) Investigate and report more fully, with recommendations, upon the subject of the upwardly inclined semaphore arm.

(3) Review, with recommendations, the subject of the operation and maintenance of interlocking plants.

(4) Confer, if possible, with the Joint Committee on Interlocking and Block Signals of the American Railway Association upon the subject of standard rules and their effect upon the design, construction, maintenance and operation of interlocking and block signal plants.

XI. COMMITTEE ON RECORDS, REPORTS AND ACCOUNTS.

(1) Present revised forms for approval.

(2) Prepare and present a form for Authority for Expenditure, covering estimate and approval authority in one or separate forms, as the Committee may decide advisable.

(3) Prepare and recommend standard conventional signs for right-of-way and topographical maps.

XII. COMMITTEE ON UNIFORM RULES, ORGANIZATION, ETC.

(1) Revise and supplement "General Rules for Government of Employés of the Maintenance of Way Department" from and below the position of Supervisor, including track, structures and signals, under separate general rules, if considered advisable.

(2) Consider the suggestions made at the annual convention that

"Water Service" should be classed under a separate subdivision, with recommendations.

(3) Consider the possibility of a general form of contract applicable to all classes of railroad work.

XIII. COMMITTEE ON WATER SERVICE.

(1) Consider and report more fully upon the minimum amount of scaling matter which will justify treatment, and the composition as affecting the same.

(2) Report more fully upon the use of barium hydrate for softening water and its advantages as compared with re-agents in common use for treatment of water containing salts of lime and magnesia.

(3) Report upon the comparison of various typical methods in use for softening water, cost of installation, maintenance, operation and resulting economy as compared with the use of untreated water.

(4) Consider the effect upon boilers and upon the operation of locomotives by the increase of soluble salts producing foaming water, resulting from the treatment of hard water.

(5) Consider and report upon some of the typical structures and methods of ordinary water supply for railroads.

(6) Report upon the use of coal and gasoline as motive power for pumping plants, with relative economy of each, under different conditions.

XIV. COMMITTEE ON YARDS AND TERMINALS.

(1) Continue the investigation into the requirements of hump yards, including the proper frog angle for ladder tracks; location of scales; length of grades and rates of gradient through classification yards; electric lighting for night service; best method of operation with respect to classifying and the proportion of yard engines used to one hump engine.

(2) Freight transfer houses and terminal freight houses in large terminals, more particularly with reference to freight handling machinery and track layout; arrangement of buildings and platforms and economical limit of number of cars standing upon parallel tracks through which freight can be trucked.

XV. COMMITTEE ON IRON AND STEEL STRUCTURES.

(1) Revise, in accordance with the action of the convention, the "General Specifications for Steel Railroad Bridges," Parts I and II. Furnish table of contents and index and present in final shape for publication in the 1906 Proceedings and Manual.

(2) Consider and report upon the advisability of changing the

phosphorous limit in steel castings from .08 to .06; also increase of the ultimate tensile strength of structural steel to 62,000 lbs. per sq. in.

(3) Report upon movable bridges and special metals.

(4) Report upon the care of existing bridges, inspection, methods of field work, records of inspection and classification as to safe carrying capacity and protection of structures from corrosion.

XVI. COMMITTEE ON ECONOMICS OF RAILWAY LOCATION.

(1) Continue the consideration of all questions connected with railway location, grades, lines and improvements of grades and lines affecting the economic operation with relation to traffic, tonnage ratings, speed, density of traffic and financial considerations, with the special aim in view of establishing uniform methods and unit values for investigating and analyzing the relative changes and costs of comparative routes or proposed grade reductions and line corrections.

SPECIAL COMMITTEE ON CLASSIFICATION OF TRACK.

(1) Report results of letter-ballot of Committee report presented at the 1906 convention and any further recommendations upon the subject.

(2) Investigate and present on any further subdivision or distinctive characteristics governing the classification of track that the Committee may consider pertinent.

ORGANIZATION OF COMMITTEES FOR 1906-1907.

I. ROADWAY.

H. J. Slifer, Contracting Engineer, New York, *Chairman.*

R. C. Barnard, Superintendent, Pennsylvania Lines, Cincinnati, *Vice-Chairman.*

John C. Beye, Resident Engineer, Union Pacific Railroad, Kansas City, Mo.

G. H. Bremner, Engineer Maintenance of Way, Chicago, Burlington & Quincy, Chicago, Ill.

F. R. Coates, Contracting Engineer, Chicago, Ill.

Paul Didier, District Engineer, Baltimore & Ohio Railroad, Allegheny, Pa.

C. Dougherty, Superintendent, Illinois Central Railroad, Clinton, Ill.

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II. BALLASTING.

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218. MOLL, J. B.,
General Roadmaster, Chicago, Milwaukee & St. Paul Railway, Chicago, Ill.

178. Montfort, R. (Vice-Chairman, Committee on Rail),
Consulting Engineer, Louisville & Nashville Railroad, Louisville, Ky.

606. Montzheimer, Arthur (Yards and Terminals),
Chief Engineer, Elgin, Joliet & Eastern and Chicago, Lake Shore & Eastern Railways, Joliet, Ill.

596. Moore, C. H. (Masonry),
Engineer of Grade Crossings, Erie Railroad, New York, N. Y.

72. Moore, H. S.,
Chief Engineer, Muskogee Union Railway, Muskogee, I. T.

287. Moore, Robert,
Consulting Engineer, Laclede Building, St. Louis, Mo.

489. Moore, R. H.,
1123 Jackson Street, Anderson, Ind.

318. Moore, W. H.,
Bridge Engineer, New York, New Haven & Hartford Railroad, New Haven, Conn.

650. More, A. S. (Ties),
Engineer Maintenance of Way, Cleveland, Cincinnati, Chicago & St. Louis Railway, Wabash, Ind.

566. Morkill, W. L.,
General Manager, Mexican Southern Railway, Puebla, Mex.

172. Morrison, J. M.,
Resident Engineer and Superintendent Bridges and Buildings, Central Vermont Railway, St. Albans, Vt.

527. Morse, C. A. (Water Service),
Chief Engineer, Atchison, Topeka & Santa Fe Railway, Topeka, Kan.

313. Morse, G. F.,
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279. Mountain, G. A.,
Chief Engineer, Canadian Railway Commission, Ottawa, Can.

626. Moursund, A. F.,
Resident Engineer, Morgan's Louisiana & Texas Railroad, Lafayette, La.

387. Murakami, Kyoichi,
Chief Engineer, Hankaku Railways, Kitahama, Osaka, Japan.

N

285. Naugle, J. A.,
Assistant General Manager, Sonora Railway, Guaymas, Sonora, Mexico.

648. Neff, F. H. (Track),
Professor of Civil Engineering, Case School, Cleveland, O.

45. Nelson, J. C. (Ties),
Division Engineer, Alabama Great Southern Railroad, Birmingham, Ala.

383. NEVILLE, M. A.,
Superintendent, Peoria & Eastern Railway, Indianapolis, Ind.

479. NEWHALL, W. S.,
Civil Engineer, Cleveland, O.

645. NEWTON, A. W.,
District Engineer, Chicago, Burlington & Quincy Railroad, St. Louis, Mo.

36. NICHOLSON, F. L. (Uniform Rules),
Engineer Maintenance of Way, Norfolk & Southern Railway, Norfolk, Va.

641. NIMMO, J. V.,
Chief Engineer, New Canadian Company, Paspebiac, Quebec.

613. NISHI, DAISKE,
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375. NORTON, A. G.,
Resident Engineer, Erie Railroad, Otisville, N. Y.

231. NORTON, C. T.,
Superintendent Road Dept., Mexican National Railroad, Porfirio Diaz, Mex.

417. NORTON, J. T.,
Principal Assistant Engineer, Guatemala Railway, Puerto Barrios, Guatemala, C. A.

O

519. OHMRA, TAKUICHI,
Chief Engineer, Hokkaido-Tanko Railway, Iwanizawa, Japan.

616. ORR, D. K.,
Engineer, Monongahela Railroad, Brownsville, Pa.

663. ORROCK, J. W.,
Chief Draftsman, Canadian Pacific Railway, Montreal, Canada.

468. OSGOOD, JOS. O. (Uniform Rules),
Chief Engineer, Central Railroad of New Jersey, Jersey City, N. J.

617. OSTROM, J. N.,
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P

545. PAGE, A. D. (Iron and Steel Structures),
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208. PAQUETTE, C. A. (Vice-Chairman, Committee on Ballasting),
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307. PARET, M. P.,
Chief Engineer, Kansas City, Mexico & Orient Railroad, Kansas City, Mo.

500. Parker, D. L.,
Assistant Engineer, New York Central & Hudson River Railroad, New York, N. Y.

503. Parsons, R. S.,
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180. Patterson, F. M.,
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567. Peabody, J. A. (Signaling and Interlocking),
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551. Pearson, E. J.
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505. Peckham, E. L. (Uniform Rules),
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262. PENCE, W. D. (Editor of Publications—Roadway),
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293. Pennington, E.,
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667. Peter, John S.,
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7. Peterson, P. Alex.,
Chief Engineer, Goderich & Guelph Railway, Goderich, Ont.

38. Pfaeflin, E. H.,
Chief Engineer, Chicago Southern Railway, Chicago, Ill.

582. Phillips, A. L.,
Principal Assistant Engineer, Frisco, Oklahoma & Texas Railroad, Oklahoma City, Okla.

302. Phillips, H. C.,
Chief Engineer, Santa Fe Coast Lines, Los Angeles, Cal.

33. Pierce, H.,
Engineer of Construction, Chesapeake & Ohio Railway, Richmond, Va.

538. Pifer, C. W. (Signs, Fences, Crossings and Cattle-Guards),
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234. Poland, W. B.,
General Manager and Chief Engineer, Alaska Central Railway, Seward, Alaska.

415. Porter, H. T. (Rail),
Chief Engineer, Bessemer & Lake Erie Railroad, Greenville, Pa.

552. Post, C. C., Jr.,
Assistant Engineer, Union Pacific Railroad, Omaha, Neb.

602. Pratt, R. B. (Buildings),
Railway Architect, Canadian Northern Railway, Winnipeg, Manitoba.

283. Prout, H. G. (Rail),
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504. PUDER, F. R.,
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348. PUGH, S. D. (Records, Reports and Accounts),
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544. PURDON, C. D. (Iron and Steel Structures),
St. Louis & San Francisco Railroad, St. Louis, Mo.

R

419. RAMSEY, J. P. (Water Service),
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311. RANDALL, E. J.,
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427. RANNO, F. W.,
Civil Engineer, Manchester, N. H.

690. RANSOM, C. L.,
Resident Engineer, Chicago & Northwestern Railway, Omaha, Neb.

230. RAWN, I. G. (Yards and Terminals),
General Manager, Illinois Central Railroad, Chicago, Ill.

655. RAY, G. J. (Water Service),
Division Engineer, Delaware, Lackawanna & Western Railway, Scranton, Pa.

126. RAYMER, A. R. (Chairman, Committee on Buildings),
Assistant Chief Engineer, Pittsburg & Lake Erie Railroad, Pittsburg, Pa.

607. REDGRAVE, W. B.,
Division Engineer, Baltimore & Ohio Railroad, St. George, S. I., N. Y.

639. REICHMANN, A. F.,
Resident Engineer, American Bridge Company, Chicago, Ill.

117. RICHARDS, JOS. T. (Rail),
Chief Engineer Maintenance of Way, Pennsylvania Railroad, Philadelphia, Pa.

63. RICHARDS, O. D.,
Chief Engineer, Ann Arbor Railroad, Toledo, O.

630. RICKERT, O.,
Division Engineer, Baltimore & Ohio Railroad, Grafton, W. Va.

659. RIGBY, JASON,
Director of South American Railroads, London, Eng.

713. ROBERTS, S. S.,
Assistant Engineer of Construction, Illinois Central Railroad, Chicago, Ill.

356. ROBINSON, A. A.,
President, Mexican Central Railroad, New York, N. Y.

363. ROBINSON, A. F. (Iron and Steel Structures),
Bridge Engineer, Santa Fe Railway System, Chicago, Ill.

685. ROCHESTER, R. K.,
Principal Assistant Engineer, Vandalia Line, St. Louis, Mo.

226. ROCKWELL, SAMUEL,
Chief Engineer, Lake Shore & Michigan Southern Railway, Cleveland, O.

4. RODD, THOS.,
Chief Engineer, Pennsylvania Lines, Pittsburg, Pa.

265. RODGERS, J. G.,
Superintendent, New York, Philadelphia & Norfolk Railway, Cape Charles, Va.

222. ROHWER, H. (Roadway),
Consulting Engineer, St. Louis, Mo.

413. ROSE, L. S. (Chairman, Committee on Track),
Engineer Maintenance of Way, Cleveland, Cincinnati, Chicago & St. Louis Railway, Mattoon, Ill.

603. ROSS, D. A. (Yards and Terminals),
Terminal Engineer, Canadian Northern Railway, Winnipeg, Manitoba.

633. ROSSITER, L. P. (Track),
Division Engineer, Baltimore & Ohio Railroad, Pittsburg, Pa.

360. ROTE, R. O., JR.,
Principal Assistant Engineer, Lake Shore & Michigan Southern Railway, Cleveland, O.

442. ROWE, S. M. (Ties),
Consulting Engineer—Forest Service, Bureau of Forestry, U. S. Dept. of Agriculture, Monadnock Block, Chicago, Ill.

355. RUDD, A. H. (Vice-Chairman, Committee on Signaling and Interlocking),
Assistant Signal Engineer, Pennsylvania Railroad, Philadelphia, Pa.

529. RUST, A. F. (Ballasting),
Resident Engineer, Kansas City Southern Railway, Kansas City, Mo.

S

708. SABIN, J. H.,
Assistant Engineer, Chicago, Lake Shore & Eastern Railroad, Chicago, Ill.

266. SAFFORD, H. R. (Ties),
Assistant Chief Engineer, Illinois Central Railroad, Chicago, Ill.

501. ST. JOHN, R. C.,
Principal Assistant Engineer, Missouri Pacific Railway, St. Louis, Mo.

377. SANDS, G. L.,
Vice-President and General Manager, St. Louis & North Arkansas Railway St. Louis.

138. SCARBOROUGH, F. W.,
Richmond, Va.

520. SCHALL, F. E.,
Bridge Engineer, Lehigh Valley Railroad, South Bethlehem, Pa.

481. SCHAUB, J. W. (Masonry),
Consulting Engineer, Monadnock Block, Chicago, Ill.

539. SCHERMERHORN, A. D.,
Division Engineer, Union Pacific Railroad, Omaha, Neb.

433. SCHIDLOVSKY, THEO.,
Chief Engineer, Orenbourg-Tachkent Railway, Orenbourg, Russia.

143. SCHINDLER, A. D.,
General Manager, Pacific Electric Railway Company and Los Angeles Interurban Railway, Los Angeles, Cal.

308. SCHNEIDER, C. C. (Iron and Steel Structures),
Consulting Engineer, Philadelphia, Pa.

700. SCOTT, W. B. (Signaling and Interlocking),
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524. SCRIBNER, G. H., JR. (Masonry),
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386. SESSER, JOHN C. (Track),
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336. SHAW, A. M. (Roadway),
Division Engineer, Mexican International Railroad, Del Rio, Texas.

95. SHAW, LOUIS,
Civil Engineer, LaCrosse, Wis.

75. SHELAH, EDWARD,
Engineer Maintenance of Way, Wabash Railroad, Decatur, Ill.

162. SHEPARD, WALTER,
Chief Engineer, Boston & Albany Railroad, Boston, Mass.

455. SHERIFF, C. E.,
Chief Engineer, Davenport, Rock Island & Northwestern Railway, Davenport, Iowa.

430. SHIRE, M. E. (Yards and Terminals),
Engineer in Charge, Chicago Union Transfer Railway, Chicago, Ill.

521. SHORT, W. A. D. (Chairman, Committee on Signaling and Interlocking),
Signal Engineer, Illinois Central Railroad, Chicago, Ill.

523. SHURTLEFF, A. K. (Chairman, Committee on Water Service),
Assistant Engineer, Chicago, Rock Island & Pacific Railway, Chicago, Ill.

584. SIMAR, V. D. (Records, Reports and Accounts),
Acting Chief Engineer, Duluth, South Shore & Atlantic Railway, Marquette, Mich.

607. SIMMONS, F. G.,
Engineer and Superintendent of Construction and Maintenance, Milwaukee Electric Railway & Light Company, Milwaukee, Wis.

516. SIMMONS, H. J. (Ties),
General Manager, El Paso & Southwestern Railroad, El Paso, Texas.

420. SIMPSON, R. H.,
Public Works Service Commission, Columbus, O.

85. SIMS, C. S.,
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21. SLIFER, H. J. (Chairman, Committee on Roadway),
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526. SMITH, F. A. (Track),
Civil Engineer, Chicago, Ill.

435. SMITH, L. D. (Buildings),
Building Supervisor, Gulf, Colorado & Santa Fe Railway, Galveston, Texas.

695. SMITH, W. A.,
Assistant Engineer, Erie Railroad, Suffern, N. Y.

335. SNOW, J. P. (Director—Chairman, Committee on Iron and Steel Structures),
Bridge Engineer, Boston & Maine Railroad, Boston, Mass.

657. SPIELMANN, J. A. (Signs, Fences, Crossings and Cattle-Guards),
Engineer Maintenance of Way, Baltimore & Ohio Railroad, Wheeling, W. Va.

684. STARBUCK, R. D.,
Assistant Chief Engineer, Michigan Central Railroad, Detroit, Mich.

345. STEELE, H. M. (Signs, Fences, Crossings and Cattle-Guards),
Chief Engineer, J. G. White Company, New York, N. Y.

665. STEFFENS, W. F. (Wooden Bridges and Trestles),
Engineer Bridges and Buildings, South & Western Railroad, Bristol, Va.-Tenn.

699. STENGEL, C. H.,
Designing Engineer, Tidewater Railway, Norfolk, Va.

24. STEVENS, F. S. (Yards and Terminals),
Superintendent, Philadelphia & Reading Railway, Reading, Pa.

352. STEVENS, THOS. S. (Signaling and Interlocking),
Signal Engineer, Santa Fe Railway System, Topeka, Kan.

472. STIMSON, EARL,
Engineer Maintenance of Way, Baltimore & Ohio Southwestern Railroad, Cincinnati, O.

533. STIMSON, F. J. (Ballasting),
Engineer Maintenance of Way, Grand Rapids & Indiana Railroad, Grand Rapids, Mich.

74. STOREY, W. B., JR. (Economics of Railway Location),
Chief Engineer, Atchison, Topeka & Santa Fe Railway System, Chicago, Ill.

496. STUART, F. L. (Economics of Railway Location),
Chief Engineer, Erie Railroad, New York, N. Y.

399. STUART, J. C.,
General Manager, Erie Railroad, New York, N. Y.

491. STYNER, E. E.,
General Manager, Mexican Central Railway, Mexico, Mex.

393. SUGIURA, SOZABURO,
Superintendent Maintenance of Way, Nippon Railway, Tokio, Japan.

98. SULLIVAN, A. W.,
General Manager, Missouri Pacific Railway System, St. Louis, Mo.

448. SULLIVAN, J. G.,
Assistant Chief Engineer, Isthmian Canal Commission, Culebra, Panama, Canal Zone.

130. SWAINE, E. L.,
General Manager, Home Telephone & Telegraph Company, Los Angeles, Cal.

315. SWAIN, G. F. (Masonry),
Professor of Civil Engineering, Massachusetts Institute of Technology, Boston, Mass.

T.

622. TABER, E. G.,
Chief Engineer, Spokane International Railway, Spokane, Wash.

159. TAIT, THOS.,
Chairman, Victorian State Railways, Melbourne, Australia.

691. TALBOT, A. N.,
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498. TALCOTT, H. R.,
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446. TANABE, S.,
Professor of Civil Engineering, University of Kyoto, Kyoto, Japan.

439. TAUSSIG, J. E. (Signaling and Interlocking),
Terminal Superintendent, Wabash Railroad, St. Louis, Mo.

426. TAYLOR, W. D. (Vice-Chairman, Committee on Economics of Railway Location),
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599. TAYLOR, W. B.,
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629. TEMPLE, H. H. (Signaling and Interlocking),
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490. TEN EYCK, P. G.,
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111. THOMAS, J. W., JR.,
President, Nashville, Chattanooga & St. Louis Railway, Nashville, Tenn.

290. THOMPSON, W. S.,
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215. TRATMAN, E. E. R. (Vice-Chairman, Committee on Yards and Terminals),
Resident Editor, Engineering News, Chicago, Ill.

67. TRIMBLE, ROBERT (Rail),
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372. TRUEMAN, HARMON,
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359. TURK, J. E. (Records, Reports and Accounts),
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477. TURNEAURE, F. E. (Iron and Steel Structures),
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379. TUTHILL, JOB (Masonry),
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112. TWEEDY, R. B.,
President, Marinette, Tomahawk & Western Railroad, Milwaukee, Wis.

364. TYE, W. F. (Economics of Railway Location),
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U

155. UNDERWOOD, F. D.,
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V

600. VAN HOUTEN, R. A. (Track),
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105. VAN VLECK, W. G.,
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103. VAUGHAN, G. W. (Rail),
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573. VON SCHRENK, HERMANN, DR. (Ties),
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712. WADSWORTH, GEO. R.,
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522. WAITE, H. M. (Signaling and Interlocking),
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396. WALKER, G. M., JR. (Ballasting),
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122. WALKER, J. O. (Wooden Bridges and Trestles),
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57. WALLACE, H. U. (Rail),
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3. WALLACE, JOHN F. (Past-President),
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76. WALLACE, J. H.,
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540. WALLACE, W. A. (Signs, Fences, Crossings and Cattle-Guards),
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632. WARE, JOHN (Water Service),
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487. WARRINGTON, H. W.,
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349. WASHBURN, E. C.,
Washburn Coupler Co., Minneapolis, Minn.

118. WASHINGTON, L. A.,
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476. WATERMAN, H. S.,
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354. WATSON, THOS.,
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421. WEATHERLY, E. P.,
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507. WEBB, G. H. (Chairman, Committee on Uniform Rules),
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686. WEBB, WALTER LORING (Economics of Railway Location),
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37. WEBSTER, G. H.,
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306. WEBSTER, WM. R. (Chairman, Committee on Rail),
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514. WELLS, L. W.,
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127. WENDT, EDWIN F. (Chairman, Committee on Records, Reports and Accounts,
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702. WENTWORTH, C. C.,
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528. WEST, O. J.,
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590. WESTON, C. V.,
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69. WHEATON, L. H.,
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228. WHITE, H. F. (Signs, Fences, Crossings and Cattle Guards),
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66. WHITE, I. F.,
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92. WHITTELSEY, T. F.,
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564. WICKHORST, M. H. (Water Service),
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185. WILGUS, W. J.,
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104. WILLARD, D.,
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271. WILLIAMS, H. R. (Classification of Track),
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689. WILLIAMS, S. N.,
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32. WILLIAMS, W. D. (Chairman, Committee on Signs, Fences, Crossings and Cattle-Guards),
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9. WILSON, C. A. (Classification of Track),
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270. WILSON, J. T.,
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459. WILSON, T. W.,
General Manager, International Railroad, Buffalo, N. Y.

610. WILLOUGHBY, J. E. (Roadway),
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474. WIRTH, A. A. (Signs, Fences, Crossings and Cattle-Guards),
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555. WOOD, B. A.,
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278. WOODS, H. A. (Records, Reports and Accounts),
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101. WOODWARD, E. K. (Records, Reports and Accounts),
Chief Engineer, Pere Marquette Railroad, Detroit, Mich.

619. WOODLE, A. S., JR.,
Division Engineer, Baltimore & Ohio Railroad, Wheeling, W. Va.

292. WOODWARD, ROLAND,
Consulting Engineer, Jacksonville & Southwestern Railroad, Jacksonville, Fla.

200. WOODWORTH, G. B. (Rail),
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395. WORCESTER, J. R. (Iron and Steel Structures),
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704. WORTHINGTON, B. A.,
First Vice-President and General Manager, Wheeling & Lake Erie Railroad, Wabash-Pittsburg Terminal and West Side Belt Railroad, Pittsburg, Pa.

412. WRIGHT, J. T.,
Vice-President and General Manager, Macon, Dublin & Savannah Railroad, Macon, Ga.

Y

456. YAMAGUCHI, JUNNOSUKE,
Chief Engineer, Sanyo Railway, Kobe, Japan.

595. YOUNG, R. C. (Roadway),
Chief Engineer, Lake Superior & Ishpeming, Munising Railway and Marquette & Southeastern Railway, Marquette, Mich.

Z

207. ZIESING, A.,
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470. ZINCK, K. J. C. (Signs, Fences, Crossings and Cattle-Guards),
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614. ZINN, A. S. (Buildings),
Engineer of Construction, Michigan Central Railroad, St. Thomas, Ont.

HONORARY MEMBER.

SHEPARD, D. C.,
Minneapolis, Minn.

MEMBERSHIP AND MILEAGE OF RAILWAYS REPRESENTED IN THE AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION

Name of Road and Membership.	Members.	Mileage.
Alaska Central Railway................................	1	50
W. B. Poland, Seward, Alaska.		
Ann Arbor Railroad	1	292
O. D. Richards, Toledo, O.		
Antofagasta & Bolivia Railroad	1	597
A. Hohagen, Antofagasta, Chili, S. A.		
Argentine Republic Railways	1	2,677
G. F. T. Dominico, Buenos Ayres, Arg. Rep.		
Atlantic & Birmingham Construction Company..........	3	331
Alex. Bonnyman, Atlanta, Ga.		
A. Q. Campbell, Oglethorpe, Ga.		
W. I. Lee, Stroud, Ala.		
*Atlantic, Quebec & Western Railroad..............	1	
J. V. Nimmo, Paspebiac, Que.		
Atchison, Topeka & Santa Fe Railway System........	13	9,389
J. W. Kendrick, Chicago, Ill.		
James Dun, Chicago, Ill.		
W. B. Storey, Jr., Chicago, Ill.		
C. F. W. Felt, Galveston, Texas.		
C. A. Morse, Topeka, Kan.		
H. C. Phillips, Los Angeles, Cal.		
E. O. Faulkner, Topeka, Kan.		
A. F. Robinson, Chicago, Ill.		
J. M. Meade, Topeka, Kan.		
F. M. Bisbee, La Junta, Col.		
Thomas S. Stevens, Topeka, Kan.		
L. D. Smith, Galveston, Tex.		
T. S. Cafferty, Topeka, Kan.		
Baltimore & Ohio Railroad..........................	27	4,442
L. G. Haas, Baltimore, Md.		
D. D. Carothers, Baltimore, Md.		
J. B. Dickson, Baltimore, Md.		
J. E. Greiner, Baltimore, Md.		
H. E. Hale, Baltimore, Md.		
H. H. Temple, Pittsburg, Pa.		
J. A. Spielmann, Wheeling, W. Va.		
H. R. Talcott, Baltimore, Md.		
William Graham, Baltimore, Md		
Paul Didier, Allegheny, Pa.		

* Under construction.

Name of Road and Membership.	Members.	Mileage.
Baltimore & Ohio Railroad—Continued.		
C. E. Bryan, Parkersburg, W. Va		
L. G. Curtis, Chicago, Ill.		
V. K. Hendricks, Baltimore, Md.		
S. A. Jordan, Cleveland, O.		
J. R. Leighty, Cumberland, Md.		
E. G. Lane, New Castle, Pa.		
W. B. Redgrave, St. George, N. Y.		
O. Rickert, Grafton, W. Va.		
L. P. Rossiter, Pittsburg, Pa.		
John Ware, Connellsville, Pa.		
J. T. Wilson, Ellicott City, Md.		
A. S. Woodle, Jr., Wheeling, W. Va.		
F. J. Bachelder, Winchester, W. Va.		
A. G. Boughner, Morgantown, W. Va.		
L. C. James, Bridgeport, O		
J. B. Jenkins, Baltimore, Md.		
H. A. Lane, Belva, Va.		
Baltimore & Ohio Southwestern Railroad...........	3	982
Earl Stimson, Cincinnati, O.		
L. F. Boeh, Cincinnati, O.		
W. Archer, Cincinnati, O.		
Bangor & Aroostook Railroad	1	415
R. D. Coombs, Houlton, Me.		
Bessemer & Lake Erie Railroad........................	1	216
H. T. Porter, Greenville, Pa.		
*Bolivia Railroad	1	
Rankin Johnson, LaPaz, Bolivia, S. A.		
Boston & Albany Railroad.............................	1	392
Walter Shepard, Boston, Mass.		
Boston & Maine Railroad..............................	1	2,287
J. P. Snow, Boston, Mass.		
*British Columbia Railway	1	
H. W. Warrington, Grand Forks, B. C.		
Buffalo & Susquehanna Railroad.......................	2	361
H. Herden, Galeton, Pa.		
H. C. Landon, Galeton, Pa.		
Buffalo, Rochester & Pittsburg Railroad................	1	516
J. M. Floesch, Rochester, N. Y.		
Cammal & Black Forest Railroad.......................	1	31
C. B. McCullough, Jersey Shore, Pa.		
Canadian Northern Railway............................	3	2,406
H. F. Forrest, Winnipeg, Man.		
D. A. Ross, Winnipeg, Man.		
R. B. Pratt, Winnipeg, Man.		
Canadian Pacific Railway.............................	6	9,425
F. P. Gutelius, Montreal, Canada.		
W. A. James, Kenova, Canada.		
H. L. Jordan, Montreal, Canada.		
A. L. Buck, Montreal, Canada		
M. P. Cotton, Winnipeg, Man.		
J. W. Orrock, Montreal, Canada.		

* Under construction.

Name of Road and Membership.	Members.	Mileage.
Central of Georgia Railway	1	1,878
J. C. Gray, Chipley, Ga.		
Central Railway of Guatemala	1	141
D. B. Hodgsdon, Guatemala, Guat., C. A.		
Central Railroad of New Jersey	3	646
W. G. Besler, New York, N. Y.		
Jos. O. Osgood, Jersey City, N. J.		
A. L. Bowman, New York, N. Y.		
Central Vermont Railway	1	531
J. M. Morrison, St. Albans, Vt.		
Chesapeake & Ohio Railway	1	1,791
H. Pierce, Richmond, Va.		
Chicago & Alton Railway	4	970
S. M. Felton, Chicago, Ill.		
W. D. Taylor, Chicago, Ill.		
W. B. Causey, Bloomington, Ill.		
C. S. Ells, Roodhouse, Ill.		
Chicago & Eastern Illinois Railroad	2	921
R. H. Howard, Chicago, Ill.		
A. S. Markley, Danville, Ill.		
Chicago & Illinois Western Railroad	1	17
O. P. Chamberlain, Chicago, Ill.		
Chicago & Northwestern Railway	7	9,112
W. A. Gardner, Chicago, Ill.		
R. H. Aishton, Chicago, Ill.		
F. H. Bainbridge, Pierre, S. D.		
G. M. Davidson, Chicago, Ill.		
J. A. Peabody, Chicago, Ill.		
C. L. Ransom, Omaha, Neb.		
L. J. McIntyre, Green Bay, Wis.		
Chicago & Western Indiana Railroad	1	49
E. H. Lee, Chicago, Ill.		
Chicago, Burlington & Quincy Railroad	14	8,625
D. Willard, Chicago, Ill.		
T. E. Calvert, Chicago, Ill.		
W. L. Breckinridge, Chicago, Ill.		
G. H. Bremner, Chicago, Ill.		
L. F. Goodale, St. Louis, Mo.		
C. H. Cartlidge, Chicago, Ill.		
M. H. Wickhorst, Aurora, Ill.		
John C. Sesser, Centralia, Ill.		
A. W. Newton, St. Louis, Mo.		
F. T. Darrow, Lincoln, Neb.		
E. P. Weatherly, St. Joseph, Mo.		
J. D. Mason, Chicago, Ill.		
J. M. Patterson, Chicago, Ill.		
E. C. Forbush, Herrin, Ill.		
Chicago Great Western Railway	1	1,321
Ole Davidson, Clarion, Iowa.		

Name of Road and Membership.	Members.	Mileage.
Chicago, Indianapolis & Louisville Railway..............	2	536
A. S. Kent, Chicago, Ill.		
W. A. Wallace, Chicago, Ill.		
Chicago, Indiana & Southern Railway................	2	328
C. W. Hotchkiss, Chicago, Ill.		
Frank Beckwith, Hammond, Ind.		
Chicago Junction Railway	1	385
J. B. Cox, Chicago, Ill.		
Chicago, Milwaukee & St. Paul Railway................	4	7,185
C. F. Loweth, Chicago, Ill.		
J. B. Moll, Chicago, Ill.		
G. B. Woodworth, Chicago, Ill.		
L. R. Clausen, West Milwaukee, Wis.		
*Chicago, Milwaukee & St. Paul Railway of Washington.	3	
H. R. Williams, Seattle, Wash.		
E. J. Pearson, Seattle, Wash.		
C. H. Byers, Seattle, Wash.		
Chicago, Peoria & St. Louis Railway..................	2	245
J. P. Ramsey, St. Louis, Mo.		
J. K. Howard, Springfield, Ill.		
Chicago, Rock Island & Gulf Railroad.................	1	386
John S. Peter, Fort Worth, Texas.		
Chicago, Rock Island & Pacific Railway................	8	7,368
J. B. Berry, Chicago, Ill.		
H. F. White, Chicago, Ill.		
J. G. Bloom, Topeka, Kan.		
A. D. Page, Chicago, Ill.		
Garrett Davis, Cedar Rapids, Iowa.		
W. H. Davisson, Topeka, Kan.		
A. K. Shurtleff, Chicago, Ill.		
G. E. Ellis, Chicago, Ill.		
Chicago, St. Paul, Minneapolis & Omaha Railroad.......	1	1,696
E. C. Blundell, Eau Claire, Wis.		
*Chicago Southern Railway............................	2	
E. H. Pfafflin, Chicago, Ill.		
F. R. Puder, Chicago, Ill.		
Chicago Terminal Transfer Railroad...................	2	259
J. N. Faithorn, Chicago, Ill.		
E. N. Layfield, Chicago, Ill.		
Chicago Union Transfer Railway.......................	1	100
M. E. Shire, Chicago, Ill.		
Cincinnati & Muskingum Valley Railroad..............	1	149
Paul Jones, Zanesville, O.		
Cincinnati, Hamilton & Dayton Railroad...............	3	1,025
C. A. Wilson, Cincinnati, O.		
I. F. White, Dayton, O.		
M. V. Hynes, Indianapolis, Ind.		

* Under construction.

Name of Road and Membership.	Members.	Mileage.
Cincinnati Northern Railroad	1	236
W. D. Williams, Van Wert, O.		
Cleveland, Cincinnati, Chicago & St. Louis Railway	10	2,276
C. A. Paquette, Cincinnati, O.		
O. E. Selby, Cincinnati, O.		
H. Baldwin, Mattoon, Ill.		
M. A. Neville, Indianapolis, Ind.		
L. S. Rose, Mattoon, Ill.		
Paul Hamilton, Springfield, O.		
A. S. More, Wabash, Ind.		
R. H. Moore, Anderson, Ind.		
H. H. Knowlton, Shelbyville, Ind.		
C. S. Millard, Indianapolis, Ind.		
Colorado & Southern Railway	1	1,121
H. W. Cowan, Denver, Colo.		
Davenport, Rock Island & Northwestern Railway	1	53
C. E. Sheriff, Davenport, Ia.		
Delaware, Lackawanna & Western Railroad	2	952
Lincoln Bush, Hoboken, N. J.		
G. J. Ray, Scranton, Pa.		
Denver, Enid & Gulf Railroad	1	117
E. L. Peckham, Enid, Okla.		
Detroit & Mackinac Railroad	1	334
H. S. Waterman, East Tawas, Mich.		
*Detroit River Tunnel Company	2	
B. Douglas, Detroit, Mich.		
J. C. Mock, Detroit, Mich.		
Detroit United Street Railways	1	533
J. C. Hutchins, Detroit, Mich.		
Duluth, Missabe & Northern Railway	2	164
W. A. McGonagle, Duluth, Minn.		
W. H. Hoyt, Duluth, Minn.		
Duluth, South Shore & Atlantic Railroad	1	583
V. D. Simar, Marquette, Mich.		
Elgin, Joliet & Eastern-Chicago, Lake Shore & Eastern Railways	2	386
Arthur Montzheimer, Joliet, Ill.		
J. H. Sabin, Chicago, Ill.		
El Paso & Southwestern Railway System	2	810
H. J. Simmons, El Paso, Tex.		
J. L. Campbell, El Paso, Tex.		
Erie Railroad	14	2,353
F. D. Underwood, New York, N. Y.		
J. C. Stuart, New York, N. Y.		
F. L. Stuart, New York, N. Y.		
R. S. Parsons, Cleveland, O.		

* Under construction.

Name of Road and Membership.	Members.	Mileage.
Erie Railroad—Continued.		
C. S. Sims, New York, N. Y.		
C. H. Moore, New York, N. Y.		
R. A. Van Houten, Susquehanna, Pa.		
W. B. Taylor, Buffalo, N. Y.		
W. M. Dawley, Youngstown, O.		
W. A. Smith, Suffern, N. Y.		
C. K. Conard, Middletown, N. Y.		
R. C. Falconer, New York, N. Y.		
A. G. Norton, Otisville, N. Y.		
Richard Mather, Cuba, N. Y.		
Esquimalt & Nanaimo Railroad........................	1	80
Joseph Hunter, Victoria, B. C.		
*Ferro-carril Occidental de Guatemala	1	
J. B. Hatch, Guatemala, Guat., C. A.		
Fonda, Johnstown & Gloversville Railroad..............	1	77
F. A. Bagg, Gloversville, N. Y.		
Fort Worth & Denver City Railway	1	453
G. F. Cotter, Fort Worth, Tex.		
*Franklin & Clearfield Railroad........................	1	
F. E. Bissell, Franklin, Pa.		
Galveston, Houston & Henderson Railroad.............	1	50
C. S. Corrigan, Galveston, Tex.		
Gila Valley, Globe & Northern Railroad................	1	125
C. C. Mallard, Globe, Ariz.		
*Goderich & Guelph Railway	1	
P. Alex. Peterson, Goderich, Ont.		
Grand Rapids & Indiana Railway	1	599
F. J. Stimson, Grand Rapids, Mich.		
Grand Trunk Railway	3	4,639
E. H. Fitzhugh, Montreal, Canada.		
F. H. McGuigan, Montreal, Canada.		
W. McNab, Montreal, Canada.		
*Grand Trunk Pacific Railway	3	
H. A. Woods, Montreal, Canada.		
A. C. Dennis, Winnipeg, Manitoba.		
K. J. C. Zinck, Montreal, Canada.		
Great Northern Railway................................	4	5,986
J. R. W. Davis, St. Paul, Minn.		
Chas. A. Dunham, St. Paul, Minn.		
J. M. Dixon, Devil's Lake, N. Dak.		
Alfred Jackson, St. Paul, Minn.		
*Guantanamo Railroad	1	
Richard Brooks, Guantanamo, Cuba.		
*Guatemala Railway	1	
J. T. Norton, Puerto Barrios, Guat., C. A.		

* Under construction.

Name of Road and Membership.	Members.	Mileage.
Halifax & Southwestern Railway	2	374
L. H. Wheaton, Bridgewater, N. S.		
W. H. Grant, Bridgewater, N. S.		
Hankaku Railways of Japan	1	69
Kyoichi Murakami, Osaka, Japan.		
Harriman Lines	20	14,646
J. Kruttschnitt, Chicago, Ill.		
W. B. Scott, Chicago, Ill.		
Morgan's Louisiana & Texas Railroad:		
E. B. Cushing, New Orleans, La.		
A. F. Moursund, Algiers, La.		
Oregon Short Line:		
E. Buckingham, Salt Lake City, Utah.		
Wm. Ashton, Salt Lake City, Utah		
J. P. Congdon, Pocatello, Idaho.		
H. B. Merriam, Salt Lake City, Utah.		
L. L. Dagron, Salt Lake City, Utah.		
Sonora Railway:		
J. A. Naugle, Guaymas, Sonora, Mex.		
Southern Pacific Company:		
W. G. Van Vleck, Houston, Tex.		
William Hood, Oakland, Cal.		
J. H. Wallace, Oakland, Cal.		
J. D. Isaacs, Oakland, Cal.		
R. Koehler, Portland, Ore.		
Thos. Fitzgerald, Ogden, Utah.		
Union Pacific Railroad:		
R. L. Huntley, Omaha, Neb.		
A. D. Schermerhorn, Omaha, Neb.		
James Keys, Omaha, Neb.		
C. C. Post, Jr., Omaha, Neb.		
John C. Beye, Kansas City, Mo.		
Hocking Valley Railroad	1	346
Wm. Michel, Columbus, O.		
Hokkaido-Tanko Railway	1	207
T. Ohmra, Iwanizawa, Japan.		
*Hudson River Tunnels	1	
J. W. Leahy, New York, N. Y.		
Illinois Central Railroad	13	5,584
W. J. Harahan, Chicago, Ill.		
I. G. Rawn, Chicago, Ill.		
L. C. Fritch, Chicago, Ill.		
A. S. Baldwin, Chicago, Ill.		
H. R. Safford, Chicago, Ill.		
D. J. Brumley, Chicago, Ill.		
O. M. Dunn, New Orleans, La.		
C. Dougherty, Clinton, Ill.		
W. A. D. Short, Chicago, Ill.		

* Under construction.

Name of Road and Membership.	Members.	Mileage.
Illinois Central Railroad—Continued.		
C. W. Pifer, Chicago, Ill.		
A. F. Blaess, Clinton, Ill.		
R. S. Blinn, Mt. Vernon, O.		
S. S. Roberts, Chicago, Ill.		
International Railway of Buffalo	1	355
T. W. Wilson, Buffalo, N. Y.		
Iowa Central	1	503
H. G. Kelley, Minneapolis, Minn.		
Kansas City Belt Railway	1	52
G. M. Walker, Jr., Kansas City, Mo.		
Kansas City, Mexico & Orient Railway	3	500
E. Dickinson, Kansas City, Mo.		
M. P. Paret, Kansas City, Mo.		
W. W. Colpitts, Kansas City, Mo.		
Kansas City Southern Railway	1	762
A. F. Rust, Kansas City, Mo.		
Lake Shore & Michigan Southern Railway	6	2,248
Lake Erie & Western Railway.		
E. A. Handy, Cleveland, O.		
Samuel Rockwell, Cleveland, O.		
G. C. Cleveland, Cleveland, O.		
W. Beahan, Cleveland, O.		
R. O. Rote, Jr., Cleveland, O.		
J. C. L. Fish, Limestone, Pa.		
Lake Shore & Ishpeming, Munising, and Marquette & Southeastern Railways	1	150
R. C. Young, Marquette, Mich.		
Lehigh Valley Railroad	3	1,434
Walter G. Berg, New York, N. Y.		
E. B. Ashby, South Bethlehem, Pa.		
F. E. Schall, South Bethlehem, Pa.		
Long Island Railroad	2	392
C. L. Addison, Long Island City, N. Y.		
J. B. Austin, Jr., Jamaica, N. Y.		
Louisville & Nashville Railroad	3	4,020
R. Montfort, Louisville, Ky.		
W. H. Courtenay, Louisville, Ky.		
J. F. Burns, Elizabethtown, Ky.		
Macon, Dublin & Savannah Railroad	2	92
J. T. Wright, Macon, Ga.		
D. B. Dunn, Macon, Ga.		
Maine Central Railroad	1	821
B. W. Guppy, Portland, Me.		
Marinette, Tomahawk & Western Railroad	1	50
R. B. Tweedy, Milwaukee, Wis.		

Name of Road and Membership.	Members.	Mileage.
Mexican Central Railway	5	3,156
A. A. Robinson, New York, N. Y.		
Lewis Kingman, Mexico, Mex.		
Hans Bentele, Mexico, Mex.		
E. E. Styner, Mexico, Mex.		
E. S. Banks, Guadalajara, Mex.		
Mexican Pacific Railway..............................	I	59
A. P. Herbert, Colima, Mex.		
Mexican Southern Railway	I	263
W. L. Morkill, Puebla, Mex.		
Michigan Central Railroad	7	1,745
W. S. Kinnear, Detroit, Mich.		
G. H. Webb, Detroit, Mich.		
R. D. Starbuck, Detroit, Mich.		
Hans Ibsen, Detroit, Mich.		
A. C. Everham, Detroit, Mich.		
T. H. Hickey, St. Thomas, Ont.		
A. S. Zinn, St. Thomas, Ont.		
*Military Railway of Japan	I	
T. Endo, Chemulpo, Corea.		
Milwaukee Electric Railway & Light Company..........	I	
F. G. Simmons, Milwaukee, Wis.		
Minneapolis & Rainy River Railroad..................	I	42
A. L. Davis, Deer River, Minn.		
Minneapolis & St. Louis Railway.....................	I	843
H. G. Kelley, Minneapolis, Minn.		
Minneapolis, St. Paul & Sault Ste. Marie Railway.......	I	2,159
E. Pennington, Minneapolis, Minn.		
Mississippi River & Bonne Terre Railroad..............	I	46
C. H. Fake, Bonne Terre, Mo.		
Missouri, Kansas & Texas Railroad....................	I	3,043
S. B. Fisher, St Louis, Mo.		
Missouri Pacific Railway System......................	8	6,340
C. S. Clarke, St. Louis, Mo.		
A. W. Sullivan, St. Louis,, Mo.		
J. W. Higgins, St. Louis, Mo.		
H. Baker, Little Rock, Ark.		
M. L. Byers, St. Louis, Mo.		
B. H. Mann, St. Louis, Mo.		
R. C. St. John, St. Louis, Mo.		
A. C. Butterworth, St. Louis, Mo.		
Mobile & Ohio Railroad	I	912
B. A. Wood, Jackson, Tenn.		
Mobile, Jackson & Kansas City Railway................	I	402
T. F. Whittelsey, Mobile, Ala.		
Monongahela Railroad	I	58
D. K. Orr, Brownsville, Pa.		

* Under construction.

Name of Road and Membership.	Members.	Mileage.
Nashville, Chattanooga & St. Louis Railway............	4	1,200
J. W. Thomas, Jr., Nashville, Tenn.		
Hunter McDonald, Nashville, Tenn.		
G. D. Hicks, Tullahoma, Tenn.		
I. O. Walker, Paducah, Ky.		
National Lines of Mexico	4	1,732
C. J. Carroll, Durango, Mex.		
F. W. Andros, Durango, Mex.		
C. T. Norton, Porfirio, Diaz, Mex.		
A. M. Shaw, Del Rio, Texas.		
*National Transcontinental Railway	2	
D. MacPherson, Ottawa, Canada.		
A. N. Molesworth, Ottawa, Canada.		
New Orleans Terminal Railway.........................	I	23
F. G. Jonah, New Orleans, La.		
New York Central & Hudson River Railroad...........	9	3,205
W. J. Wilgus, New York, N. Y.		
G. W. Kittredge, New York, N. Y.		
G. W. Vaughan, New York, N. Y.		
H. S. Balliet, New York, N. Y.		
Azel Ames, Jr., New York, N. Y.		
A. B. Corthell, New York, N. Y.		
D. L. Parker, New York, N. Y.		
H. A. Lehn, New York, N. Y.		
G. F. Morse, New York, N. Y.		
New York, Chicago & St. Louis Railway................	3	523
A. W. Johnston, Cleveland, O.		
E. E. Hart, Cleveland, O.		
A. J. Himes, Cleveland, O.		
New York, New Haven & Hartford Railroad............	3	2,046
E. H. McHenry, New Haven, Conn.		
E. P. Dawley, New Haven, Conn.		
W. H. Moore, New Haven, Conn.		
New York, Ontario & Western Railroad..............	I	494
C. E. Knickerbocker, Middletown, N. Y.		
New York, Philadelphia & Norfolk Railroad............	I	149
J. G. Rodgers, Cape Charles, Va.		
New Zealand Government Railways....................	3	2,374
James Burnett, Wellington, N. Z.		
D. T. McIntosh, Auckland, N. Z.		
F. W. MacLean, Dunedin, N. Z.		
Nippon Railway of Japan	I	860
Sozabura Sugiura, Tokio, Japan.		
Norfolk & Southern Railroad.........................	I	223
F. L. Nicholson, Norfolk, Va.		
Norfolk & Western Railway	2	1,834
Chas. S. Churchill, Roanoke, Va.		
C. C. Wentworth, Roanoke, Va.		

* Under construction.

Name of Road and Membership.	Members.	Mileage.
North & South Texas Railway	1	250
P. A. McCarthy, Lufkin, Texas.		
Northern Pacific Railway	3	5,305
H. Elliott, St. Paul, Minn.		
W. L. Darling, St. Paul, Minn.		
W. I. Bassett, Scott, Wash.		
Ohio River & Columbus Railroad	1	24
G. C. Millett, Ripley, O.		
*Oklahoma City, Denver & Gulf Railroad	1	
A. L. Phillips, Oklahoma City, Okla.		
Pacific Electric Railway	1	345
A. D. Schindler, Los Angeles, Cal.		
Pennsylvania Lines West of Pittsburg	6	2,721
Thos. Rodd, Pittsburg, Pa.		
W. C. Cushing, Pittsburg, Pa.		
Robt. Trimble, Pittsburg, Pa.		
E. G. Ericson, Pittsburg, Pa.		
A. A. Wirth, Pittsburg, Pa.		
R C. Barnard, Cincinnati, O.		
Pennsylvania Railroad	6	5,190
J. T. Richards, Philadelphia, Pa.		
R. Bell, Buffalo, N. Y.		
E. F. Kenney, Philadelphia, Pa.		
A. H. Rudd, Philadelphia, Pa.		
C. C. Anthony, Philadelphia, Pa.		
W. S. Thompson, Oil City, Pa.		
Peoria & Pekin Union Railroad	1	20
Curtiss Millard, Peoria, Ill.		
Pere Marquette Railroad	2	2,398
E. K. Woodward, Detroit, Mich.		
Job Tuthill, Detroit, Mich.		
Philadelphia & Reading Railway	4	1,481
Wm. Hunter, Philadelphia, Pa.		
C. H. Ewing, Reading, Pa.		
F. S. Stevens, Reading, Pa.		
J. E. Turk, Tamaqua, Pa.		
*Philadelphia Elevated Railroad & Subway	1	
Chas. M. Mills, Philadelphia, Pa.		
*Philippine Railway Commission	1	
F. A. Molitor, Manila, P. I.		
*Pittsburg, Binghamton & Eastern Railroad	1	
H. C. Ferris, Canton, Pa.		

* Under construction.

Name of Road and Membership.	Members.	Mileage.
Pittsburg & Lake Erie Railroad	4	191
J. A. Atwood, Pittsburg, Pa. A. R. Raymer, Pittsburg, Pa. Edwin F. Wendt, Pittsburg, Pa. E. W. Boots, McKeesport, Pa.		
Queen & Crescent Route	6	1,158
W. A. Garrett, Cincinnati, O. C. C. Harvey, New Orleans, La. H. M. Waite, Somerset, Ky. E. Ford, Vicksburg, Miss. J. C. Nelson, Birmingham, Ala. J. C. Haugh, New Orleans, La.		
Rio Grande, Sierra Madre & Pacific Railway	1	160
J. P. Hallihan, El Paso, Texas.		
St. Louis & North Arkansas Railroad	2	130
G. L. Sands, St. Louis, Mo. W. S. Dawley, St. Louis, Mo.		
St. Louis & San Francisco Railroad	3	5,076
J. F. Hinckley, St. Louis, Mo. C. D. Purdon, St. Louis, Mo. John V. Hanna, St. Louis, Mo.		
San Pedro, Los Angeles & Salt Lake Railroad	1	1,042
R. K. Brown, Salt Lake City, Utah.		
Santa Fe, Prescott & Phœnix Railroad	1	403
W. A. Drake, Prescott, Ariz.		
Sanyo Railway of Japan	1	370
J. Yamaguchi, Kobe, Japan.		
*Seoul-Fusan Railway of Japan	1	
J. Inagaki, Fusan, Corea.		
Southern Railway	6	7,492
C. H. Ackert, Washington, D. C. D. W. Lum, Washington, D. C. B. C. Milner, Louisville, Ky. W. F. H. Finke, Washington, D. C. C. C. Coffee, Princeton, Ind. P. S. Fitzgerald, Birmingham, Ala.		
Southern Indiana Railroad	1	148
J. F. Cassell, Terre Haute, Ind.		
South & Western Railroad	2	67
M. J. Caples, Bristol, Va.-Tenn. W. F. Steffens, Bristol, Va.-Tenn.		
South Side Elevated Railroad of Chicago	1	18
C. V. Weston, Chicago, Ill.		
Spokane International Railroad	2	140
E. G. Taber, Spokane, Wash. J. H. Abbott, Spokane, Wash.		

* Under construction.

Name of Road and Membership.	Members.	Mileage.
Susquehanna & New York Railway.....................	1	94
C. A. Derr, Williamsport, Pa.		
*Tachko-Kent Railway	1	
Theo. Schidlovsky, Orenbourg, Russia.		
Tehuantepec National Railway	1	210
J. B. Body, Mexico, Mex.		
Temiskaming & Northern Ontario Railway...............	1	113
J. A. McCarthy, North Bay, Ont.		
Texas Midland Railroad	1	125
L. W. Wells, Terrell, Texas.		
Tidewater Railway	4	60
H. Fernstrom, Norfolk, Va. B. T. Elmore, Norfolk, Va. C. H. Stengel, Norfolk, Va. F. W. Hawks, Lurich, Va.		
Uintah Railroad	1	55
M. W. Cooley, Mack, Colo.		
Union Belt Railroad of Memphis......................	1	22
H. G. Fleming, Memphis, Tenn.		
Union Railroad of Pittsburg	1	57
E. J. Randall, Port Perry, Pa.		
Union Stock Yards & Railroad Company..............	2	50
W. J. C. Kenyon, South Omaha, Neb. W. S. King, South Omaha, Neb.		
Vandalia Line	3	821
F. T. Hatch, St. Louis, Mo. R. K. Rochester, St. Louis, Mo. Maurice Coburn, Terre Haute, Ind.		
Vera Cruz & Pacific Railway..........................	1	265
W. A. Hill, Vera Cruz, Mex.		
Victorian State Railways of Australia...................	1	3,113
Thos. Tait, Melbourne, Australia.		
Wabash Railroad	5	2,517
F. A. Delano, Chicago, Ill. A. O. Cunningham, St. Louis, Mo. J. E. Taussig, St. Louis, Mo. Edward Shelah, Decatur, Ill. W. W. Greenland, Moberly, Mo.		
Wabash-Pittsburg Terminal Railway	3	60
F. A. Delano, Chicago, Ill. B. A. Worthington, Pittsburg, Pa. H. T. Douglas, Jr., Pittsburg, Pa.		
Wellington & Manawatu Railway	1	84
James Marchbanks, Wellington, N. Z.		

* Under construction.

Name of Road and Membership.	Members.	Mileage.
Western Maryland Railroad	2	543
V. G. Bogue, New York, N. Y. A. W. Buel, New York, N. Y.		
Western Pacific Railway	2	40
V. G. Bogue, Oakland, Cal. A. W. Buel, New York, N. Y.		
Western Railways of Australia......................	1	1,605
Thos. Watson, Coolgardie, West Australia.		
Wheeling & Lake Erie Railroad......................	3	462
F. A. Delano, Chicago, Ill. E. A. Worthington, Pittsburg, Pa. H. T. Douglas, Jr., Pittsburg, Pa.		
Wisconsin & Michigan Railroad......................	1	125
B. C. Gowen, Peshtigo, Wis.		
Wisconsin Central Railway	1	977
C. N. Kalk, Milwaukee, Wis.		
Miscellaneous	119	
Total	550	214,263

DECEASED MEMBERS.

Bouscaren, L. F. G.
Burke, S. E.
Caffrey, Richard.
Clark, J. M.
Clarke, L. H.
Carpenter, C. A.
Casey, D. J.
Collins, E. M.
Curtis, W. G.
Draper, H. C.
Frey, J. J.
Gardner, G. W.
Goode, J. V.
Hall, Ferdinand.
Hartigan, John G.
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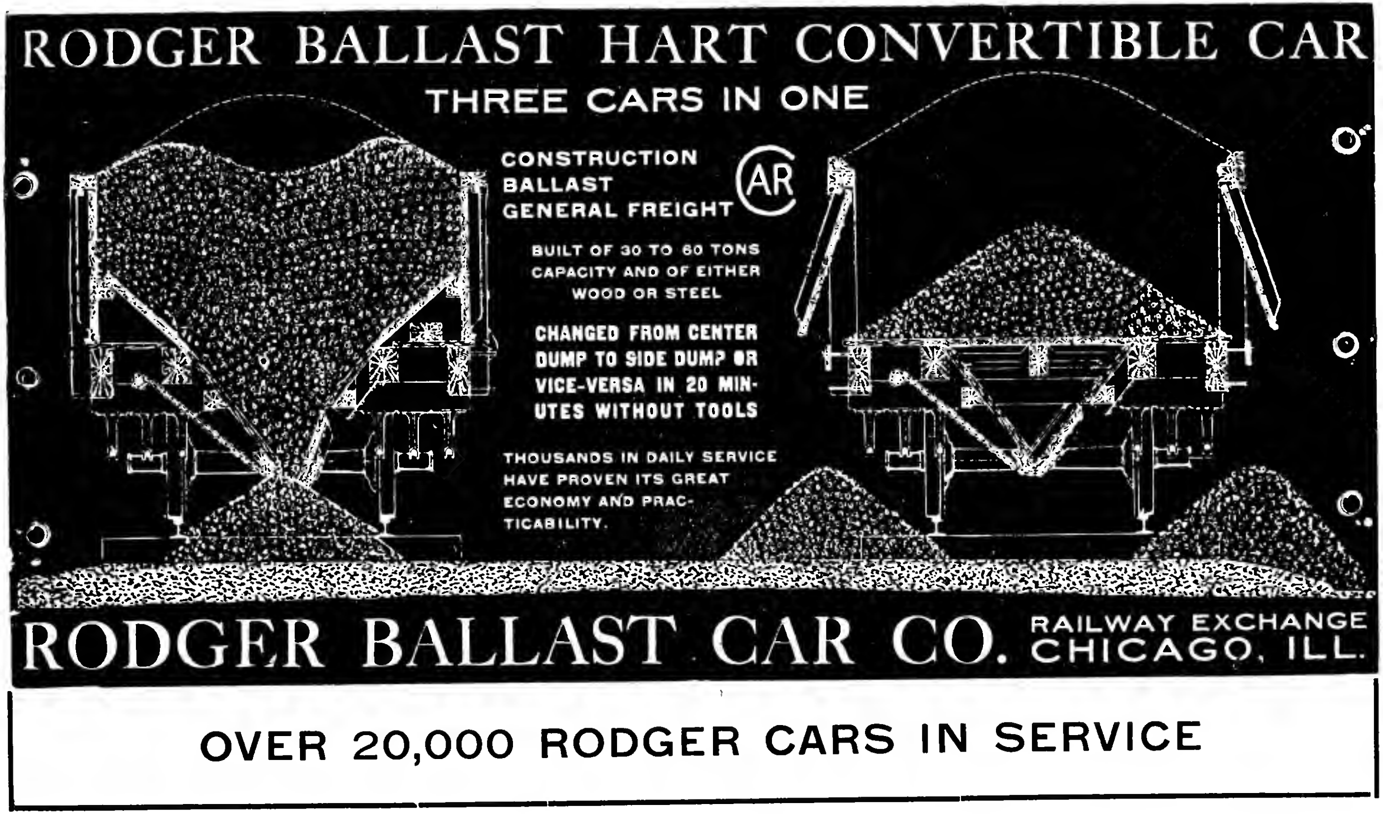
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CHANGED FROM CENTER DUMP TO SIDE DUMP OR VICE-VERSA IN 20 MINUTES WITHOUT TOOLS
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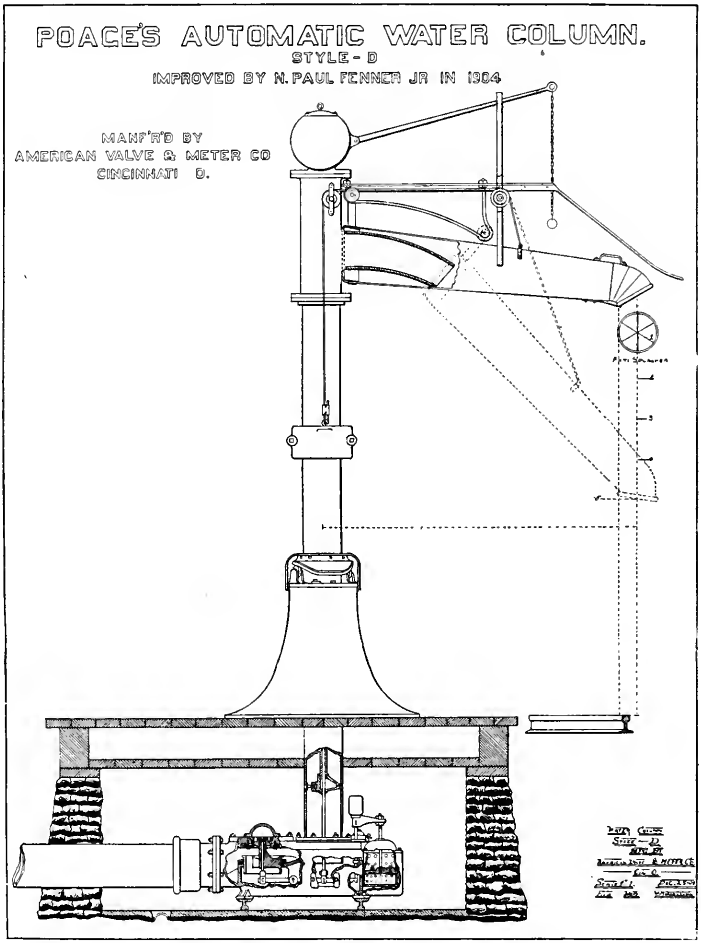
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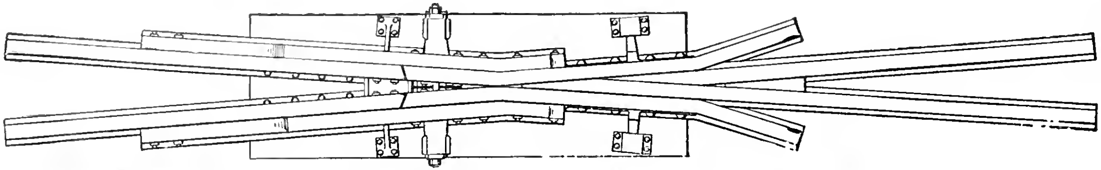

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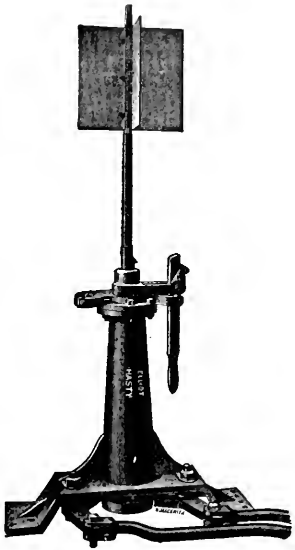

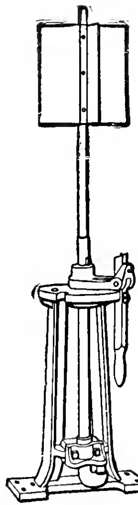

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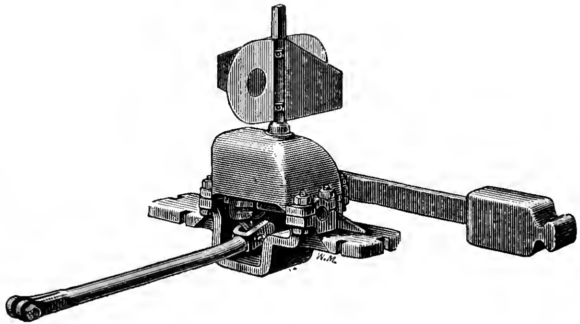
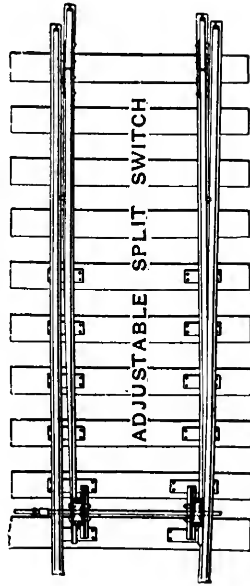
HIGH MAIN LINE STAND





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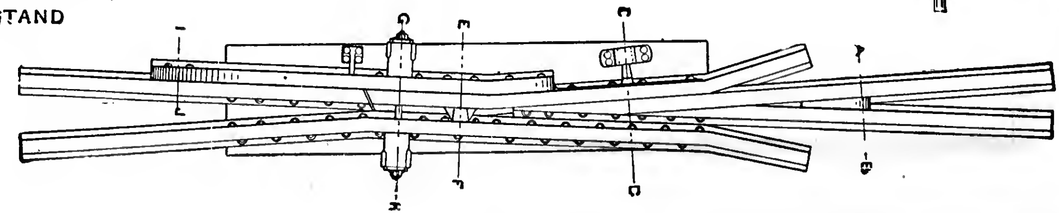
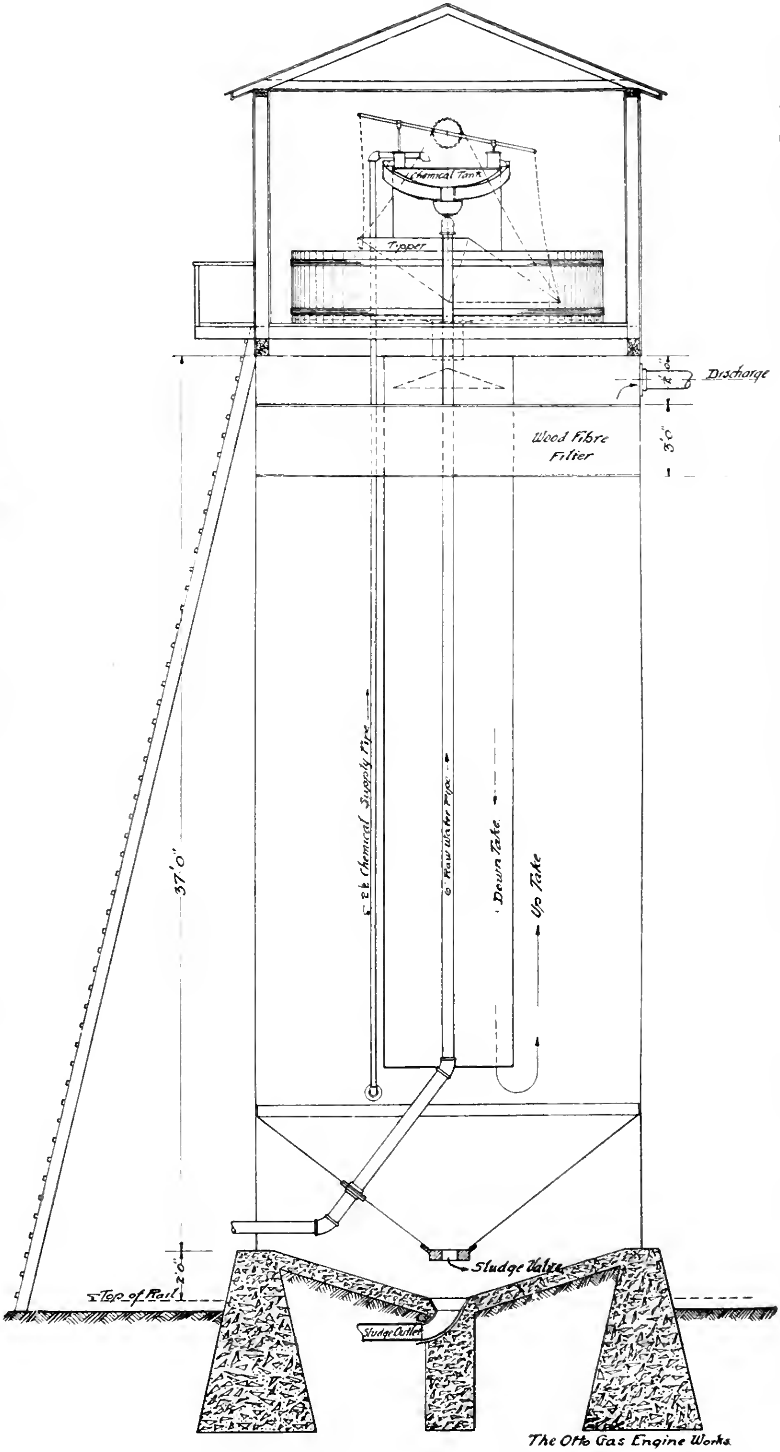


Type of our Continuous Water Softening Plant.



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