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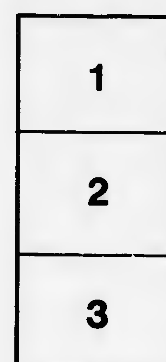

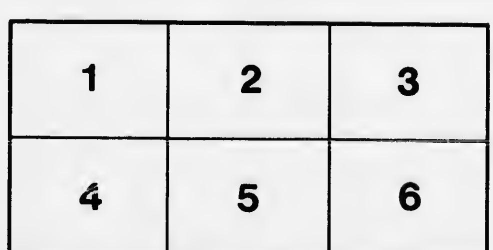

REPORT OF BOARD

Collingwood Schreiber

CONVENED TO DETERMINE ON A STANDARD FOR

CONSTRUCTION OF THE PACIFIC RAILROAD,

MADE TO

HONORABLE JAMES HARLAN, SECRETARY OF THE INTERIOR,

FEBRUARY 24, 1866,

WITH

ACCOMPANYING DOCUMENTS.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1866.

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REPORT

OF

BOARD ON CONSTRUCTION OF PACIFIC RAILROAD.

DEPARTMENT OF THE INTERIOR, ENGINEER OFFICE,
Washington, D. C., February 24, 1866.

SIR: I have the honor to submit, herewith, a report of the proceedings of a board of government commissioners, directors, and engineer, convened by your direction, to determine on a standard for the Pacific railroad and branches, with the accompanying documents.

The replies from eminent engineers and others to a circular sent, asking their views on certain points of railroad construction, and which are included with these papers, will be found to contain much valuable and interesting information.

Their views and suggestions have been of much service in establishing the standard recommended by the board, since, although not practicable to give this road the solidity and perfection recommended by these replies, from the outset, without preventing its rapid progress and completion at an early date, as required by law, yet, as the character of road they all recommend is clearly that which will be needed when it is fully opened and doing a heavy business, the board have endeavored to make such a standard as will secure a good track without retarding the progress, and advise that every step of the work be made with a view to ultimate perfection.

Thus, while the board deem it essential that the work shall be thoroughly ballasted, and all the bridges provided with masonry piers and abutments, yet, knowing that the high embankments will require some time to settle before the track is finally adjusted, and that, in many cases, both ballast and stone for masonry must be brought by rail, they have thought best not to make the acceptance of any section contingent on the completion of its masonry and ballasting, but prefer that such parts of the road be accepted in case this work shall have been commenced and is progressing vigorously on the preceding sections.

It has been the aim of the board to give due and impartial consideration to the questions of economy, of first cost, and of ultimate working, as well as to the rapid progress and final adaptation to the traffic to be expected from this great work.

I am, sir, very respectfully, your obedient servant,

J. H. SIMPSON,
Lieutenant Colonel Engineers, Chairman of Board.

HON. JAMES HARLAN,
Secretary of the Interior.

DEPARTMENT OF THE INTERIOR,
Washington, D. C., February 24, 1866.

COLONEL: The report of the proceedings of the board to determine on a standard for the construction of the Pacific railroad, with the accompanying documents, has been received.

The results arrived at by the board, as embodied in the report it has adopted in regard to the construction of the road, are approved, and it is hereby directed that said report be used by the directors and commissioners as a guide for their action in directing or accepting the work. To this end you will cause copies to be furnished these officers as soon as printed.

I am, very respectfully, your obedient servant,

JAMES HARLAN,
Secretary of the Interior.

Colonel J. H. SIMPSON,
Corps Engineers U. S. A., Ch'n of Board, Chief Eng. Dep. Interior.

Journal of proceedings of board convened to determine on a standard for construction of the Pacific railroad.

WASHINGTON, D. C., *February* 1, 1866.

The first meeting of a board to determine on a standard for the construction of the Pacific and other railroads in which the government has an interest, convened by order of the Hon. James Harlan, Secretary of the Interior, was held at 12 o'clock m., in the Washington Aqueduct office.

The board was organized in compliance with the following instructions, &c., from the honorable Secretary of the Interior:

1. Orders for the government commissioners and directors to report in Washington, as members of the board.—Appendix A.
2. Invitations to presidents of several companies interested to be present in person or by proxy.—Appendix B.
3. Order appointing as chairman of the board Lieutenant Colonel J. H. Simpson, corps of engineers, and as secretary Mr. John R. Gilliss, assistant engineer.—Appendix C.

In compliance with his instructions, Colonel Simpson took the chair and called the board to order.

The board of government commissioners, directors, and engineer were present, as follows:

Government Commissioners.—Lieutenant Colonel J. H. Simpson, corps of engineers U. S. army, chief engineer Department of the Interior, and commissioner for Union Pacific railroad and Union Pacific railway, eastern division; Major General S. R. Curtis, of Iowa, commissioner for Union Pacific railroad and Union Pacific railway, eastern division; Hon. Wm. M. White, of Connecticut, commissioner for Union Pacific railroad; Hon. P. H. Sibley, of California, commissioner for Central Pacific railroad; Hon. Wm. P. Smith, of Maryland, commissioner of Union Pacific railway, eastern division.

Government directors on Union Pacific railroad.—Hon. George Ashmun, of Massachusetts; Hon. Jesse L. Williams, of Indiana; Hon. Springer Harbaugh, of Pennsylvania; Hon. Timothy J. Carter, of Illinois; Hon. Charles T. Sherman, of Ohio.

The following gentlemen were also present as representatives of the several companies engaged in constructing the Pacific road and branches:

C. P. Huntington, esq., vice-president Central Pacific railroad; Hon. S. C. Pomeroy, president Atchison Branch Pacific railroad; Hon. Wm. B. Allison, vice-president Sioux City and Pacific railroad; Hon. Oakes Ames, Sioux City and Pacific railroad; R. M. Shoemaker, chief engineer Union Pacific railway, eastern division; Geo. W. McCook, esq., attorney Union Pacific railway, eastern division; Hugh L. Jewett, esq., director Union Pacific railway, eastern division.

The chairman then stated that to obtain information on some points having an important bearing on the subject before the board, he had, by direction of the Hon. James Harlan, Secretary of the Interior, addressed a circular (No. 2) to eminent railroad engineers and others, asking their opinions on certain important details of railroad construction.

Circular No. 2 and the replies to it were then read. (See appendices D to M, inclusive.)

On motion of General Curtis, these papers were referred to a committee of five, to be appointed by the chairman.

The following named gentlemen were appointed on this committee: S. R. Curtis, Jesse L. Williams, P. H. Sibley, Springer Harbaugh, and Timothy J. Carter.

On motion of Mr. George Ashmun, it was resolved that the Pacific railroad committees of each house of Congress be invited to attend the meetings of the board.

Invitations to this effect were accordingly sent by the chairman.

On motion of Mr. Charles T. Sherman, it was resolved that when the board adjourn, it be to meet at 10 a.m., February 2, that early hour being selected to accommodate the congressional committees

On motion of Mr. Charles T. Sherman, it was resolved that a committee of three be appointed by the chairman to report whether any additional congressional legislation be desirable in connexion with the action of the board.

The following named gentlemen were appointed on this committee: Charles T. Sherman, George Ashmun, Wm. M. White.

A debate then ensued as to the organization of the board, especially as to whether those present who were not government officers, but only represented the companies, were authorized to vote. The question was decided in the negative by the chairman, who referred to the instructions under which the board was organized.

A debate as to the character of road that should be built then ensued, participated in by Messrs. Shoemaker, Ames, Williams, the chairman and others.

At half past two o'clock p. m. the board adjourned, to meet again at 10 o'clock a. m., February 2.

WASHINGTON, *February* 2, 1866.

In pursuance of adjournment, the second meeting of the board was held at 10 o'clock a. m.

In addition to members at the previous meeting, the Hon. Hiram Price, of Iowa, chairman of House committee on Pacific railroad; Hon. J. P. Usher, attorney for Union Pacific railway, eastern division, and others, were present.

After the board had been called to order the minutes of the last meeting were read.

Mr. Huntington called attention to the fact that the Central Pacific railroad was not represented in the committee on legislation.

On motion of Mr. Sherman, it was resolved that the committee on legislation be increased to four members by the addition of Mr. Sibley, commissioner on Central Pacific railroad.

A debate then ensued, participated in by General Curtis, Mr. Williams, and others, as to the duties of the committee to whom replies to circular No. 2 and other papers had been referred.

On motion of Mr. Williams, it was resolved that said committee be the business committee of the board, and that the chairman be *ex officio* a member of it.

A debate then followed on the subject of establishing a standard—the practical objections to it on the one hand, and the importance of securing a good road, and of uniformity of action on the part of all concerned, on the other. It was participated in by nearly every member of the board.

On motion of Mr. Ashmun, at 1 p. m., it was resolved that the board adjourn, to give the committees an opportunity to prepare their reports.

WASHINGTON, *February* 3, 1866.

The third meeting of the board was held at 11 a. m. After it had been called to order the minutes of the last meeting were read.

General Curtis, as chairman of the business committee, then read its report on a standard to be recommended for the construction of the Pacific railroad.

Mr. Shoemaker suggested that the report be so amended that bridges could be accepted if the masonry had been commenced.

After some discussion the following proviso was agreed upon and inserted in the report:

"*Provided,* That temporary trestles may be adopted upon assurances, to the satisfaction of the commissioners, that stone abutments will be substituted immediately after the lines shall be opened, so that stone can be transported thereon."

A debate followed as to the credentials of some of the representatives of companies present, participated in by the chairman, General Curtis, and others.

On motion of General Curtis, it was resolved that technicalities be waived, and that representatives of the companies present be allowed to give their opinions.

A clause in the report of the business committee recommended that the commissioners inspect the location of the work before construction was commenced. Messrs. Curtis, Pomeroy, Sibley, Shoemaker, and others, gave their views at some length on this clause. It was finally resolved that it be left out.

On motion of Mr. Ashmun, it was resolved that the report of the business committee be read and debated by sections.

The preamble and succeeding sections on grades and curves were then read and adopted.

The section on embankments and excavations was then read. It was objected to by Mr. Shoemaker, and a debate followed as to the proper width for cuts at the grade line, participated in by Messrs. Curtis, Williams, Sibley, and the chairman.

A motion was made that the section on embankments and excavations be amended; which was not agreed to: Yeas, 4—Messrs. Curtis, White, Sibley, and Smith. Nays, 6—Messrs. Simpson, Ashmun, Williams, Harbaugh, Carter, and Sherman.

The next two sections, relating to mechanical structures and ballasting, were then read and adopted without dissent.

The section relating to cross-ties was then read. One paragraph in the report recommended that "sawed ties should not be less than 6 inches thick, 8 inches wide, and 8 feet long, nor less than 2,400 to the mile."

This was objected to by Mr. Shoemaker, and the subject was discussed by Messrs. Williams, Shoemaker, Sibley, Carter, and others.

During this debate Mr. Smith stated that it was necessary for him to leave; that he was satisfied with the report; that it was a reasonable common-sense document, and that he wished his name recorded on the vote in its favor. He then proposed the following as a conclusion to the report, which was agreed to and added to it:

"It is the aim of this board to secure all these objects, and it is also our belief that they are not incompatible, it being only necessary, on the part of the government, to insist upon the reasonable requirements embodied in this report, to hasten the completion of the great work, and at the same time adapt it to the high public interest which it is intended to subserve."

On motion of Mr. Williams, it was resolved that the paragraph be amended so as to require 2,500 ties per mile, of not less than 7-inch face, if sawed: Yeas, 6—Messrs. Simpson, Ashmun, Williams, Harbaugh, Carter, and Sherman. Nays, 3—Messrs. Curtis, White, and Sibley.

The section relating to rails was then read. One paragraph recommended that if found impracticable to use the fish-joint immediately, holes should be punched in the ends of the rails so that fish-plates might be used afterwards.

This was objected to by some of the members; and on motion of Mr. Harbaugh, it was resolved that the clause recommending holes to be punched in rails for fish-plates be left out. The section relating to rails was then adopted.

The section relating to side tracks was, after some debate, amended to read "eight feet apart in the clear between the rails," instead of "ten feet," as at first written.

On motion of Mr. Sibley, the section relating to rails was reconsidered, but after being debated by Messrs. Sibley, Williams, Curtis, and Huntington, was not altered. The next two sections, on sidings, as previously amended, and on rolling stock, were passed without debate.

The section relating to buildings was then read, and, at Mr. Shoemaker's request, after "engine-houses and repair shops" the words "at the principal stations" were inserted. As thus amended the section passed.

The concluding section was then read.

At the suggestion of Mr. Shoemaker, an amendment was proposed by the insertion of a general proviso, as follows:

"The limitations contained in this report are not intended to interfere with the work already commenced, or materials delivered or *in transitu*, but all such cases are left subject to the inspection of the commissioners, whose duty it shall be to inspect the work."

Messrs. Williams, Harbaugh, and the chairman objected to the amendment, and it was lost.

The concluding section, with the additional paragraph proposed by Mr. Smith, was, after some further debate, adopted.

On motion of General Curtis, it was resolved that where the word "shall" occurs in the report, it be made to read "should" or "may," and that for the word "convention" be substituted the word "board."

On motion of Mr. Ashmun, the report was recommitted to the business committee to engross and present at the next meeting.

On motion of General Curtis, at 4 p. m., the board adjourned to meet again at 10 p. m., February 5th.

WASHINGTON, *February* 5, 1866.

The fourth and last meeting of the board was held at 11 a. m. After it had been called to order the minutes of the previous meeting were read.

General Curtis, as chairman of the business committee, read its report as amended at the previous meeting.

Mr. Williams suggested that the paragraph relating to sawed ties be amended to read, "If sawed, they should not be less than eight inches wide, and not less than 2,400 per mile, or such number as will have the same bearing surface, provided that if any sawed ties have been already delivered or contracted for, only seven inches wide, they may be laid down."

On motion of Mr. White, the amendment was adopted unanimously.

At the suggestion of Mr. Harbaugh, and on motion of Mr. Williams, the following addition was made to the report:

"Wherever cattle-guards and road-crossings are necessary they should be made."

On motion of Mr. Sherman, the report of business committee, as finally amended, was then adopted unanimously by the board.

REPORT OF BUSINESS COMMITTEE.

Your committee, to whom were referred various communications of experienced and scientific engineers concerning a suitable standard for the work on the Pacific railroad and its several branches, and to whom was also assigned the duty of presenting to the board proper subjects for its consideration, as contemplated by the call of the honorable the Secretary of the Interior, have the honor to present the following report:

The various locations through which the Pacific railroad and its branches are destined to run occupy such a variety of country as to render a specific style of work suited to all localities extremely difficult. The topographical features of the surface, the great variety of soils and lower strata of the earth, the singular variety of climate as to cold and heat, wet and dry, all have to be considered in determining details of location, material, and form of the work. It was, probably, because of these difficulties the laws of Congress authorizing the construction give only general or very meagre specifications as to the details of the Pacific railroad.

But your committee, after availing themselves of the views expressed by the several engineers to which they have referred, and in contemplation of the reasonable construction of the law of Congress, recommend to the board the adoption of the following general rules as those which should govern all parties engaged in directing, constructing, or accepting the work:

Every step taken in the work, and especially in the location of lines and grades, should be adapted to ultimate perfection, whatever may be immediate interests or necessities, so as to secure to the nation a grand and complete structure, every way worthy of our country and honorable to the distinguished men who involve their capital and energies in so vast an enterprise.

LOCATION.

Great care should be observed in the determination of the general and detailed location of the main line and branches, so as to secure the shortest lines consistent with economical grades to the most desirable passes of the mountain ranges. The law names but few points; still it is clearly the interest of the government and not prejudicial to the companies to determine such points as a great general line should have, so as to unite, as far as possible, all the great ultimate purposes of a central and convenient channel for the commerce of nations that is likely to traverse the road.

With this general view of the work, careful and extended surveys should be made and well considered.

GRADES AND CURVES.

While the law makes the grades and curves adopted on the Baltimore and Ohio railroad a standard, this is only to be considered as a limit to be adopted in mountain districts. To introduce grades of 116 feet per mile, or curves as sharp as 400 feet radius, on other parts of the road, would manifestly violate the spirit and intent of the law. Grades and curves should be settled upon principles of true economy and adaptation, based upon careful scientific and practical investigations, having due regard both to cost of construction and future working of the road.

It is safe to say, in advance, that on the Platte and Kansas valleys, and on similar smooth valleys or level plains, no grade should exceed thirty feet elevation per mile.

EMBANKMENTS AND EXCAVATIONS.

In all parts of the main line of road or branches, embankments should not be less than fourteen feet wide at the grade line. Excavations, if the cuts are lengthy, should be twenty-six feet wide, and in shorter cuts at least twenty-four feet; thus leaving in all cases room for continuous side ditches of ample depth and width, so as to secure that most essential requisite, a well-drained road-bed. Rock excavations should be not less than sixteen feet wide, and all tunnels should be excavated for a double track. Slopes of earth embankments should be one and a half base to one rise. Excavations, except in rock, should have slopes from one to one and a half base to one rise, depending upon the material; or if steeper, then to have increased width at grade, so as to remove the same quantity of earth contained within the slopes.

MECHANICAL STRUCTURES.

Culverts and abutments for bridges and drains should be of stone, whenever a durable article can be obtained within a reasonable distance—say from five to eight miles, depending upon circumstances; provided that temporary trestles may be adopted upon assurances, to the satisfaction of the commissioners, that stone abutments will be substituted immediately after the line shall be opened, so that stone can be transported thereon. But if good stone be too remote, then hard-burned brick or wooden trestle work may be adopted. The wood to be of the most durable character the country will afford; and the wood or brick to be replaced by stone when that material can be conveyed conveniently by rail. Bridges of stone, or iron or wood, (such as the Howe truss, or other equally good structure,) should be used at the discretion of the company.

BALLASTING.

A railroad cannot be considered complete until it is well ballasted. If composed of gravel or broken stone it should be from 12 to 24 inches thick, depending on the lower material. In view of the settling of new embankments, which require time and rains before ballasting can be properly placed, and also in view of the number of miles required by the law to be constructed annually, the perfect finish of the road-bed in this respect must be progressive and the work of time. Yet it is the opinion of the board that such work of perfecting the ballast must proceed as usual on first-class railroads; otherwise subsequent sections should not be accepted, because the whole work is not then being carried forward as a great Pacific railroad, such as the law contemplates.

CROSS-TIES.

Oak or other suitable timber should be used, where it can be obtained with reasonable transportation. When such timber cannot be had for all the ties at reasonable cost, then the best the country affords may be adopted; but if it be cottonwood, or similar soft material, it must be Burnettized or kyanized thoroughly so as to increase its durability. But in all cases the joint tie should be of oak, or other suitable timber, the better to hold the spikes at these points. There should be at least 2,400 ties to the mile. They should be eight feet long, six inches thick, and, if hewn, six inches on the face. If sawed, they should not be less than eight inches wide and not less than 2,400 per mile, or such number as will have the same bearing surface, provided that if any sawed ties have been already delivered or contracted for only seven inches wide, they may be laid down.

RAILS.

These are to be of American iron, as required by law, of the best quality, and should weigh sixty pounds to the yard. But in consideration of the great cost of transportation from the present location of rolling mills to the remote sections of this road, iron may be adopted which weighs only fifty-six pounds to the yard. In mountain districts, however, where heavier engines will be used, not less than sixty-pound rails should be adopted; provided that if any of the companies have on hand or *in transitu*, or contracted for, any rails of different weight from that herein specified, and not under fifty pounds per yard, such rails may be used. The rails should be attached to each tie by spikes driven on both sides of the rail. As the nearest approximation to a continuous rail, the so-called fish-joint is preferred and recommended; but if found that it will retard the progress of the work, the common American wrought-iron chair may be used.

SIDINGS.

The length of side tracks should be at least six per cent. of the line completed, to be increased as the number of passing trains shall demand. Side tracks should also be laid eight feet apart in the clear between the rails. Wherever cattle-guards and road-crossings are necessary they should be made.

ROLLING STOCK.

Locomotive engines and cars must be provided in liberal proportion to the traffic and the convenient construction, to be increased from time to time as the completion of additional sections and the increase of business seem to require.

BUILDINGS.

Engine-houses, repair shops, and station buildings should be adapted to the wants of the service.

At the opening of business, the extent and capacity of buildings may be only such as to provide liberally for the existing rolling stock and the business of the road, and such probable early increase as may seem likely; yet the plans in all cases, both as to the buildings and grounds, should be arranged for prospective enlargements and extensions equal to any future business of the road, the buildings at first erected forming appropriate parts of a complete and systematic whole.

Engine-houses and repair shops at the principal stations must in all cases be of stone or brick, with good stone foundations. The covering should be slate or metallic, to guard as far as possible against fire.

Water stations should be erected at convenient distances to suit the wants of the trains.

Extensive and convenient locations of ground should be procured to accommodate a future large business, and the proper titles should be carefully secured. All this is the more desirable, as lands are now easily obtained at moderate prices.

In these specifications it is believed that nothing is required which may not be regarded as essential to a commodious and complete railroad. Nothing is proposed to retard the progress of the companies. The importance and public desire for accelerated movement have been fully appreciated, and the board earnestly desires to favor and foster the energy and fidelity which now seems to animate those engaged in the construction. But while guarding against delay on one hand, the public interests require, on the other, a substantial and complete work, and the highest perfection of track reasonably attainable on a new road is expected and projected as the standard to which the workmen are to arrive. The argument in favor of speedy construction must be subordinate to the substantial objects of the road, and the government must be certain to have a work that will convey her mails, troops, and munitions of war, and commerce of the country with entire certainty, celerity, and convenience. It is the aim of this board to secure all these objects, and it is also our belief that they are not incompatible, it being only necessary on the part of the government to insist upon the reasonable requirements embodied in this report to hasten the completion of the great work, and at the same time adapt it to the high public interest which it is intended to subserve.

Mr. Sherman, as its chairman, then read the following report of committee on legislation:

"The committee to whom was referred the subject of legislation on the matters under consideration by this board respectfully report: That the results arrived at cannot properly be enacted in the form of a statute, and we therefore do not deem it advisable for us to ask any legislation from Congress at the present time.

"We, however, deem it proper to suggest that it is possible legislation may be proposed hereafter, and, in that case, this committee should be charged with the duty of giving its attention to the proposed action."

On motion of Mr. Ashmun, this report was adopted.

The following papers were submitted by different members of the board, and their motions to have them filed with its records were adopted:

Letter from Philip S. Justice to Hon. Springer Harbaugh in relation to steel rails—Appendix N.

Letter from Wm. P. Shinn to Hon. M. Welker in relation to fish joints, and letter from Hon. M. Welker to Hon. Chas. T. Sherman transmitting the same.—Appendix O.

Letter from T. C. Durant, esq., vice-president Union Pacific railroad, to Colonel Simpson—Appendix P.

Telegram from H. H. Gardner to J. L. Williams in relation to fish joints—Appendix Q.

On motion of Mr. Ashmun, it was resolved that the remarks made during debates be omitted from the minutes of the board.

Messrs. Shoemaker and McCook then expressed their appreciation of the courtesy shown to representatives of the various companies by the chairman and board.

On motion of Mr. Ashmun, the following resolution was passed unanimously:

"*Resolved*, That we desire to express the thanks of this board to the officers and representatives of the different companies engaged in building the Pacific railroad, who have attended our meetings, and have given valuable information to enable this board to arrive at its results; and also to express our great satisfaction at the earnest and vigorous efforts which the several companies engaged in the prosecution of the great work they have in hand are making to press it forward to as speedy and creditable completion as the means within their power will justify."

The board then called, in a body, on the Hon. Secretary of the Interior to pay their respects. After stating to him, through their chairman, that their labors had been ended in a manner mutually satisfactory, and his expressing gratification at the result, the convention adjourned *sine die.*

J. H. SIMPSON,
Lieut. Col. Corps Engineers, Gov't Com'r and Chairman.
S. R. CURTIS,
Com'r U. P. R. R., and U. P. R., E. D.
WM. M. WHITE,
Commissioner U. P. R. R.
P. H. SIBLEY,
Com'r Central P. R. R.
WM. P. SMITH,
Com'r U. P. R., E. D.
GEO. ASHMUN,
Gov't Director U. P. R. R.
JESSE L. WILLIAMS,
Gov't Director U. P. R. R.
SPRINGER HARBAUGH,
Gov't Director U. P. R. R.
T. J. CARTER,
Gov't Director U. P. R. R.
CHAS. T. SHERMAN,
Gov't Director U. P. R. R.

JOHN R. GILLISS, *Secretary.*

APPENDIX A.

DEPARTMENT OF THE INTERIOR, ENGINEER OFFICE,
Washington, D. C., September 8, 1865.

SIR: A board, to consist of the government commissioners, directors and engineer of the Pacific railroad, will convene in this city, at 12 meridian on the 10th day of January next, at this office, for the purpose of adopting some uniform standard of road to which the several companies organized under the acts of July 1, 1862, and July 2, 1864, shall conform.

You are hereby respectfully requested to attend at the time and place designated, and the Secretary would be pleased to be informed, both by telegraph and letter, if you will be able to comply.

I am, very respectfully, your obedient servant,

J. H. SIMPSON,
Lieutenant Colonel Engineers, in charge

Hon. P. H. SIBLEY,
Government Com'r Central Pacific R. R. Co.,
San Francisco, California.

Same as the above sent to Hon. Josiah Johnson, Sacramento, California, and Hon. F. F. Low, San Francisco, California, commissioners Central Pacific railroad. Subsequent to this letter similar requests were sent to the government commissioners and directors of the Union Pacific railroad, and to the government commissioners on the Union Pacific railway, eastern division; and the day for the meeting was postponed to February 1.

APPENDIX B.

DEPARTMENT OF THE INTERIOR, ENGINEER OFFICE,
Washington, D. C., January 24, 1866.

SIR: The honorable Secretary of the Interior has instructed me to inform you that a convention of the government directors, commissioners, and engineer will be held in this city on the first proximo, to fix a standard for the Pacific railroad and branches, and that you are invited, by proxy or otherwise, to attend.

I am, sir, very respectfully, your obedient servant,

J. H. SIMPSON,
Lieutenant Colonel Engineers.

Hon. S. C. POMEROY,
President Atchison Branch Union Pacific Railroad,
United States Senate.

A similar letter to the above was sent to the following persons: Jno. D. Perry, esq., president Union Pacific railway, eastern division, St Louis, Missouri; and John J. Blair, esq., president Sioux City and Pacific Railroad Company, New York city.

APPENDIX C.

DEPARTMENT OF THE INTERIOR,
Washington, D. C., February 1, 1866.

A board, consisting of the government directors, commissioners and engineer, will meet to-day at 12 m. in the Washington Aqueduct building, for the purpose of consulting together and fixing a standard to which the Union Pacific Railroad Company and branches and the Central Pacific Railroad Company shall conform. Lieutenant Colonel J. H. Simpson, corps engineers, government engineer, will preside over the board, and Mr. John R. Gilliss, assistant engineer, will record the proceedings, which will be reported to this department.

JAS. HARLAN, *Secretary.*

APPENDIX D

In order that the deliberations of the board might be aided by the experience of the best engineering talent of the country, copies of the following circular were sent to forty-five of the leading engineers, railway superintendents, &c.

It is much to be regretted that the majority of the engineers to whom the circular was sent either did not receive or did not find time to reply to it; since the answers from those who did reply contain an amount of information on railroad construction seldom met in such a condensed form.

Certain questions were asked in the circular to indicate points on which information was especially desired; but it was not intended to confine the replies to these questions, and it will be seen that most of the engineers used the questions simply as guides for the general arrangement of their answers, and complied with the request that they would give their views on other points having an important bearing on the subject.

(CIRCULAR No. 2.)

DEPARTMENT OF THE INTERIOR, ENGINEER OFFICE,
Washington, D. C., December, 1865.

It being desirable to establish a standard to which the Pacific and other railroads in which the government has an interest shall be made to conform, I am instructed by the Hon. James Harlan, Secretary of the Interior, to solicit your opinions on any of the following points which your experience and observations will enable you to give:

1st. Weight of rail for a first-class road, relative durability of rails of different weights with same traffic, best cross section for same, and merits of different varieties of American iron.

2d. Best plan for chairs, spikes, or other joint fastenings.

3d. Dimensions of and distances between ties.

4th. Width of road-bed at grade, in excavation and embankment, dimensions of side ditches in the former, depth of ballast, and expense per mile it would be worth incurring to get it.

5th. Relative advantages of different plans and materials for railroad bridges.

6th. Weight and other characteristics of engines and rolling stock suitable for a large business and different grades.

7th. Ratio in which rails and rolling stock deteriorate with different velocities.

In the above, interest on first cost is to be considered in connexion with expense of repairs and deterioration, so that their annual sum shall be a minimum.

Your views on these points, as well as on any others having an important bearing on the subject, are desirable, in order that they may be laid before a meeting of the government commissioners, directors, and engineer of Pacific railroad, early in January next, and should, if possible, be sent to this office before the first of January. They will be very valuable in aiding the government in establishing such a standard for these roads that, when finished, they will subserve the purposes for which they are built, and be a credit to the nation.

Please address me under cover to the Secretary of the Interior.

I am, very respectfully, your obedient servant,

J. H. SIMPSON,
Lt. Col. Engineers.

To ———.

APPENDIX E.

QUARTERMASTER GENERAL'S OFFICE,
Washington, D. C., December 26, 1865.

COLONEL: I have to acknowledge the receipt of a copy of circular No. 2, soliciting on the part of the Hon. James Harlan, Secretary of the Interior, my opinion on any of several points in relation to the construction of a "first-class railroad," with a view to establish a standard for the construction of the Pacific railroad.

The fifth point, the relative advantages of different plans and materials for railroad bridges, is the only one upon which I have time to offer any opinions. Upon all the others you will doubtless receive information from persons engaged in the construction and working of railroads. Most of them are indefinite. The heavier and stronger the construction, the better and more durable. Financial considerations finally fix the limit of weight and excellence of track, beyond which even the governments of the Old World, in railroad construction, do not go. I cannot, however, too strongly urge the importance, in view of safety and ultimate economy, of requiring all the bridges to be built of permanent and durable materials. Stone, brick, wrought and cast iron alone should be permitted to enter into the main features of construction, wood being admitted only under the rails for the sake of giving elasticity to the track.

The experience of the French engineers has shown that it is not necessary, in order to build stone arched bridges of considerable span, to use expensive cutstone masonry. There are arches of ninety feet span, and even longer, built of brick and of rubble masonry, which stand secure. There is no difficulty with a sound, strong stone, breaking into reasonably good shapes, in constructing a stone bridge with arches of 120 feet span entirely of rubble masonry, laid in a strong cement mortar.

Cast and wrought iron bridges can be prepared in the workshops of the settled districts of the country, and sent by rail to their destination. Temporary, cheap trestle bridges, such as served to supply the armies in the field during the war upon all the railroads operated by the Quartermaster's department, 1,700 miles in extent, can be erected and used to forward the necessary material for erecting permanent stone or iron structures.

I prefer, when it is possible to erect without too great expense proper abutments, bridges supported upon arched ribs of cast or wrought iron, to the framed structures so generally used in this country and Great Britain.

The French have many such, of which the later wrought-iron bridges over the Seine at Paris, and the Tarascon railroad bridges, are good examples; the latter has cast-iron arches.

The Fink framed or truss bridge, and the Bollman bridge used on the Baltimore and Ohio railroad, and on the Louisville and Nashville railroad, are good forms of truss bridges, in which the roadway is suspended by oblique suspension rods, and the thrust is taken by a horizontal top chord of cast or wrought iron.

In both these bridges the details are wrought out and proportioned in a masterly manner. They are good bridges when a sufficient abutment to support the thrust of an arch would be too costly.

I place the railroad bridges, then, in the following order:

Masonry arches, for all spans up to 120 *feet.*—1. Cut stone. 2. Rubble stone. 3. Brick.

Iron bridges.—1. For spans not exceeding twenty feet, wrought-iron H beams or girders. 2. For spans exceeding twenty feet, and not exceeding two hundred feet, arches of cast or wrought iron, spandrel filling wrought iron. 3. For spans below two hundred feet, when good abutments for arches will be too costly, trussed or framed bridges of wrought iron, in which cast iron may be admitted for the posts and struts, and horizontal beams subjected to compression. 4. For spans much exceeding two hundred feet, either wrought-iron arches or framed bridges entirely of wrought iron should be used.

I am, very respectfully, your obedient servant,

M. C. MEIGS,
Quartermaster General, Brevet Major General.

Lieut. Colonel J. H. SIMPSON,
Corps Engineers, United States Army.

APPENDIX F.

PHILADELPHIA, *December* 27, 1865.

COLONEL: I proceed briefly to notice your interrogatories in circular No. 2.

1. I have no very recent experience in the practical operation of first-class railroads, and cannot give the relative durability of rails of different weights from my own experience. My general idea is, that the rapid deterioration of the permanent way, so called, arises from the enormous increase in the weight of engines without a corresponding increase in the wearing surface of the rails, When the engines weighed only from six to ten tons, the durability of the rails, which were then chiefly of English manufacture, appeared to be almost unlimited. Attempts have been more to increase the durability of rails by the substitution of a better material, and steel-headed rails have been tried. Half a mile of such rails were laid on the Pennsylvania railroad, but the result, I believe, was not entirely satisfactory, the difficulty arising from the imperfect connexion between the steel and iron. Steel rails also have been proposed, and I believe used to a very limited extent. As at present manufactured they are too expensive for ordinary use.

I have great confidence that the processes for the manufacture of steel will be so far improved and simplified that this superior material will be used universally in rails, resulting in a great increase of durability. In regard to the shape of section, I will say that as large a portion of the material as possible should be placed in the head; and the stem may be thinner than is usually made, without injury to the strength of the rail. I have never known a case of failure by the thinness of the stem, but I have seen a piece of an old rail taken from the Philadelphia and Columbia railroad, the head nearly worn off, and the stem very high and thin, with parallel sides.

With the present class of engines I am satisfied that no iron can be found that will long stand the excessive pounding and rolling of a heavy traffic with high velocities. To increase durability, the surface of the rails and the diameters of the drivers should be as large as practicable, and the speed of freight trains limited to, say, twelve miles per hour.

Rails are manufactured at the Cambria Iron Works, Johnstown, Pennsylvania, the Phœnixville Works, and the Rensselaer Iron Works, Troy, fully equal to any imported.

2. As to the best form of joint fastening, the smoothest and most perfect surface when first laid is given by the compound rail, but experience condemns it for want of durability. It will only answer for light engines and trains. The best joint, everything considered, is a fished joint, with a long splice extending over the next tie on each side of the joint. I do not like a chair at any time. It acts as an anvil and the wheels as sledges to hammer out the ends of the rails. I obtained a very good result on the Southern Vermont railroad by putting the joint between the ties, and the ties at the joint about one foot apart. A cast-iron splice about eight inches long was fitted close to the outside of the rails. Holes were punched in the rails about two inches from the end, and a U-shaped bolt (of seven-eighths inch round iron) connected them. The joint cost no more than the ordinary chair, and was very smooth and strong. On one occasion 150 feet of trestle-work was carried away by a flood, but the rails and cross-ties hung as a catenary, and hand-cars were run over without breaking the connexion.

3. I use ties eight feet long and as large in cross-section as can conveniently be procured, not less than six inches surface and six inches thick, but eight inches would be preferable. The distance apart two and a half feet from middle of ties, but with heavy engines it is better to reduce the distance to two feet.

4. The width of road-bed, even on the same line of road, should not be considered a fixed and invariable dimension. The elements which determine the width of road-bed are the gauge of the track, the distance between tracks, and the width of the side ditches.

The dimensions of the ditches depend on the character and extent of the slope, the quantity of water, and the greater or less tendency to slides and washes. The slope of an excavation should correspond to the natural angle of repose of the material. If too flat, the surface exposed to rain and frost is unnecessarily increased and the side ditches rapidly filled. In the south, where the frost does not act severely, clay cuts are best finished and made durable when the slopes are perpendicular. The rain has in this case very little effect, while with flat slopes the wash is excessive. On steep hill-sides, covered with shrubs and bushes, the roots form the best protection against washes, and it is often good practice in such cases to widen the road-bed and leave the upper slope vertical.

After this statement, it is scarcely necessary for me to add that in my practice I conform to no prescribed dimensions for side ditches and no uniform angle for slopes, but leave all such details to the judgment of the engineer in charge. If the slopes are found too steep they are easily flattened after the track is laid.

As the wash from the side slopes is in proportion to the length, or possibly in a still higher ratio, since the velocity and degrading power of currents are increased by distance of fall, it would not be good engineering to make the side ditches in a shallow and dry cut the same as in a very deep one. As a minimum, it may be stated that in a shallow excavation in dry earth, in the latitude of Pennsylvania, I would give a width of five feet at top, three feet at bottom, and slopes of forty-five degrees. And in this case, allowing the gauge of tracks to be four feet eight and a half inches, the distance between tracks six feet, the length of cross-ties eight feet, and two feet from ends of ties to edge of ditch, the minimum width would be twenty-two feet eight and a half inches; but twenty-four feet is better.

On the subject of ballast my opinions are very decided. I prefer broken stone to gravel. The drainage is more perfect, the ties last much longer, and there is far greater freedom from dust. Before placing the ballast the road-bed should be sloped from the middle to the side ditches. *No trenches whatever should be made for the ballast.* Two parallel walls should be built of dry stone, twenty-two feet apart from out to out, and about one foot high. Stones equivalent to about four inches cube should be thrown in to a depth of one foot. The surface should then be broken and six inches more of stone added and broken into two-inch cubes. On this surface the ties are laid. This will make a first-class road-bed.

Where stone cannot be procured it may be best to lay the track without ballast and haul it in cars afterwards. Ballasting can very readily be done in this way. Without ballast in a soil subject to wet and frost a good road-bed cannot be obtained, and any reasonable expenditure to obtain it would be justifiable.

5. I am decidedly in favor of iron or stone for railroad bridges. As to plans, my ideas are given in my general theory of bridge construction, published by Appleton. There are many plans in general use which give good bridges if properly proportioned. The Howe, Pratt, Fink, and Bollman are all good bridges. I will state here that in planning bridges for a long line of road I would seek for uniformity in plan and dimensions. A series of spans—say 50, 75, 100, 125, and 150 feet—will suit almost every locality, and the parts can be made of exact dimensions and interchangeable. If desirable, I may communicate further with you on this subject.

6. Independently of injury to permanent way, heavy engines are most economical for a heavy business. They transport a greater number of tons at a given expense, and by reducing the number of trains reduce the liability to acci-

dent. There is a limit, however, to the increase of weight in engines, arising from their crushing effect upon the rails, and this limit appears to have been already exceeded. When rails are made of steel, with four inches of bearing surface in the head, drivers not less than five or six feet in diameter, good joints at the ends, and good ballast under the rails, and the speed reduced to twelve miles per hour, I have no doubt that the expenses of repairs will be greatly reduced.

In the construction of freight cars the great problem is to reduce, as far as practicable, the proportion of dead weight to paying load without sacrifice of strength; and I do not know that the ordinary eight-wheel freight car admits of any very great improvement.

7. I have never instituted experiments or made careful observations to determine the ratio of deterioration with different velocities, but I am decidedly of opinion that only light engines should be allowed to run with high velocities.

Time has not permitted me to answer your communication of the 15th instant except in a very hurried manner.

I will mail a pamphlet which contains some of my ideas on the subjects of grade, distance, and cost of construction; and if I can be of any use to you hereafter call upon me.

Yours, very respectfully,

H. HAUPT.

Lieut. Col. J. H. SIMPSON,
Corps of Engineers.

APPENDIX G.

CHICAGO, *December* 28, 1865.

COLONEL: Yours of the 22d instant reached me last evening. I have concluded to catch a little time for some general remarks on your circular No. 2. I will take your circular in order.

No. 1. *As to weight of rail.*—I consider 60 pounds to the yard of rail a fair weight for a good railway. In form I would put as little material in the waist as would answer, and the web or bottom as light as could be well rolled, and get all the material practicable in the head. The top to have at least one and a half inch flat, with rounded corners, height about four inches, not to exceed four and one-eighth. As to American rails there is great range. The best American rails I have known were made by Cooper & Hewett, of Trenton, N. J., and Wheeler & Co., of Boonton, N. J. Some American rails are hard and brittle. These wear well, but are very liable to break; others are soft, and though not liable to break, wear out rapidly. The iron of a rail should be hard and strong to do good service.

No. 2. *Fastenings.*—The hook-head spike is the only kind used on American railways. If chairs are used, I think the best yet used is the broad wrought-iron plate with lips turned up from the centre. The plate should be, before cut in the centre, about eight inches square and full five-eighths of an inch thick. But chairs are not indispensable if the fish-plates are used. We do not use chairs in laying new rails on the Pittsburg, Fort Wayne and Chicago railroad. The fish-plates are twenty-two inches long, two bolts in each rail and a plate on both sides. It is a little more expensive than chairs, but in my judgment greatly superior. I should not think of laying a first-class rail without the fish-joint. It is the best method I have known to join rails, and very safe.

No. 3. *Ties.*—Ties six inches thick, seven inches wide, and eight feet long, (for common gauge,) placed two feet from centre to centre, is about right for a sixty-pound rail. If the rail were heavier, the cross-ties should be heavier, or larger and not quite so close.

No. 4. Width of road-bed at grade, &c.—In excavation the road-bed should be considered the base of the ballast. If this is two feet below the rail, the width should be for road and slopes about sixteen feet. The slopes will occupy three feet each side, and ten feet for breadth of road and proper support for the ties. The ballast should extend full breadth of bed, in order to drain properly. It is important, especially when the material is tight or impervious to water, that the road-bed be formed with sufficient height in the centre and graded smooth, so as to allow water to pass off freely to the side ditches. The excavation should be made as much wider than the road-bed as will allow of suitable side ditches. The ditches should not be less than three feet deep below the base or bottom of cross-ties, and of such dimensions that all rains would pass off in ordinary times in a depth of water not exceeding six inches, and not to rise over one foot in the heaviest rains.

The width of any considerable embankment should be five to six feet beyond the rail. This is important in order to have a margin that will hold a car that leaves the rail.

In regard to ballast: This depends very much on the material of the natural road-bed. If the material is clay loam and impervious to water, no good road can be maintained without ballast. It will do very well in dry weather without ballast, but rains and frosts will destroy the track at such times, or greatly impair its usefulness. The road in such cases cannot be regarded as completed without ballast. A light business may be done, but no heavy or fast traffic can be well done without a good ballast.

The depth of ballast will depend on the climate; in general two feet from bottom to top of rail is little enough. If the natural material is sandy and porous it may do pretty well without ballast.

As to what I would pay rather than not have ballast, would of course depend on the natural bed or materials. But if the material requires ballast to make a good track, I should not hesitate to spend three thousand dollars per mile for this item. If broken stone had to be used, I should go for a larger expense, for the reason that it would necessarily in most cases cost more than gravel and would be much more permanent. Circumstances must have an influence on this question, but it may be regarded as indispensable to a good railway that it be well ballasted. Thorough ballasting and thorough drainage are the great requisites of any railway that is expected to be run in all weather.

No. 5. Materials for bridges.—Good stone is the best material for bridges. If the situation does not admit of stone arches, then stone abutments and piers, with a wrought-iron superstructure, is the best resort. Of course, when stone and iron are not to be had, wood must be substituted until facilities are afforded for more durable works.

No. 6. Rolling stock and machinery.—This is a great subject, and one that in my opinion has been very inadequately studied; and I have very little faith that my views will prevail.

It is very evident that the weight of machinery has exceeded the ability of iron rails for profitable endurance, and it is very generally considered that steel must be substituted for iron. If steel is used, then, according to the prevalent views of railway managers, the weight of machinery may be increased; also speed of trains. This will increase the difficulty of maintaining the road-bed. How steel will stand the frost of winter, as compared to iron, is yet to be determined. However this may be, I suppose iron will be considered for the present as the material for rails.

All engine-builders that I have known favor large engines; they regard their reputation as depending on the load their engines will haul. Their influence usually controls railway superintendents. The latter are rarely men who have any knowledge of mechanical science, and regard the load an engine will haul as the evidence of its economy. Any man can see that if two light engines are required to haul a train for which a single heavy engine is sufficient, there is the additional expense of a driver and fireman, and so in proportion; but there are very few railway men that can see the relative wear and tear in the two cases. In fact, it is a difficult question to fully understand, arising from the mixed character of railway traffic; but by long-continued observation, the influence of the two cases becomes manifest. The great and the true question is, not what size of train may be hauled, but by what sort of engine and train can the transportation of a ton of freight be reduced to the lowest rate of expense.

In the early history of railways the rails were more durable than at present. While it was considered, twenty years ago, that rails could be maintained for ten per cent., it now costs, on a railway with a traffic of $18,000 to $20,000 per mile per year, 25 per cent., or about this. But I have not time to pursue this subject, and must content myself with a few general remarks. There is more necessity and inducement to have large engines on a single than on a double track railway, on account of the difficulty of passing a great number of trains. The greatest objection is to passenger engines; their trains cannot well be divided, and are subject to much irregularity of load; and with a single track it is not convenient to multiply trains; also, the speed of passenger trains demands greater power. Much will depend in passenger trains upon the grades they have to meet. With a double track, trains may be run more frequently, and in this way reduce the weight of engines.

The weight of passenger engines must depend on the character of the traffic. I should prefer not to have an engine of over twenty-five tons weight; but there may be, and no doubt are, cases in which a heavier engine would be necessary, when heavy express trains have to be provided for. There is no necessity nor economy in a freight engine of over twenty-five tons. The cylinders of such an engine would be fourteen by twenty-two inches. It would not take so large a train as a thirty-ton, with cylinders fifteen by twenty-four; but it may be assumed that the twenty-five-ton would make more car mileage in a year than the thirty-ton. This arises from the more steady running, as light engines are laid by for repairs a less ratio of time. There is much to be said on this subject, but I have not time. I close this with the expression of my opinion, that to effect economy of transportation will eventually lead to a reduction in the weight of engines.

In freight cars I have yet to hear of any experience that justifies the large cars. Smaller cars are more easily and cheaply loaded and unloaded, do not break up as much in collision, carry more freight in proportion to dead weight, and are more easily and conveniently handled at the stations. I would not have a freight car of eight wheels to carry over eight tons of freight. I regard the heavy freight cars as simply senseless; they are liked because they are larger, and not from any substantial reason in favor of economy.

As to passenger coaches, you will probably adopt the fifteen-window car of sixty seats. I would reduce the size, and, had I time, could give my reasons; but I am well aware I am not in the fashion on this subject. A big engine, a big coach, and a big car, is the prevailing fashion, and has about the same merit as other fashions that are instituted without reflection, or a due consideration of means to an end.

7. *Influence on rails from velocity.*—The only thing I have time to say on this point relates to the comparative expense of keeping up the two tracks of a double road on a grade of forty feet per mile. The up track bore its trains at a slow speed, and the down track at a high speed. The down track, I was credibly informed, cost twenty-five per cent. more to keep it up than the up track. To be run with economy, freight trains on all grades should be run

slow; there is very little freight that would pay real cost as between actual expense of fifteen over ten miles per hour; it is better to run two hundred miles in twenty-four hours, or about eight miles per hour. But I must close with a general remark.

The government, for valid reasons, wants a railway from the Missouri to the Pacific. In my opinion they have taken a very unwise way to get it. I have little faith the thing will be accomplished in any reasonable time on the present plan. It may go along on easy parts, but when you get to the mountains it will probably rub long and slow. There should now be competent engineers surveying the mountain districts and getting them ready for contract at the earliest day. There will no doubt be very important examinations to be made to ascertain the most favorable route. If these matters are left until the easy part is carried along, the heavy work will delay progress, and a long time must elapse before the company will get through. A better, and, in my opinion, the true plan would be for government to constitute a board of six competent men, that were too high-minded to steal, and authorize them to do the work in the best and most economical method. Then the railway might be done in probably five years and the country enjoy the benefit.

Very respectfully and truly yours,

JOHN B. JERVIS, *Civil Engineer.*

Lt. Col. J. H. SIMPSON, *Corps Engineers.*

APPENDIX H.

GREAT WESTERN RAILWAY, HAMILTON, C. W.,
December 30, 1865.

SIR: Your circular letter, dated the 18th instant, was handed to the chief engineer of this company for his remarks. I have now the pleasure of forwarding them to you.

He feels that it is impossible to do justice in his answer to questions put in so summary a way. Indeed, several of them cannot be satisfactorily answered in a general manner, inasmuch as they are dependent upon all the contingent circumstances of the railway in question, such as gradients, the predominant features of the soil, the respective values of wood, iron, &c.

If, however, it should be your pleasure to require any further information, and you should depute any gentleman to inspect our road and consult our engineer, I shall be most happy to make the necessary arrangements, and to offer every possible facility in my power.

I have the honor to be, sir, your obedient servant.

THOS. SWINYARD, *General Manager.*

Lieut. Col. J. H. SIMPSON, *Corps Engineers.*

[In giving the enclosed views of the chief engineer of the road the questions of circular No. 2 were repeated in a parallel column, with answers as follows:]

1. Rail 65 to 70 pounds per lineal yard, T pattern, having a width of flange or base of 4 inches with the same weight.

2. Fish joints, all of iron, or partly iron and partly wood, such as the Trimble joint; the rails being spiked to the ties in the usual manner, excepting on steep grades, where the flange of the rails ought to be drilled for a fang-bolt, (or for a bolt secured by a key and cotter,) which passes through the tie and is secured underneath by a fang-nut.

3. Ties to be of white oak, 9 feet long, 9 inches wide, and 6 inches thick, to be laid 11 to a 24 feet rail, or 2,420 per mile.

4. Road-bed of embankments at sub-grade, *i. e.*, underneath the ballast, to

be 17 feet wide for the narrow gauge of 4 feet 8½ inches. In excavations the sub-grade to be not less than 24 feet, and wider in wet soils or where there is a large amount of surface drainage to carry off. The ditches to be 3½ feet wide and 1 foot deep at sub-grade. The ballast, even of the best quality, to be not less than 12 inches underneath the ties, or 18 inches in all, being about 4,000 cubic yards per mile.

5. Masonry for piers and abutments of all bridges, and iron girders for superstructure of all spans exceeding say 60 feet. If timber is plentiful and cheap, it may be used for all spans under 60 feet, as such spans can very quickly be replaced in the event of loss by fire.

6. This depends almost solely upon the characteristics of the railway, and upon the nature of its traffic.

7. The same remark applies as in No. 6.

GEO. LOWE REID,
Chief Engineer Great Western Railway of Canada.

DECEMBER 30, 1865.

APPENDIX I.

LAMBERTVILLE, N. J., *January* 1, 1866.

COLONEL: Below please find answers to the questions in your circular No. 2:

Answer 1. I enclose section of rail weighing sixty-two pounds per yard, which I have recently adopted, and consider the best for a road with heavy traffic. If rails were cheaper, I would make it a little heavier. On a road but little used I would make it somewhat lighter; with a very light traffic, as low as forty-two pounds per yard.*

I am now using rails made at Bethlehem, Pennsylvania, from a mixture of the hard magnetic ores of New Jersey and the hematites of the Lehigh valley. This makes a good rail, but, doubtless, numerous other mixtures make as good.

Very good or very poor rails may be made from the same ores. I have rails from a well-known mill that have been in use fifteen years, and that are now in good order; and on the same track other rails from the same mill, and worn out in less than one year's use. If a good rail, such as we used to get, is worth $260 per ton, such rails as we frequently do get now are not worth $20.

Answer 2. I prefer the fish joint, with an iron plate fifteen inches long on the inside, and a wooden block five feet long on the outside. The section herewith sent is calculated for such a joint. Without it I would fill in the angle more between the shank of the rail and the top and bottom flanges.

Sir Morton Peto told me he was using the fish joint on his roads in different parts of the world, using the iron plates on both sides and making the joint between ties. The objection to the iron on both sides is that the bolts break.

To prevent this I have used leather washers under the heads and nuts with good effect. Sir Morton Peto thinks well of the wooden blocks, although he has not used them. I quote him because his experience is very great and recent.

I do not know anything better than the common dog-headed spike.

Answer 3. I use ties eight to nine feet long, six inches thick, averaging eight inches wide, and from twenty-two hundred to twenty-six hundred to the

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* It being impracticable to include a section of the rail recommended, its principal dimensions are given in appendix S.

mile. When ties are cheap and the traffic heavy, I would use ties eight inches deep and cover one-third of the ground with them.

Answer 4. I make road-bed at grade fourteen feet wide for single track, with side ditches in excavation eight feet wide at grade and two feet deep; the size of the ditches, however, varying with the circumstances. Ballast should be at least one foot deep under the tie; on a sandy soil it may be less; on clay, in a cold climate, it should be more. On a road with heavy traffic I can scarcely fix a limit to the expense that should be incurred to get it.

Answer 5. Except on a road with immense traffic, I would, under present circumstances, use wooden bridges on some simple plan, such as the Howe bridge.

Answer 6. I would not allow more than two gross tons on a car-wheel, including the weight of the car, and then only with good springs, nor more than ten thousand pounds on a driver. If building a road unconnected with any other, I would limit the weight to two-thirds of that stated. With such materials as we now have, all other things being equal, the injury to the rail by a weight over a ton on a wheel probably increases as much as the square of the weight. This, of course, varies with different materials.

Answer 7. Within moderate limits, the injury to the rails and rolling stock increases as the square of the velocity. Above a limit, which varies with the material and condition of the rails and machinery, the injury increases much more rapidly than the square of the velocity; probably in many cases reaching the cube.

Very respectfully yours,

ASHBEL WELCH, *Civil Engineer.*

Lieut. Col. J. H. SIMPSON,
Corps Engineers, U. S. A.

APPENDIX J.

BALTIMORE, *January* 2, 1866.

COLONEL: Your circular of the 14th ultimo was duly received, and I embrace the first leisure allowed by other engagements to reply to its several questions; premising that they cannot be answered with the definiteness that could be desired, for reasons sufficiently apparent, and as the answers themselves will show.

1. The best weight of rail for a first-class road is, and must always continue to be, a matter of professional opinion. With a good foundation of ballast upon a well drained and settled road-bed, and suitable cross-tie supports, together with a well-spliced joint, I consider *sixty* pounds per yard as abundantly heavy for a first-class road.

No increase in the weight of rail can compensate for the absence of a good support; indeed, the heavier the rail the less readily will it accommodate itself to the irregularities of the sub-structure, and the more subject it will be to permanent bending or breakage and dislocation at the joints, and hence to endanger passing trains.

The "best cross-section" appears now to have been determined by the almost unanimous judgment of railway engineers, founded upon an experience of a third of a century, to be the broad-based or inverted ⊥. It is true that the double-headed or I rail is still a favorite in England and the continent of Europe, but as it requires a chair or pedestal to support it, and has no advantages which, in the judgment of American engineers, warrant its increased cost, on this account it has never been used, that I am aware of, in the United States.

The general form of section may be considerably varied in its lines, but the *proportions* most usually preferred for a sixty-pound rail would give an equal base and height of three and one-half to three and three-fourths inches, a thickness in the smallest part of the neck of five-eighths of an inch scant or full, and a top breadth, including the curved edges, of two and one-fourth to two and one-half inches. Many engineers prefer a slightly rounded top surface, but I have always preferred at least one and one-half inch of flat bearing on top.

As to the "relative durability of rails of different weights with the same traffic," it is manifestly impossible to offer any definite estimate. If for "a first-class road," that is, a road constructed in the best manner for a heavy trade and travel, a sixty-pound rail is, on the whole, the best medium weight; then it will last longer than either a lighter or heavier rail, but in what proportion it would be difficult to frame a formula to express. The lighter rail would possess too much, and the heavier too little elasticity, as experience has, indeed, shown with the extremes of light and heavy rails. If, however, the substructure be well adapted to the weight of rail (that is, the cross-ties duly spaced and sized) and the quality of the metal be similar, I should be disposed to treat the *durability* of the rail as not sensibly influenced by an increase or reduction of weight of five or six pounds per yard, while below fifty-five pounds, or above sixty-five pounds, an increased wear would take place, and probably in pretty nearly the degree in which it receded from the medium weight.

Of the "merits of different varieties of American iron" it is equally difficult to speak decisively. My own experience with the products of several rolling mills has been in favor, on the whole, of the rails made at the Cambria Iron Works at Johnstown, Pennsylvania. This iron is a little deficient in hardness, but it has proved strong and free from danger of breakage—the latter a very valuable property.

2. The plans of "chairs and other joint fastenings" vary a good deal in their details, although depending upon the same general principles. Understanding by the term chair a simple support for the contiguous ends of the rail, designed to extend their bearing on the cross-tie, and secure them from lateral displacement and endwise movement, the double-lipped plate, or the single-lipped, with the absence of the other lip supplied by a *gib* holding the chair and base of rail together, are, I think, as efficient a fastening as can be used. The weight, if of wrought iron, to be not less than fifteen pounds; and if of cast iron, twenty pounds; wrought iron being much to be preferred, as less liable to break, and being more economical in the end, although dearer in first cost.

The "chair," however, is now rarely used, except for its comparative cheapness at first for new roads with deficient capital. The necessity of a *splice* of some sort at the joint is now universally admitted, (after a much longer experience than should have been required,) and "fishes," in the quaint English dialect, are regarded as indispensable adjuncts. These fastenings have the usual variety of forms, and I am not prepared to say which I would choose of them all. There is a very good one now being applied on the Louisville and Nashville railroad, of which the superintendent of that road can give a suitable description. Mr. Arthur, general superintendent of the Illinois Central, has designed what struck me as a very substantial splice. The wooden bar or block splice, (Trimble's patent,) used on the Baltimore and Ohio and Philadelphia and Baltimore railroads, I regard as an excellent joint fastening. All these different forms should be adjusted (as most of them are) by screw-nuts; and those into which wood is introduced, to a greater or less extent, are to be preferred, in my judgment, as having an element of elasticity that is wanting in those wholly of iron.

The best form of "spike" has long since been settled as the "hook-headed" spike, weighing from one-half to three-quarters of a pound each, and from six to seven inches long.

3. The "dimensions of, and distances between, cross-ties," must depend on

the weight of rail. For a sixty-pound rail a tie seven inches thick, with at least an equal width of flat surface, top and bottom, and for the joints not less than eight inches, placed two and a half feet from centre to centre, and eight feet in length, will give about the best result, in my judgment.

4. The "width of road bed at grade," if for two tracks, should be not less than twenty-six feet, and for one track not less than sixteen feet; and the same dimensions are applicable to both excavations and embankments, although the latter are often, and perhaps mostly, made narrower; but I think this injudicious, except for strict reasons of economy in first cost.

The "dimensions of side ditches" must depend upon the duty they have to perform. A total width of twenty-six feet for two tracks allows only two feet top width of ditches, which is sufficient for ordinary drainage in short and dry excavations, but an increase to three or four feet, or even more, is sometimes required. For two tracks and a gauge of not exceeding five feet, with six feet between tracks, the width in the clear between ditches should not be less than twenty-two feet, and for single track not less than twelve feet. The additional width allowed for side ditches to be not less than four feet in either case, and more for extraordinary flow of water, as stated.

"Depth of ballast, and expense per mile it would be worth incurring to get it." The first question is easily answered; not so the second.

Ballast should not be *less* than twelve inches in depth. This, with a cross-tie seven inches deep, will give but five inches underneath for drainage and bearing. A less depth will afford no protection from frost, and even this depth is but an imperfect one. The deeper the ballast—up to two feet, or even more—the better. Ballast only twelve inches deep—nine feet wide on top and eleven feet at bottom—and deducting nothing for space occupied by cross-ties, will give 1,955 cubic yards per mile; which, at prices formerly prevailing along roads through rocky or gravelly regions, would cost about $1,200; a sum certainly well spent, and which would soon refund itself even if *doubled*. Beyond, say, $2,500 per mile, (or $3,500 at present prices,) it may not be advisable to go in many cases in the first instance, but to wait until the facilities for transportation over the opened line will permit the material to be hauled from a distance. More definitely than this it would be difficult to estimate the economic value of ballast, which, in a soil retentive of water, may be regarded as *indispensable* to a good track. In open soils, especially sand or gravel, the case is very different; in such soils ballast, indeed, should be used as soon as it can be applied in adjusting the track, but where haste in opening the line is necessary, the track may be laid at first upon the natural surface, and the ballast subsequently introduced.

5. To answer this question fully would demand much more time than is at my disposal. It so happens, however, that a short treatise on the principal forms of bridge superstructure now in use has just been published, to which I have attached my name as consulting engineer, although not its author. Of this I will send you a copy, and from it you will learn the views I entertain on the subject. As between different materials for bridges I but express the general opinion of my profession in placing them in the order of preference usually accorded them, viz: First, stone or brick; second, iron; third, wood, or a combination of wood and iron—the more of the latter the better. The limit of span to which stone or brick can be carried must, of course, exclude them from competition in many cases. The high price of iron has checked its exclusive use in bridge superstructure for some time past, but a return to former prices must cause it ultimately to supersede wood altogether in cases where neither stone nor brick can be employed.

6. In regard to the "weight and other characteristics of engines and rolling stock," the opinions of engineers and railway managers are not in perfect accord. My own views have always been in favor of the use of a heavy eight-wheel engine, with all its wheels connected, and not more than three and a half to four feet

diameter, with correspondingly large cylinders, for heavy freights, at speeds not exceeding ten miles per hour; for fast freight, especially live stock, an engine of lighter weight, and with four or six driving wheels four and a half feet diameter and a truck in front; for passenger trains the engine of the ordinary improved model, with four drivers of five to five and half feet diameter, and cylinders proportioned to the resistances offered by the grades of the road upon the stage or division of the road on which the locomotive is run.

As to other rolling stock—that is, cars; the platform, box and house cars in general use for ordinary freight, and for coal—a car with an iron body of circular or rather cylindro-conical form, such as is exclusively used for the purpose upon the Baltimore and Ohio railroad, is the lightest and most durable car, for the weight it carries, that I know of upon any road in the country.

7. "Ratio in which rolling stock and rails deteriorate with different velocities." This is, again, one of the points upon which no two engineers will agree. So far as experience speaks, it would not seem to confirm purely theoretical ideas on this subject. Thus we find that passenger locomotives which travel twenty-five to forty miles per hour cost usually much less for their repairs than freight engines which move at half the speed. It is true they draw less than half the loads of the latter, and the internal strain upon their boilers and machinery is correspondingly reduced. Upon roads much curved, the effect of increased velocity will necessarily be the most felt. Yet, although the pressure against the outer rail should be in the double ratio of the velocity, the actual cost of maintenance is not in that proportion as between slow and fast trains, if the testimony or rather the opinions of track-repairers is to be believed, which is the only specific evidence that can be had upon the subject, as it is impossible to assign to each class of trains its true share of the expense of adjustments and renewals. On the whole, inasmuch as there are several elements of the cost of maintaining track and rolling stock which are independent of the speed of the trains, while there are others which may increase more rapidly than the simple velocity, and as the effect of speed is variously felt upon roads of different amounts and degrees of curvature, I think no reliable formula can be framed for application to every variety of road. Yet, while this may be true, it would not do to leave this element out of view in comparing different lines of road.

Thus, if the same aggregate time is allowed for traversing two lines of unequal length, the longer line would require the higher velocity, and the wear and tear of rolling stock and road would be increased thereby, relatively to the other line, and perhaps no safer, certainly no simpler, rule would be than the ratio of the velocities as that of the wear and tear of the movable machinery (as distinguished from the fixed, such as boiler, frame, cylinders, &c.) of the engines, and the wheels and running gear of the cars, excluding the bodies of the latter.

Your remark, that interest on first cost should be considered in connexion with expense of repairs and depreciation, is undoubtedly just, and no lines could be properly compared without capitalizing their current expenses and adding the result to their original cost of construction.

If time allowed, and my knowledge of the practical application of the points of your inquiry were greater, I might offer some further suggestions.

As it is, I must close by expressing the regret I have felt that the question of gauge for the great Pacific railroad had not been more maturely considered before it was fixed by President Lincoln. The very peculiar character of this great national highway demands, in my judgment, a plan of its own, or, at least, unlike in several respects the majority of our railway lines.

I am, sir, very respectfully, yours,

BENJ. H. LATROBE,
Civil Engineer.

Lieut. Col. J. H. SIMPSON, *Corps Engineers.*

APPENDIX K.

READING, PA., *January* 5, 1866

COLONEL: I beg to answer your circular of the 18th ultimo as follows:

Question 1. I think a steel rail from sixty to seventy pounds per yard, and of the section in enclosed sketch, would be best suited for the Pacific railroad.*

On the Philadelphia and Reading railroad our experience of the last ten years gives the following results:

Total tonnage passed of all kinds averaged for one year, including weight of coal, merchandise, and passengers, but exclusive of engines, fuel, tender, and cars, in tons of two thousand pounds..	3, 181, 460
Average number of miles run by locomotives in one year.......	2, 229, 723
Average number of tons of new rails used to repair tracks in one year, passing above business, in tons of twenty-two hundred and forty pounds..	4, 415
Average length of railroad track reduced to single track, over which above business passed per year, in miles.............	295

Question 2. I send herewith an isometrical sketch of the most improved railroad joint we have found to answer under our heavy tonnage. Several year's experience thereof, with a tonnage for three years past of over 4,000,000 tons per annum, justify us in preferring it to anything we have tried or seen elsewhere.

Question 3. Our sills are seven inches thick by nine or ten inches face, and eight feet long, for a four feet eight and one-half inch gauge. They are laid about 2,450 to the mile.

Question 4. On a double track railroad the two main tracks should be not less than six feet apart, and sufficient room should be allowed in cuts for good and thorough drainage on each side. On embankments the edge of the bank should not be less than two feet outside ends of sills. Ballast should not be less than ten inches thick, making about 1,760 cubic yards per mile of single track. In building a first-class railroad for a heavy business of tonnage and passengers, I think one dollar per cubic yard would not be too much to pay for such an important feature as good ballast.

Question 5. This inquiry embraces so extensive a field that it is impossible to answer in the limits of this letter.

Question 6. I send you enclosed herewith photographs of one of each kind of our most approved freight and passenger engines, with weights and all dimensions.

Question 7. The reciprocal injury to rails and rolling stock caused by speed is about in proportion to the square of the speed. On bridges, however, it is higher.

Respectfully, your obedient servant,

G. A. NICOLLS,
General Supt. Philadelphia and Reading Railroad.

Lieut. Col. J. H. SIMPSON,
Corps Engineers United States Army.

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* The section is omitted in printing, but the principal dimensions are given in appendix S.

APPENDIX L.

47 EXCHANGE PLACE, NEW YORK, *January* . 1866.

COLONEL: I intended answering the circular you did me the honor to address to me before this, and now have only time to answer it hurriedly. I deem the matters spoken of in the circular as of the greatest importance, and worthy of the highest consideration of the government.

As to establishing a standard for railways, I fear it will be a difficult undertaking, as the most eminent engineers differ so widely in their views of important points. The war of the gauges in England; the difference of opinion between Brunel and Stephenson as to the longitudinal and transverse systems of bearings; the great difference in weight, power, and construction of the engines on the two divisions of the London and Northwestern railway; the endless variety of fastenings for rails; the great national and sectional differences of opinion as to designs, material, and construction of bridges; and the never-ending discoveries and improvements in everything connected with railways, all point to the fact that we cannot have a fixed standard; but by collecting and discussing facts and opinions we can improve immensely on the present system of railways in this country, for much of it is abominable in the extreme, and might be considered a national disgrace. This, in a measure, grows out of want of capital to build with permanency and correctly; I will not say scientifically, for that is a word that most railway capitalists in this country appear to look upon with fear, having made up their minds that all science is humbug. They ask for practical men, and often get what they understand to be such, regardless of the man never having read a book or knowing what is going on in the engineering world outside of the little circle in which he was brought up. Another cause for selecting incompetent men to construct railways in this country is that they can be had cheap. Still another cause is that railway presidents and directors wish to engineer the works themselves, and employ men who will do as they are told to.

These causes, together with the howlings of the public for low fares for goods and passengers, have led to frightful accidents, to the loss of thousands of valuable lives, to the wasting of many millions of dollars in location and construction, and to the destruction of vast amounts of valuable property, to say nothing of delays and confusion to business and the world of agony that seizes on every man's brain when he now takes a ride by rail.

I will now answer categorically your questions as near as I can.

WEIGHT OF RAIL FOR A FIRST-CLASS RAILWAY.

I consider that a first-class rail can be made with 65 to 67 pounds of metal per yard, provided the metal is first quality, properly piled and rolled. Many thousands of tons of rails have been used in this country which were of Scotch pig, chiefly made from old scoria heaps, after the invention of the hot blast. Cheating in making rails, the result of railway companies cheapening the price, has become universal in England, and pretty generally adopted in this country.

Robert Stephenson gave me a paper he wrote to the London and Northwestern Railway Company after examining forty miles of new line of rails, in which he says: "After being cheated by all the Welsh houses, you took your orders to the Staffordshire houses, close to the line of your road, and the rails they furnished you six months since have already begun to laminate. I would advise you to erect rolling mills and to roll your own rails." This I consider first-class advice for every great railway company to carry out.

The United States government find that they can make muskets better and cheaper than they can get them made. Why should not a great railway company find the same advantage in making their own rails?

As to the "durability of rails of different weights with the same traffic," I would say that some important and valuable data on this point will be found in the work of Colburn & Holley on "European Railways," and also in the work of Holley on "American and European Railways." The great variety of rails, the difference in the make and iron used, the difference in the speed, engines, ballast, drainage, distance between sleepers, care with which repairs are done, and other causes, make it impossible to form a rule as to the traffic which may be done over rails of different weights. I would here mention that it is the engine and speed which are the chief elements in destroying rails. I will not say wearing them out, for they are never worn out, they are crushed out. Another element in the life of a rail is the width of the bearing surface of the head, the experiments of Rennie and Morin to the contrary notwithstanding. Their experiments on friction go to show that weight is everything, surface nothing. The fallacy of this was shown by the Franklin Institute some years since in a series of experiments on the adhesion of engines to rails. It was then shown that all railway frictions are crushing frictions; this admitted, as it must be when it is known that engines have utilized forty per cent. of the weight on the driving wheels, and then it is evident that width of head of rail has something to do with its life.

BEST CROSS-SECTION OF RAIL.

This is a difficult question to answer. My belief is, that the best section that can be made must have the head and base the same. This calls for a chair on every sleeper, or to sandwich the rail between longitudinal bearings, a system of railway track I have long been anxious to see tried in this country. This sandwich system allows of the rail being deep, with a thinner stem and more stiffness than can be obtained from any other section of rail of the same weight used in a different system of track. Plans of sandwich rails and bearings will be found in the works of Colburn & Holley. This plan of longitudinal bearings placed at the sides of the rails does not interfere with the drainage, as did Brunel's of the Great Western railway of England, when timbers 10 by 12 were placed under the rail. It allows of having as many square feet of bearing surface per mile as is obtained from the transverse system. It has all the bearing surface where it belongs, close to the line of pressure; it assists to *fish* the joints; requires less labor to surface and line up the track; and, in addition, the rail being a symmetrical one, with head and base the same, can be turned bottom up when the head is worn out. The difficulty with the English rail, which is symmetrical, having a heavy chair on each sleeper, is the crushing the rail in the chair, making an indentation at each chair which prevents it being reversed when the head is worn out. The difficulty with the rail in general use in the United States is, that not having much width of base, it cuts through the sleeper when under a heavy traffic, rendering the chemical preservation of the timber of no use, as the timber is cut to pieces before it can decay.

Brunel, of the Great Western railway of England, having become dissatisfied with his bridge rail on longitudinal bearings, ordered a rail similar to the American rail, with a base of six inches, and weighing sixty-six pounds per yard. This rail was tested at the Brunswick works in England in 1858, at the same time with a rail I was having made under my own specifications, with a base of $3\frac{8}{10}$ inches, weighing sixty-three pounds per yard, with bearings three and a half feet apart. The sixty-six pound rail broke with $17\frac{1}{2}$ tons; the sixty-three pound rail broke with 21 tons. Both these rails cost one-third more than ordinary rail. They were made of good iron, and piled and rolled under rigid specifications. I mention this to show that rails cannot easily be rolled with a wide base, and give the full value of the iron for strength. This being the case, there is no remedy for the cutting of sleepers, (with a good section of rail for strength,) where the transverse system is used; but, by placing a bearing plate or chair of some kind under the rail at each sleeper, I am convinced that a saving could be effected by so doing, besides making the track more secure.

Another system of track which allows of a symmetrical rail is that where the sleepers are of cast iron, one at each intersection of each rail. A track of this kind has been patented in England, and known as "Griffin's." It is now being used on a long railway in the Argentine Confederation, but it is, in my opinion, far inferior to a track patented in this country, known as the "Iron railway," which also has iron sleepers with a round base and a chair on each, with a plate of India-rubber between. A few lengths of this track was tried under the heavy traffic of the Erie railway near Passaic for more than two years without breaking the sleepers, and requiring but little attention or repairs. These sleepers were light, and of an inferior pattern to those now proposed. This design for a track is exceedingly simple, having no screws, spike, bolts, or keys for fastenings; in fact it has no fastenings, yet it cannot, when laid, be pulled to pieces except by a full gang of men. It is now being laid on a railway near London. It is not likely to come into general use in this country for some time, on account of its cost. Iron is dear; timber is cheap. Americans study economy in first cost, and often pay more attention to their pockets than their necks.

THE MERITS OF DIFFERENT VARIETIES OF AMERICAN IRON.

Others will write more knowingly than I can on this point, but I will say that from Maine to Georgia, and from the waters of the Atlantic to beyond the Mississippi, the country is full of iron ore of a superior quality, from which rails can be made of a much better quality than any we have had or can get from England. They have more experience, and, as a general thing, more skill, in working iron than we have, but they have not got the ore. One fact will prove this: among all the experiments made by Colonel Wilmot, of the royal engineers, through a series of years, with various mixtures of iron from all parts of the kingdom, to get the strongest cast iron for cannon, he did not get a tensile result as high as 29,000 pounds to the square inch; while Major Wade, of the United States ordnance, in experiments for the same purpose, and using only Greenwood iron, got one result as high as 45,970, another of 44,425, and a number of mean results of over 40,000 pounds per square inch. The tensile strength of the iron in an English gun imported by the ordnance office for experiments gave only 18,145 pounds per square inch. It is not generally understood why England is striving so earnestly to make a good gun from wrought iron, and why she ignores the value and importance of 11-inch and 15-inch cast-iron guns. The simple fact is, that there is no ore in the United Kingdom from which this class of guns can be made and prove reliable.

In a parliamentary report on "cast iron experiments," published in 1858, there is not one result on tensile strength among some thousands of experiments above 34,300 pounds per square inch. Most of the results range between 15,000 and 25,000; some are as low as 9,000 and 10,000.

Much valuable information on iron in England can be obtained from a parliamentary report of 1849, entitled "The Application of Iron to Railway Structures," in which the popular fallacy of its being safer to run quick over a bridge than slow is exposed and settled by experiment.

The value of the American iron ore was known in England long prior to the Revolution, at which time it was imported into England in considerable quantities. Of late, American ores have been again sent to England. The franklinite iron of New Jersey would be all taken in England to assist the Bessemer process, were there no uses for it here. The English engineers are now talking of importing American Salisbury iron ore to assist in making car-wheels, as they have utterly failed in making good cast-iron chilled wheels from any iron in England. The American cast-iron wheels drove the English wrought-iron wheels from the railways of Canada. Alexander M. Ross, engineer of the Grand Trunk railway of Canada, says in a letter now before me: "I was myself instrumental in the introduction of the English pattern of wheel, and after two or three years' trial had to abandon them altogether."

An English engineer of note, writing to me lately to send him some cast-iron wheels of Salisbury iron, asked me to get a guarantee that each wheel should stand a load of two tons at ordinary speed. The wheel-founder said, "I will give him a guarantee that each wheel will stand twenty tons at any speed." I think I have now said enough to prove that American iron has some virtue.

BEST PLAN FOR CHAIRS, SPIKES, OR OTHER JOINT FASTENINGS.

The best chair in a track, when the transverse system of bearings is adopted, is, in my belief, one of wrought iron, with continuous lips made so long that they will answer to suspend the joint between sleepers, and serve as fish-plates. This kind of chair must be made of good, tough iron, and rolled so that it will not easily split lengthwise. The lips should extend up to the head of the rail, and screw-bolts put in through the lips of chairs and stem of rail. I have never been able to understand why railway engineers and superintendents pay so little attention to the joints, and the importance of fishing, or splicing, or holding the joints of the rails with great firmness, as they must all see that the rails are destroyed at the joints first. The joints are the weak points in the track, being often below the general level, to the serious detriment not only of the rails but of all the engines and cars that pass over them, to say nothing of the extra fuel burnt while running heavy trains over an uneven track, or one where the joints give as each wheel passes over them. The hook-headed spike made in this country by machinery makes a good fastening when made of good iron, and not less than $\frac{9}{16}$ inch square, but it is a question if wood screws of large size could not be made to answer better, and prove more economical in the end. In England the chairs are fastened to the sleepers by pins of compressed oak, which answer the purpose very well. With the sandwich rail and bearings screw-bolts are used; chairs are dispensed with, but fish-plates are introduced at the joints with good effect.

DIMENSIONS OF AND DISTANCES BETWEEN SLEEPERS.

When the transverse system is adopted, the sleepers for the ordinary gauge of 4 feet 8½ inches should not be less than 9 feet long, 10 inches wide, and 6 inches thick, laid 2½ feet from centre to centre. They should be uniform in size, laid at right angles to the centre line of road, and at equal distances apart. When the joints are fished and made as stiff as any part of the rail, it is not necessary to have large joint sleepers, or the adjoining spaces less than at the middle of the rail. The sleepers used in this country are on almost every road deficient in size, the usual dimensions called for being 7½ feet long, 8 inches wide, and 6 inches thick; but in most cases the sleepers fall short of these dimensions. Recently railway companies, finding that the tracks would not stand the increased traffic and increased size of engines, have resorted to putting more of these small sleepers in the tracks. In some cases the spaces between sleepers are not much greater than their own width. This calls for the use of many more spikes, and adds largely to the labor expended in repairs. I mean by this that with the same amount of timber in fewer sleepers the labor account for surfacing and lining track would be much reduced, the drainage would be better, the surface exposed to decay would be less, and the number of fastenings would be much reduced.

I will not leave the subject of sleepers without mentioning the great importance of chemically preparing the timber. Various methods have been invented, most of which are valuable, and have proved of much benefit, particularly in France and Germany. Some methods are expensive, calling for the timber being brought to a costly apparatus, and much time consumed in treating it. The method invented by Paine, called "Payanizing," which results in forming an insoluble salt in the capillaries of the wood by first forcing in chloride of lime in solution, and then sulphate of iron, is probably the best. Timber prepared in this way is almost incombustible; it adds to the weight and hardness, and gives it great durability.

The system usually adopted in England is to soak the sleepers in creosote, in ordinary wooden vats, the creosote used being coal tar with the ammonia taken out.

The process invented by Dr. Boucherie, in France, and used there, appears to have many advantages, and is worthy of much attention. A liquid containing a mineral sulphate of copper or chloride of zinc is run through the timber when first felled, and when the sap is in a liquid state; this is done by elevating a tub containing the liquid about 18 to 20 feet above the ground, and conveying the liquid to one end of the stick or log by a flexible tube. With this head to the liquid the sap is readily and quickly driven out, and its place supplied by the mineral solution.

I fear that there is but little use in preaching the preservation of timber to Americans; they have it in abundance, and intend to waste it, to destroy it, and to be as prodigal of it as they possibly can; but the day will come when the posterity of this generation will mourn over the folly of their fathers, as the people of France of the present day lament over the timber-destroying propensities of their ancestors.

WIDTH OF ROAD-BED AT GRADE IN EXCAVATION AND EMBANKMENT.

The road-bed in excavation should be in earth cuttings not less than 26 feet, and in rock cuttings not less than 24 feet wide, for a single-track railway of ordinary gauge. This leaves sufficient room for side ditches, which should be not less than two feet deep, with slopes 1½ to 1 in earth cuttings; the slopes of the earth cutting from bottom to top should be never less than 1½ to 1; in some cases, where the material has a tendency to run or slide, the slopes may be, and should be, increased to 2 to 1 and sodded. In open rock cuttings the slopes should never be less than ½ to 1.

Embankments should have a top width of 18 feet, with slopes of not less than 1½ to 1. This top width should be kept up with care, after the road is completed, by hauling from the cuttings. Embankments are easily and quickly washed away at top by storms; it is a common thing to leave them so. When in this reduced condition, if an engine leaves the rails, it is sure to topple over the embankment, often dragging the train to destruction. It should be recollected by railway men and legislators that a railway is never finished, nor can the capital account ever be closed with propriety where there is a growing traffic requiring additional stations, enlarged buildings, more sidings, and increase of rolling stock. The practice in this country, as to capital account, is open to much and deserved criticism. In many cases the capital account has been closed, and the net earnings which belong to dividend accounts applied to new constructions to accommodate increased traffic; in other cases capital has been used to pay the current expenses of traffic, and the whole earnings applied to dividends. It is evident that both these ways of management are wrong; but who can remedy them as long as the spirit of stock gambling pervades every branch of society in country as well as city, and often shows its hydra-head in the deliberations of State legislatures?

DEPTH OF BALLAST.

Two feet is the least depth that can be used on a first-class road. The importance of ballast is often not appreciated as it should be where there is much rain or frost. Some roads that were built under my direction in the rainless region of Peru and Chile, South America, did not require ballast; but the English engineers, who came out to build railways in the same region, expended more money on ballast than the whole of track grading and rolling stock cost.

The importance of ballast in railway construction was first discovered in England, and the name (as told me by Robert Stephenson) derived from the ballast heaps of the London coal colliers, discharging ballast (coarse gravel raked from the bed of the Thames) at Newcastle. This was the first material used under a railway track to improve its condition. In the south of England, where gravel is not to be had, they burn clay into a material like broken brick to use for ballast. Now, if ballast is considered so important in England, it should be held in higher esteem here, where we have such severe frosts and storms. If any one doubts this, let him get an English engine, one that can work with success on any road in England, and try to operate it on one of our railways in the spring or fall.

The notoriously inferior character of the American tracks have called for much and wonderful improvements in the construction of locomotives and cars, particularly the former, which now, for rough roads and mountain work, where steep gradients and sharp curves are encountered, stand unrivalled in the world. The engineer of the Grand Trunk railway, of Canada, had, at first, fifty English-made engines; finding he could not work them with success, he altered them to American patterns; he then ordered 110 locomotives in this country, paying 12½ per cent. duty on their going into Canada, and at the date of a report he sent me in 1859 he had 43 more built in his own shops after American patterns. In a letter written for me by Mr. Ross, engineer of this great Canadian railway, he says: "On the breaking up of the frost in the spring we never could keep the English engines on the track except at a slow pace, which defeated our objects." This in itself will show the great importance of ballast in a country where the climate is severe; that a first-class road cannot be built without it; that a road cannot be worked with any degree of certainty without it; and that it must be obtained at any cost. Ballasting need not necessarily be put in at first, and when a road is first opened for traffic; but it should be done as soon after as possible, and the road should not be looked upon as completed until it is fully and properly ballasted with suitable material, which should be coarse gravel, broken stone, burnt clay, or broken scoria.

RELATIVE ADVANTAGES OF DIFFERENT PLANS AND MATERIALS FOR RAILWAY BRIDGES.

In answering this question, I will start with the assertion that no first-class railway can afford to have bridges of wood; for when any bridge of magnitude is burnt the whole traffic of the road is paralyzed for weeks, the effects of which last for months, telling severely upon its character, its capital, and its influence, to say nothing of the distress occasioned to every one doing business upon it. Cases of this kind are numerous in this country, but the apparently idiotic part of it is, that companies should rebuild with wood when the first structure was lost by fire, and that, too, in the midst of populous and wealthy districts, as was recently the case at Troy, in this State.

Iron, stone, and brick are the only three reliable materials to build with; for all small structures, such as culverts under embankments, stone and brick have a decided advantage over iron; but for all large structures iron has much the advantage over stone or brick. Bridges such as the Britannia, the Victoria, the Saltash, and all suspension bridges, could not be constructed of stone.

Two hundred feet, or thereabouts, appears to be the limit to which stone arches can be built with success, and within any reasonable cost. The largest span for a single arch of stone ever built in modern times you have on the line of the Washington aqueduct; the largest in Europe is the Grosvenor bridge over the Dee, in England, and the largest we have any record of is one said to have been 251 feet span over the Adda, near Trezzo, in Italy; but there is no record to show when it was built or when it was destroyed. With iron we have extended this limit of stone to spans of 459 feet in rigid girders, as in the Britannia bridge, and to 821 feet by suspension, as in the Niagara bridge, and this limit by suspension is likely to be much exceeded in a short time, since a bridge of 1,224 feet span is in course of construction over the Kentucky river.

Mr. Barlow, an engineer of note in England, and the first authority on the strength of materials, after visiting this country to see the Niagara bridge, reported it as a reliable bridge, and as likely to endure, if taken care of, as any bridge of stone, (he, of course, meant the iron part, the cables,) and then offered to build a bridge of 3,000 feet span of steel wire over the Mersey, at Liverpool. It is not necessary to say any more to show the great and wonderful value of iron as the best material for building bridges of large span, say all spans over 50 feet.

As to the relative merits of different plans much may be said. The solid plate girder, as used by Robert Stephenson in the Britannia bridge, under the peculiar circumstances of having to build it in one place, and erect it while whole in another, became the rage among engineers in England, and to a certain extent has remained so to this time. Many bridges on this plan have been built, which are reliable and have an abundance of strength, but they have also an abundance of iron, more than is necessary to obtain the same strength with other plans of construction. The solid plate girder, or the box girder, or any other girder of large span, made of plate iron riveted, is behind the scientific knowledge of bridge-building of the age in which we are living. An admirable and well-written article on the comparative merits of the plate girder as used in the Victoria bridge, and some of the American iron truss girders, will be found in the American Railroad Journal of five to eight years since.

The Warren girder, as used in England, appears to be a reliable, good plan of construction; it was used in the great Crumlin viaduct; the tests applied to which, when finished, were very satisfactory. This plan of bridge, like the plate girder, is entirely of wrought iron, ignoring the merits of cast iron in bridge-building. I contend that cast iron is the proper material to use, and is vastly superior to wrought iron in bridge building, when its duty brings in play its compressive strength, and that wrought iron is the material to use where the duty is a tensile one. American engineers of note, in designing new plans for bridges, did not lose sight of the comparative merits of cast and wrought iron when used in their right places. This is seen in studying the plans of Colonel Long, Bollman, Fink, and Whipple, all of which plans are worthy of much attention and consideration. All have posts and top chords of cast iron, which are always in a state of thrust or compression; while the suspension rods, lower chords, (Fink's and Bollman's have no lower chords,) diagonal bracing, &c., which are always in a state of tension, are of wrought iron. The largest bridge structure in South America is one of iron, on the plan of Colonel Long, which was built in New York and erected under my direction in Chili, in 1858. It has eleven spans of thirty-three metres each, and consists of many thousand parts, all of each kind interchangeable; it was not erected or put together until brought to its destination; it was then erected without any one piece being found deficient in size or finish. When keyed up it had the exact camber called for, which it has preserved under the traffic of heavy engines to the present day, without any expenses for repairs, watching, or other items, save an occasional inspection. This should be considered sufficient proof that the plan is a good one.

The plans of Bollman and Fink can be seen on the Baltimore and Ohio railroad, where they are, I believe, held in high esteem. I consider each of these plans as a valuable invention and worthy of great attention. I have no doubt of the practicability of building reliable bridges on either of the last-named plans up to and beyond 400 feet clear span.

The plan of Fink appears to be based upon the most scientific principles, and capable of the clearest and most simple demonstration, as to the duty performed and the distress sustained by each and every part, of any bridge yet invented.

Every bridge of iron should be constructed of the best material. The cast iron should be tested (every piece separately) for flaws. The limit of elasticity of the wrought iron should be not less than 30,000 pounds per square inch; the dimensions so arranged that the distress resulting from its own weight and the passage of the heaviest trains should not exceed 8,000 pounds per square inch for cast-iron, and 9,000 per square inch for wrought iron. Every bridge should have an ultimate strength of at least six times the amount of distress it is daily subjected to. The system of making iron-steel, semi-steel, and homogeneous metal, as it is called by Bessemer, and patented by him in England, will no doubt revolutionize all large things made of iron, and particularly iron bridges and rails. Cold-rolling iron, as introduced by Mr. Lauth, of Pittsburg, is also likely to be introduced with advantage in the wrought iron of bridges; but in reducing the amount of material used in a bridge, weight is an element of importance which must not be lost sight of. The only writer on bridge construction that has ever, as far as I know, introduced this element in his discussions, was Mr. Roebling, in treating of the merits and capabilities of his Niagara bridge—a work which will make his name imperishable among engineers; a work which may rank as one among the only four great engineering structures accomplished by man since the creation.

WEIGHT AND OTHER CHARACTERISTICS OF ENGINES.

This is an important matter in the economy of a railway, to discuss which fully would fill a volume. In no country in the world has so much ingenuity and happy invention been applied to locomotives as in the United States. As railway companies were determined to have poor tracks, it became a necessity to have not only good engines, but wonderfully good engines and cars, or abandon the railway system altogether; for with cars on four wheels and ten feet between axles, and engines with a wheel base of sixteen to eighteen feet, as is common in England, with the axles parallel and fixed in a rigid frame, it would be impossible to work our railways, particularly where mountain work necessitated steep gradients and sharp curves. The English engine may be compared to a four-legged stool, which will only stand firm and steady on a true and level floor. The American engine may be compared to a three-legged stool, which will stand steady on any floor, all three legs touching and supporting. The American engine is a creature of necessity; and a magnificent creature it is, when properly handled by skill and intelligence, which is not always the case; for railway companies, instead of striving to improve the condition of locomotive engineers by giving increased wages, good houses, schools for their children, and pensions for their families when killed while pursuing their hazardous and trying duties, appear to ignore the great value of this class of men, and think it economy to treat them as near as possible like laboring men, forgetful that their duties are most arduous, and that there is more responsibility of life and limb intrusted to their charge than to any other class of men, to say nothing of the care and good keeping of a costly and most intricate machine. If any one doubts the skill required, and the arduous nature of the duties performed by a first-class engineer, let him mount, as I have done, on the foot-board of an engine with one of these men, when he is about to drive his hundred miles in two hours and a half on a dark, stormy, cold and cheerless night; then, while shivering and holding on to a stanchion, let him watch that man, who, with one hand on the throttle and the other on the reversing bar, gives thought to his fire and water, and while his ear keeps guard over each pulsation of the engine, his eagle eye peers into darkness to watch for some signal or obstruction as his wonder-working machine flies through space and appears to laugh at time. I think I see the doubter turn pale as he stands by that cool and fearless man, and regret that he ever attempted to solve his doubts by such a perilous adventure. Let him reflect when his ride is over, when his courage returns, and when he feels grateful that he escaped with his life, that that engineer has had his brain taxed, his constitution exposed, and his nerves strung and unstrung in that way almost every night in the year, and that when he retires to his bed, it is often in a state of perfect exhaustion. I beg pardon for this digression, but the engineer is to me an important point in railway economy.

The weight of an engine should be, in a measure, governed by the number of wheels on which it rests. In England, engines have been built of forty tons on four wheels, and sixty tons on six wheels; this must be ruinous to any track, and should not be admitted on any road at any speed. Four tons to a wheel for fast trains, and five and a half tons to a wheel for slow trains, would, I consider, be a fair limit when the economy of the whole railway becomes a study. I am satisfied that speed is in most cases more destructive to rails than weight. Mr. Dodamead, superintendent of the Virginia Central railway, wrote me, in 1861, that the rails wore better on the mountain division of that road, where they used their heavy engines called "climbers," than they did on the level portions of their road, where they used lighter engines at higher speed. In 1853 one of the superintendents of the London and Northwestern railway said to me, in answer to some questions, "I do not believe that there has ever been an express train run over this road that has paid its expenses." I mention these things to show that high speed is attended with great expense; and as all roads are worked with trains at different velocities, it is impossible to get at the exact destructive results of trains at high speed. Dr. Lardner, in his work on "Railway Economy," published in 1850, says in reference to express trains: "I have no doubt, from long and careful practical investigation into the effects produced by the action of engines on railways, that the damage sustained directly and indirectly by railway proprietors in consequence of express trains moving at extraordinary speed, is far greater than any profits derivable from such trains can cover; and I have no hesitation in saying that, considered in a commercial point of view, railway proprietors would be fully justified either in laying a much higher rate of fare upon express trains, or, which would be much more advisable and more consistent with their own interests, suppressing them altogether." I will close this matter of engines by recommending all passenger trains to be worked at a speed not exceeding thirty miles an hour with thirty-ton engines, on eight wheels, four of which are drivers; that all goods trains be worked at a speed not exceeding fourteen miles an hour, with engines of thirty-five to forty tons, on eight wheels, six drivers and two wheels with "Hudson's improved Bissell truck;" that all the engines be fitted with steel tyres to the driving wheels, and Gifford's injector as well as pumps; that the materials used and the workmanship be of the very best; that all engines be built at first-class works, and a fair price paid, to insure first-class machines

The private reports made to the London and Northwestern railway by Mr.

Edward Woods in 1853, as to the economy of the different classes of engines on that great railway, contain valuable information, and prove clearly that the heavy crank engines of the southern division cannot be made to work with the same economy as the light outside cylinder engines of the northern division.

RAILWAY CARS.

The passenger and freight cars in general use on American railways are in design admirably fitted for railway service. The cast-iron wheels used in American cars, when made by experienced founders from good American iron, are superior to the wheels used in any other country for endurance. It is, however, common for American companies to demand wheels at a low price. When this is the case, Scotch pig and poor qualities of American iron are used, and an inferior wheel delivered.

The great merits of the American wheel are becoming known in Europe. They are adopted in seven English railways in South America, and, I believe, on all the English railways in Canada.

The American journal-box was tried by Mr. McConnell on the London and Northwestern railway in 1852 on the tender of a locomotive, while a set of English boxes were tried on another tender. They were both run on express and gravel trains for a distance of six thousand miles, and the result, as reported to the Institute of Mechanical Engineers at Birmingham, in October, 1852, was as follows: American boxes, six in a set, cost one and one-half penny per day for oil, cotton-waste, and leather; English boxes, six in a set, cost nine pence per day for axle-grease—showing a saving of seven and one-half pence per day (equal to fifteen cents) on each set of six boxes. Besides this, there was a saving in the first cost of boxes, the American set of six weighing one hundred and seventy-six pounds less than the English. To show how difficult it is to introduce any improvement in railway matters, and particularly in England, I would state that the American box is not introduced on any railway I know of in England, although this experiment was made on the road of the largest moneyed railway corporation in the world by an eminent mechanical engineer, and given to the public through an institution composed of all the first mechanical and railway men of the kingdom.

It has been acknowledged in England by "The Engineer"—a leading authority in railway matters—that American engines running, as they say, "over what we know to be a notoriously inferior track to those in England," perform an average duty of twenty to twenty-five per cent. more than the English engines; but they have not in any way attempted to account for this difference. I have before said that the American engines in design are superior to the English, particularly on steep gradients, sharp curves, and inferior track; but this superiority would not be so prominent and glaringly evident were both engines on good, straight tracks, with light gradients. There must be another cause: it is in the different systems of cars used. The English use four-wheeled, the Americans eight-wheeled cars. The English cars, when loaded, have about half their loads overhanging the axles. When in a train, and it is started in motion, they feel quickly all the irregularities of the track, and begin to oscillate in the direction of their length, using up in this way a large portion of the power of the engine. The American car has but little of its load as overhanging weight. The trucks oscillate as they pass irregularities of the track, but the load does not, leaving the engine to utilize its whole power in traction. If any engineer can give a better reason for the American engines doing more duty on an inferior track than the English engine does on a superior track I would like to hear it.

The American cars are all they should be when built by first-class builders. When improvements are made they will be introduced by the car-builders, and not by the railway companies. All the public ask or expect of the companies is that they will keep their cars clean and in repair. This in most instances the public do not receive, nor will they get it as long as there is but one class of cars provided, and one fare charged for high and low, rich and poor, saint and sinner, clean and unclean.

RATIO IN WHICH RAILS AND ROLLING STOCK DETERIORATE WITH DIFFERENT VELOC TIES

It is impossible to give any mathematical answer to this question, nor could there be without having two roads laid at the same time, side and side, with the same iron, gradients, curves, sleepers, fastenings, ballast, number of stoppages, &c., and run with equal weight engines at different velocities. The answer must be a general one, and can be no more than an opinion. My belief is that the duration in the life of the rails, engines, and cars would be increased over one hundred per centum by decreasing a speed of forty miles to twenty miles per hour; and I believe that nearly the same result would be found between speeds of thirty and fifteen. Again, with the same track, the iron would last longer with the same velocities by using twenty-ton engines, with corresponding trains, instead of forty-ton engines and trains to utilize their tractive power.

Having answered all questions, I must now apologize for not having done what I proposed—give categorical answers instead of the rambling and digressive nature of this paper, and for having introduced many things apparently foreign to the snbject; but, thinking and believing that there may be an occasional line or idea in it worthy of notice, and that may in some way directly or indirectly assist in railway reform, I respectfully submit it, and remain, colonel, your obedient servant,

W. W. EVANS.

Lieut. Col. J. H. SIMPSON,
Corps Engineers.

APPENDIX M.

UNION PACIFIC RAILROAD COMPANY, ENGINEER DEPARTMENT,
13 *William street, New York, January* 29, 1866.

COLONEL: I have the honor to acknowledge the receipt (some weeks since at Omaha) of your circular letter of the 18th of December, 1865, accompanied by a circular from the honorable Secretary of the Interior, in which you invite my opinion on several points connected with the construction and operation of railroads, with a view of laying it, with others of the same character, before a board of "government commissioners, directors, and engineer of Pacific railroad," for the purpose of "aiding the government in establishing such a standard for these roads" (the Union Pacific and its branches) "that, when finished, they will subserve the purposes for which they are built, and be a credit to the nation."

A reply to your communication would have been forwarded at an earlier day had you not informed me, in person, that the meeting of the board had been postponed from early in January to early in February.

The position which I have the honor to occupy, of consulting engineer, of by far the most important of the roads referred to in your letter, might be regarded as placing me in a position of some embarrassment, and possibly of warping my judgment in relation to the subject-matter of your letter; but I shall endeavor, in what I may say, to be entirely frank, as well as independent of any interests which I may be supposed to represent. I shall claim your pardon, however, if from this or any other consideration my discussion of the subject takes a somewhat wider range than appears to be contemplated in your letter.

The law of Congress, granting government aid to the Union Pacific railroad and branches, provides that they shall be built as "*first-class railroads*." It also provides that the President of the United States shall appoint three commissioners, whose duty it shall be to examine the roads and certify to this fact. It also provides that the President shall appoint five government directors for the Union Pacific Railroad Company, one of whom shall be placed upon each of the standing committees of the board. It also provides that the President shall fix the eastern terminal point, the point of crossing the 100th meridian of longitude, and approve the location between these points. It also fixes the extreme limit to the grades and curves of the road, the width of gauge, and character of the iron rails.

With all these safeguards thrown about these roads, for the purpose of protecting the interests of the government and securing their proper construction, it would seem almost impossible (unless the government officers fail in the performance of their duty) for the railroad companies to evade a proper discharge of the responsibilities imposed upon them by Congress; and it will, in my opinion, be equally difficult for the board of government commissioners, directors, and engineer, referred to in your letter, to establish a common and unvarying standard for the construction and equipment of these roads.

The term "*first-class*" railroads, as generally used in this country, does not, so far as my experience and observation extend, either depend upon or apply to any particular "weight or cross-section of rail, plan of chair, spike or other joint fastenings, dimensions of and distance between ties, width of road-bed at grade in excavation and embankments, dimensions of side ditches, depth of ballast, different plans and materials for railroad bridges, weight and other characteristics of engines and rolling stock, or ratio in which rails and rolling stock deteriorate with different velocities."

You will find that all the foregoing characteristics which are specified in your letter not only vary materially on the different first-class roads throughout the country, but upon *the same road.*

I do not know of a first-class railroad of any considerable length that has not almost every variety of weight and pattern of rails, chairs, engines, cars, plan of bridges, width of road-bed and ditches, machine-shops, station-houses, &c., &c. These are or have been generally governed either by the location of the road, the grades and curvature, the peculiar views of engineers, the financial condition of the company, or the nature and extent of the traffic for which the road was constructed. You may, therefore, select any number of the acknowledged first-class roads throughout the country, and you will find that their general characteristics will vary just in proportion as their peculiar location, the views of their builders, and the character of their business varies.

You will also find that these roads have generally, if not in all cases, been constantly improving their condition in regard to structures, outfit, and other particulars, since their first construction in order to keep pace with their constantly increasing traffic, so that a road five or ten years old presents an entirely different aspect from what it did when first opened to the public as a first-class railroad. Hence it may be considered perfectly safe to assume that all these things will be regulated by the managers of the road as fast as the interests of the company or the requirements of the public may demand.

In view of the foregoing facts and considerations I have assumed that the term *first-class railroad*, as intended by Congress to be applied to the Union Pacific railroad and its branches, means a railroad suitable and proper in all respects for the nature and extent of the traffic which the whole or any portion of the road may reasonably be expected to do when first opened to the public, of which the commissioners appointed by the President were to be the judges;

and that everything beyond this was intended to be left to the future control of the stockholders and managers of the road, whose interests will at all times be at least twice and, perhaps, three times as large as those represented by the government; and further, that in granting a liberal donation of lands and loans of government securities to aid in the construction of these roads, the character of the roads and their outfit was a secondary consideration with Congress when compared with the great importance to the government and country of their speedy construction.

I have therefore advised that the line should be so located as to admit of the present or future adoption of the easiest gradients and curvatures consistent with reasonable length of line and cost of construction; that the excavations, embankments, side-ditches and cross-drainage, should be of liberal dimensions; that the culverts and bridge abutments should be permanently built of stone whenever it was to be found within reasonable distance; and when it was not, to use the most durable timber attainable, with a view to the substitution of stone hereafter; that the truss bridges of long spans should be of the best plans in use, and composed of durable timber; that the cross-ties should be of liberal dimensions, of the most durable timber attainable, and laid not less than twenty-four hundred to the mile; that the iron rails should be of the most approved quality and pattern, weighing not less than fifty pounds per lineal yard, and thoroughly secured to the ties with wrought-iron chairs and spikes; that the track should be ballasted with the best material on hand; that sidings not less than two thousand feet in length should be inserted, and water-stations constructed at intervals of ten, twenty, or thirty miles, as the probable running arrangements of the road would require; that permanent and capacious machine-shops and engine-house should be constructed at the eastern terminus, and at proper locations along the line, to afford the necessary facilities for repairs, at intervals of from two to three hundred miles; that passenger and freight stations should be constructed of suitable dimensions and at proper points, to accommodate the probable business of the road when opened to the public; that the road should be fenced, and cattle-guards put in wherever it passed through cultivated farms or districts; that the rolling stock should be of uniform pattern, of the best quality and workmanship attainable, and sufficient in kind and quantity to accommodate the traffic, and that beyond this no money should be expended at present, except in pushing the work forward with the greatest possible energy and despatch.

I have never for a moment doubted that a road of the character above described would come clearly within the requirements of the law, entitle the company to the government aid which Congress intended should be placed at their disposal, "subserve the purposes for which it was built, and be a credit to the nation."

Having thus stated the general principles which, in my opinion, should govern the action of your board, I will now proceed to state, as concisely as possible, my views on the specific points submitted in your letter.

1. I consider that a rail of good quality of iron, weighing fifty pounds per linear yard, of the Union Pacific railroad pattern, when properly supported, is the best and most durable rail that can be used for ordinary traffic on level or moderate grades. The weight of rail, or underlying support, should be increased proportionately as the weight or draught of the engine is increased, by reason of steeper grades or other causes.

2. The best joint-fastening now in use I believe to be the *fish-joint;* next to that is the wrought-iron chair of the pattern adopted by the Union Pacific Railroad Company.

3. Cross-ties should be eight feet long, and six by (not less than) eight inches square, and should be laid not less than twenty-four hundred to the mile.

I desire to say in this place that I am not now, and never have been, in favor of a cross-tie track. I believe that a continuous bearing of timber (say eight by twelve inches) is much the safest, as well as cheapest in the end. I have scarcely taken up a newspaper within the past month that has not recorded a serious accident and loss of life occasioned by a broken rail. These accidents could not occur with a continuous bearing of longitudinal timber underneath the rail; if the rail should break it could not get out of place. Broken axles and wheels, as well as most other accidents to the running machinery, occur from the same cause, or from the shock occasioned by passing from a full bearing on a cross-tie, over the vacant space between the ties. The rail in time becomes disintegrated and weakened, and finally breaks. I would rather have a forty-pound rail, laid on a continuous bearing of timber, than a fifty-pound rail laid on cross-ties two feet apart from centre to centre. The saving in the wear and tear of rolling stock and rails will be at least ten per cent. per annum.

4. The width of road-bed proper at grade, or bottom of tie, both in excavation and embankments, composed of material that does not wash or slide, should not be less, and need not be more, than twelve feet. The dimensions of side-ditches should be governed by the probable amount of drainage and the width between bottom slopes of excavations, by the character of material and depth of cut.

5. I consider the "McCallum patent inflexible arched truss railroad bridge" to be the best in use. The "Howe truss" is the next best; either are good enough for any ordinary purpose. I have never been in favor of iron bridges for railroads.

6. A locomotive with five-feet drivers, cylinders sixteen by twenty-four inches, and weighing from twenty-eight to thirty tons, is the best for ordinary work on ordinary grades. If you wish to transport extraordinary loads on high grades, you must increase the power and weight or adhesion proportionately.

7. I think that, as a general rule, and with ordinary use, the rails and rolling stock of a railroad depreciate about fifteen per cent. per annum; and, with reference to different velocities, that they deteriorate in the ratio of the increase of speed—that is, the wear and tear is twice as great at a speed of twenty miles per hour than at ten, and so on to any reasonable limit.

The foregoing, I believe, covers substantially all the points specified in your letter. The views upon them are expressed hastily, and without resort to calculations or statistics.

In conclusion, I desire to express my entire confidence in the disinterestedness of the motives of yourself and the other officers who are associated with you on the part of the government in connexion with this great national enterprise, in whatever you may do to elevate and establish the standard of the work. In doing this within reasonable and proper limits, you will always have my hearty co-operation and support.

I desire also to express the hope that you will not lose sight of the other great idea, that all these things are, or should be, subordinate to the vigorous prosecution and speedy completion of the road. Whatever you may do to facilitate this result will be regarded as a great public benefit.

I am, colonel, very respectfully, your obedient servant,

S. SEYMOUR.

Colonel J. H. SIMPSON,
U. S. Engineer, Washington, D. C.

APPENDIX N.

PHILADELPHIA, *January* 20, 1866.

SIR: Referring to the late conversation between us in the office of the Pittsburg and Fort Wayne Railroad Company, in which you requested me to write you my views on the economy of substituting the Bessemer cast-steel rail in place of the iron, I start upon the broad ground of the absolute necessity of employing some better material than the ordinary iron now used. Were it possible to always obtain iron rails of the quality formerly made, (regarding the endurance of which we occasionally hear such wonderful accounts,) I question whether Mr. Bessemer would have ever thought it necessary to roll steel rails.

The difficulty of late with iron seems to have arisen more from an absence of homogeneity in its fibre than an inherent want of tensile strength; although instances are not wanting in which both the tensile and transverse strength of iron rails have been proven to be but little greater than that of cast iron.

The realization of these facts has led to the introduction on most of the railways of England and the continent of the Bessemer steel rail, and thus far with the most entirely satisfactory results. If iron rails were only taken up when *worn* out by the sheer abrasion of their surface, their endurance on the main line of the track would probably reach to fifty instead of five years, which may be taken as their average life in the United States. The facts, however, prove that it is the *lamination* and *splitting* of the rail which are the potent causes of its destruction, and that soon after these weak points begin to show, the rail is *crushed* out and must be re-rolled. This rapid destruction of the rail may be traced to several causes, among which are the following:

1st. An inherent defect of the iron itself.

2d. The imperfect condition of the road-bed, and the equally imperfect fastenings by which the rail is kept in place.

3d. The great increase of weight in our locomotives and trains, without a corresponding increase of weight in the rails.

4th. The too-often imperfect and rigid springs on which the locomotives are suspended, which more than any other cause hammers out the rail when in rapid motion.

This last cause has, perhaps, been the one least regarded by railway men, and yet to my mind is one of the most serious of all the evils in the motive power.

Locomotive builders have been more intent on carrying up their weight, than giving room for a *broad, long*, and *elastic* spring of the *best* metal. No spring should ever be admitted under an engine of a less length than between thirty-six and forty inches, nor of a less breadth than three and a half to four inches, and the materials used should be only the best *cast* spring steel, as light as will carry the load.

With a maximum speed of six to eight miles per hour it would, perhaps, be of small importance whether any spring be used; but if it be increased to eighteen or twenty miles, the pounding on the rails is more than in an arithmetical progression. In England the question of using iron or steel rails has been definitely settled, as every leading road appears to have determined to re-lay with Bessemer steel as rapidly as possible. In the United States only a few of our leading railway men seem to have had the courage to advocate the use of steel. Among these few, however, may be named the first railway talent we possess, which openly avows that the only salvation of our railway system will be found in the use of the steel rail.

These advocates of the Bessemer metal have backed up their conviction by giving out orders varying from 100 to 4,000 tons for early deliveries, and have expressed their intention to put down the entire line of their track in cast steel as rapidly as the old rails may require to be replaced.

Such a decision will not appear hasty, if a few moments be taken to estimate the cost of continually re-rolling and re-laying iron rails.

An experience of several years in the use of steel rails on one of the leading roads in Great Britain led to the establishment of the rail mills at Crew, where

10,000 tons per annum of Bessemer steel rails are now produced for their own use on the London and Northwestern road. After using them a little over three years, it was found that each steel rail had outlasted more than twenty of iron on one portion of their road at Camdentown. At this spot, where the strain and destruction of the rail is particularly severe, the iron had to be re-rolled every two months during a period of three years; while the steel, at the end of the same period, had endured the same traffic and was yet good.

If an estimate be made of the total cost, say of one mile, (or 100 tons,) of such iron road, for three years, (which was less than the lifetime of the steel rails,) it will be found, if the iron be taken at our value to-day, say $85, and the re-rolling $35, re-laying $5 per ton, with interest at six per cent., the entire cost would reach the enormous sum, in three years, of $84,150, or $28,050 per mile each year; while the steel, at its present full value for small lots, say $165 per ton, would only have cost $19,470 for the three years, or $6,490 each year, making a total saving of $64,680 by the use of steel on one mile of track in three years.

Some may urge this to be an exceptional case, and that each six months would be nearer the estimate for re-rolling, even in the worst portion of our leading roads. If we still give the steel the same proportion of endurance, eighteen times that of iron, the result would be a total cost of $99,450 per mile for the iron rails in nine years, while the steel cost only $26,000, making still a balance of $73,450 in favor of the steel. Should this be carried still further, and the iron only rolled each twelve months, the result would be a balance in favor of the steel of $85,770; and if the re-rolling only be done once in five years, the total saving (continuing the same proportion for the steel) would be $170,000 per mile in its favor. These figures, although hastily gone over, are near enough for all practical purposes; and if to them be added the very great saving to the locomotives and rolling stock generally, in having a smooth, non-laminating surface to traverse, in lieu of the battered iron now in general use; whilst to this may be added an entire freedom from those very expensive accidents arising from "broken rails," as the tensile strength of the Bessemer steel is more than double that of the iron; whilst, at the same time, they will bend double cold, and you have a grand total which will place the steel rail far beyond any competition from iron as at present manufactured.

If I have not already tired out your patience, I may at another time present some further views with regard to railway matters which may interest you.

I am, sir, very respectfully, yours.

PHILIP S. JUSTICE.

Springer Harbaugh, Esq.,
Government Director to P. R. R., Pittsburg, Pa.

APPENDIX O.

House of Representatives,
Washington, February 2, 1866.

Dear Sir: I received the enclosed letter from W. P. Shinn, late superintendent on our Pittsburg, Fort Wayne, and Chicago railway, whom you know to be a very intelligent gentleman, as well as an experienced railroad man. Your Pacific railroad committee being now in session, I desire to call attention to the suggestions made by Mr. Shinn as to the character of the rails to be used in the construction of your great road. It should be made a first-class road at the start.

Very truly yours,

M. WELKER.

Col. T. C. Sherman.

PITTSBURG, FORT WAYNE, AND CHICAGO RAILWAY CO.,
Office of the General Freight Agent, Pittsburg, January 3, 1866.

DEAR SIR: I am not fully informed as to the control of the government in the matter of details of construction of the Union Pacific railroad; but I cannot forbear to call the attention (through you) of the proper authorities to the fact that the rails are being laid with "chairs" at the joints, instead of the more modern "fish bars" or "slice joints," the advantages of which are now so well known and so generally adopted on lines of railway doing a heavy business, such as the Union Pacific railroad must do. The saving in wear of iron at the joints, and the reduction in wear and tear of machinery in using the splice joint, amounts, in my opinion, to at least 50 per cent. on the cost of the rails. I have no interest in the joint, direct or otherwise.

Yours, respectfully,

WM. P. SHINN.

Hon. M. WELKER, *Washington, D. C.*

APPENDIX P.

WILLARDS' HOTEL, WASHINGTON, *February* 2, 1866.

SIR: Your note of the 1st instant, inviting Colonel Seymour and myself "to be present at a convention of the government directors, commissioners, and engineer, to meet in the Washington aqueduct building at 12 to-day," (yesterday,) was handed to me at 2 p. m. yesterday.

This is the first official notice received by the Union Pacific Railroad Company of the meeting referred to in your letter, and I am, therefore, not advised of the objects and purposes of the meeting.

I am at present in Washington on very pressing business of the company, which requires my whole time and attention, and, being without authority from the board of directors to represent the company before such a convention as you refer to, I shall be compelled to decline your invitation.

I have the honor to be, colonel, very respectfully, your obedient servant,

THOS. C. DURANT,
Vice-President Union Pacific Railroad Company.

Col. J. H. SIMPSON,
United States Engineer, Washington, D. C.

APPENDIX Q.

[Telegram.]

CHICAGO, *February* 2, 1866.

Track with fish-joints can be laid as fast as with chairs. It will cost from thirty to forty dollars per mile extra for laying.

H. H. GARDNER.

J. L. WILLIAMS, (care Interior Department.)

APPENDIX R.

A copy of circular No. 2 having been sent to Hon. Jesse L. Williams, government director of the Union Pacific railroad, he prepared the following paper submitted it to the business committee, and subsequently sent it, with the prefatory letter, to be included with the records of the convention:

FORT WAYNE, *February* 19, 1866.

COLONEL: In response to your request of the 12th instant, I append a copy of the paper respecting a standard for the construction of the Pacific railroad, submitted to a committee of the late convention of the government commissioners, directors, engineer, and others. This paper was not designed as a full answer to all the points of inquiry embraced in your circular No. 2, and is of less general interest to railroad men than the elaborate replies from distinguished engineers read before the convention. Its purpose was, under a reasonable view of the circumstances, so to apply the requirements of the Pacific railroad act in its letter and spirit to the condition, topography, and building materials of that distant and sparsely inhabited region, as to secure the two-fold object of Congress, to wit: first, a reliable and efficient first-class railroad, which, on its full completion, shall subserve in the highest degree the great public interests by reducing both time and cost of transit to a minimum; and second, the speediest possible opening of the work to the mining districts, both from the Missouri river and the Pacific seaboard.

Very respectfully,

J. L. WILLIAMS.

Lieut. Col. J. H. SIMPSON,
Corps of Engineers.

PACIFIC RAILROAD—WHAT SHALL BE ITS STANDARD OF CONSTRUCTION.

This is a great national work, to be built mainly by the nation's means, for important public and governmental objects. From considerations of public policy and convenience, the instrumentality of an incorporate company is used in its construction and working. The munificence of the grants made by Congress, and the great interests which the road is to subserve, no less than the language of the law, demand the construction of a first-class railroad.

In what sense and scope is the term "first-class" used in the law? Very few railroads in this country, even though the company may have had abundant means, have met at their first opening, in every particular, the characteristics here specified. Railroads do not ordinarily spring at once into perfection of track and equipment. In respect to solidity of road-bed, on which smoothness of track chiefly depends, completeness and extent of shops, station buildings, and rolling stock, railroads rather grow into the condition described by the term "first class."

But while this is true, the plans from the beginning may embrace the idea of a perfect and complete road to be realized very soon, and every step should be taken in accordance with such plans. There are certain leading characteristics, both of location and construction, fixing and governing the future character of the work, in which even a new road can and should conform literally and strictly to the specification contained in the law. Some of these I will enumerate:

1. *As to grades and alignments.*—While the letter of the law makes the Baltimore and Ohio railroad the standard, this must be considered as a limit to be

reached only in the mountain districts. To introduce grades as high as 116 feet per mile, or curves with radii as short as 400 feet on other parts of the route, would manifestly outrage the spirit and intent of the law. In the location of each general division, the question of ruling grades and curvature should be settled upon principles of true economy and adaptation, based upon careful scientific and practical investigation, having regard both to cost, construction and future working. It is safe to decide at this time that on the Platte Valley division extending from the Missouri river to near the foot of the Black Hill range, some 500 miles, and also along the Kansas valley, and wherever on any portion of the road or its branches a valley should be followed or a level plain passed over, no ascent should be allowed higher than at the rate of 30 feet per mile. As regards the Platte valley, its ascent is so uniform that 20 feet per mile would probably be a more judicious limit.

2. *As to width of embankments and excavations.*—On all parts of the road or its branches, where a single track is contemplated, embankments should not be less than 14 feet wide on top, this width being necessary to receive ballast, whether put on before or after the track is laid. The slopes of earth embankments should generally have one and a half base to one rise.

Excavations in earth, if the cuts are of much length, should be 26 feet; or if short, 24 feet wide at bottom; giving in every cut room for side ditches, of such ample depth and width as to secure that most essential requisite, a well-drained road-bed. Slopes (except in rock) should have one to one and a half base, to one rise, depending upon the character of the earth or if steeper, then a greater width at bottom, so as to remove the same quantity of earth as would be contained within these slopes, allowing the banks to form their own slopes.

In rock the cuts will be 16 feet wide at bottom.

3. *Mechanical structures.*—Culverts, drains, and bridge abutments should be built of stone whenever that material of a durable character can be found within reasonable hauling distance say five to eight miles, depending upon circumstances. But if stone be too remote, then trestle-work of best timber available may be used until stone can be delivered by the road. For the bridges, the Howe truss, or other equally safe and reliable plan, should be adopted.

4. *Ballasting.*—A railroad cannot be called complete until well ballasted. This is a branch of the construction, most economically performed when gravel is used, after the road is opened for construction trains. But it should be commenced immediately upon such opening, and continued with diligence, from time to time, until the track is fully ballasted. Ballast, if of gravel, should be 12 to 24 inches in depth, or, if of broken stone, 12 inches. But in parts of the Platte and Kansas valleys, and on other like formations, where neither coarse gravel nor stone is found within reasonable distance, then the best of the sand or sandy materials furnished by the excavations, or found in the contiguous river-bed, must suffice for a time.

5. *Cross-ties.*—Oak, or other equally durable timber, should be used wherever it can be obtained, with any reasonable transportation, from the contiguous groves, or delivered by water at the starting-points, and carried forward by construction trains. Where such timber in sufficient amount cannot be obtained at any reasonable cost, then the best the country affords must be used. But if cottonwood, or other like timber, is of necessity used, the ties must first be thoroughly Burnettized or Kyanized. In all cases the joint tie should, for the better holding the spikes, be of oak or other hard wood. The number of ties will be such as to average about two feet apart from centre to centre, or 2,600 per mile. They should be eight feet long and six inches thick; and if sawed, not less than eight inches wide; or if hewn on two sides, six inches face. The joint tie should be ten inches wide.

6. *Rails.*—These to be of American iron, as required by the law, of best quality, and should weigh sixty pounds to the yard; or, on condition of special

care in the manufacture, to use only the best iron; then, on account of the tedious and expensive transportation at the present time from rail mills so distant, the weight may be reduced to fifty-six pounds per yard. In the mountain districts, where heavier engines will be used, 60-pound rails should be laid. As the nearest approximation to a continuous rail within our reach at moderate cost, instead of the ordinary chair, the "fish-joint," so called, should be used at the joining of the bars, consisting of two well-fitted pieces of wrought iron, twenty-two inches long, one on each side, clasping the rails, and secured by four $\frac{7}{8}$-inch bolts. The rail should be spiked to each tie, both inside and outside, using four spikes to the tie.

7. *Sidings.*—The length of the side track laid at the opening should be at least six per cent. of the line opened, to be increased as the number of passing trains shall demand. Side tracks at all stations should be laid eight feet apart in the clear between rails.

8. *Rolling stock.*—Locomotive engines and cars must be provided in liberal proportion to the traffic and the work of construction, to be promptly increased from time to time with the opening of the additional sections and the increase of business.

9. *Engine-houses, repair shops, and station buildings.*—These must be adapted to the wants of the rolling stock and the accommodation of the business, having in view the efficient and satisfactory working of the road. While at the opening of any division the extent and capacity of the buildings erected may be only such as to provide liberally for the existing amount of rolling stock and the business of the road, with such increase thereof as is in near prospect, yet the plans in every case, both as to the buildings and grounds, should be arranged for prospective enlargement and extension equal to any future business of the road, the buildings, so far as erected at first, forming appropriate parts of a completed and symmetrical whole. Engine-houses and repair shops should in all cases be of stone or brick, with permanent stone foundations, and slate or metallic roofing, guarding with all care against fire. For convenience and certainty in running trains water stations should be provided at convenient points, meeting the wants of the trains, and generally ten or fifteen miles apart. Grounds for depots, shops, and station purposes of very liberal extent, adequate to any possible future want, should in all cases be laid off and secured to the company on the location of any section while land is of little value.

It will be seen that the importance of rapid progress, reaching the mining regions at the earliest day practicable, has been fully recognized in shaping these suggestions. No work not essential as a basis for an efficient and reliable railroad is required, but, on the contrary, there is on some points, from the necessities of the case, an abatement of the strictness observed in specifications for railroad construction on lines less remote from the sources of labor and materials.

But while guarding against delay on the one hand, the public interests demand on the other an efficient and reliable road, with the highest perfection of track reasonably attainable on a new line, and giving assurance, from judicious location and plans, of a speedy advance in its condition, and the efficiency of its working to the standard of a first-class road, so that the mail and military service of the government and the commerce of the nation shall meet with the least possible hindrance.

The argument for the rapid progress of the work, so legitimate in its place, should not be perverted into an excuse for imperfect construction, nor a justification of needless high grades, which, upon principles of sound economy, should have been cut down or avoided in the location.

It is sometimes alleged that the railroad company which becomes the transporter is alone affected by the extra cost resulting from high grades and imperfect construction. This is a mistaken view. The commerce of the country must finally pay every burden, in the shape of compensatory charges upon traffic, in order to make the work financially sustaining.

J. L. WILLIAMS.

FORT WAYNE, INDIANA, *January* 20, 1866.

APPENDIX S.

Weight and dimensions of rails recommended by different engineers, and of rails now used on Pacific railroad and branches, &c.

Names of engineers and of railroads.	Weight in pounds per yard.	Dimensions, in inches.					Joints.	Ratio of deterioration, velocity = v.
		Height.	Width of base.	Thickness of neck.	Width of head.	Bearing surface.		
H. Haupt							Fish	
J. B. Jervis	60	4				1½	Fish	
G. L. Reid	65	4	4				Fish	
A. Welch	62	4½	4	½	2⅜	1½	Fish	v^2
B. H. Latrobe	60	3⅝	3⅝	⅝	2⅜	1½	Fish	v
G. A. Nicolls	64	4	4	11-16	2½	2	Fish	v^2
W. W. Evans	66						Sandwich	v to v^2
S. Seymour	50						Fish	v
Union Pacific railroad	50	3½	3⅝	9-16	2½	1½	Common chair	
Do do	56	3½	3⅝	9-16	2⅝	1¼	do	
Union Pacific E. D. railroad	56	3½	3⅝	11-16	2⅝	1¼	do	
Central Pacific railroad	60						do	

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