REPORT

Of the Consulting Engineer on the Location between Omaha City and Platte Valley.

Dated Dec. 21, 1864.

Office of the Union Pacific Railroad Co.,
Engineer Department, 13 William st.

New York, Dec. 21, 1864.

Sir,—Inasmuch as I have recommended a change in the location of a portion of the line of the Union Pacific Railroad, between Omaha City, the point on the Missouri river fixed by the President of the United States for its eastern terminus, and the Platte Valley, at the crossing of the Elkhorn river, a point about twenty-three miles, by the present line, west of Omaha; and as you have already directed the necessary surveys to be made, with a view to adopting the proposed change, I deem it proper, both on my own account, and for the vindication of the Railroad Company, in case the proposed change in the location is finally adopted, to place in your hands some of the reasons, which, after mature deliberation, have induced me to make the recommendation.

In order to a full understanding of the subject, it will be necessary, in the first place, to state some of the leading characteristics of the present line, as compared with the one proposed as a substitute. These will consist in: 1st. Location, and length of lines; 2d. Maximum grades; and, 3d. Cost of construction.

1st.—Location and Length of Lines.

The proposed new line will leave the present location, at Station No. 150 from Omaha, which is at the head of the first grade, ascending westerly; from thence it is proposed to diverge southerly, and follow down the valley of Mud Creek to its inter.
This table shows, that from Station No. 150 to Station No. 1109, the maximum grades ascending easterly, are between seventy-nine and eighty feet per mile; and the maximum grades ascending westerly, are sixty-six feet per mile. The total rise and fall between Stations 0 and 1109 is 1,016 2/5 feet.

The maximum grade ascending westerly, between Station No. 0 and Station No. 150 (the proposed point of divergence), is also sixty-six feet per mile. This portion of the line is now nearly graded, and it is, therefore, not proposed to change it at present, but it is assumed, that it will be changed hereafter, to correspond with the maximum grade that may be adopted in ascending the valley of the Pappillon. This question is, therefore, reserved for future consideration. With a view, however, to such a future change, it is recommended that for the present, as little money as practicable be expended in grading in the valley of Mud Creek, between Station No. 150, and the point where a line with moderate grades in both directions would naturally leave this valley, to enter the valley of the Missouri River.

In the absence of any profile of the proposed line down the valley of Mud Creek, it will be necessary to assume certain ruling grades in both directions, that will be likely to come within the facts, when ascertained. From an examination of the profile of an experimental line through the Pappillon Valley, and the study given to the subject, I shall, for the purposes of this report, assume that the maximum grades upon the proposed new line, if judiciously located, will not exceed forty feet per mile, in both directions.

3d.—Cost of Construction.

The estimated cost of grading, masonry, and bridging of sections 3, 4, 5, 6, 7, 8, and 9, is $517,205; by adding one-half of Section No. 2 (west of Station No. 150), the amount would be $538,490. The sections average one hundred stations each, making the distance covered by the above estimate, fourteen and two-tenths miles. This gives an average per mile of about $38,000 for the present line. It is believed that the character of the profile of the new line, from Station No. 150 to Station No. 900, will be about the same as the succeeding Section No. 10,
of the present line. This section is estimated to cost $11,980, or about $6,000 per mile. We will, however, call it, with the proposed limit to the grades, $10,000 per mile.

Then we have:

14.2 miles of present line, costing .......... $538,490
23.2 " " proposed " " .............. 232,000

Difference of foregoing items in favor of new line ..................... $306,490
Deduct nine miles of superstructure at $18,000 per mile .............. 162,000

Making difference in cost of construction, between Station 150 and Station 900 .. $144,490

This fact, however, has very little to do with the real proposition under discussion. It is merely stated in this place for the purpose of showing that the Company, in adopting the present location, and paying a comparatively large amount for high grades, has reversed the rule generally recommended by engineers, and adopted by railroad companies, of paying comparatively large amounts for low grades.

As the above difference may hereafter be appropriated to reducing the first heavy grade west of Omaha, and as a considerable amount has already been expended on the present line between Station 150 and Station 900, the aggregate cost of construction will be assumed as equal upon both lines.

The general characteristics of the two lines may therefore be briefly stated as follows:

1st. The present line affected by the change is twenty-three miles in length, and has ruling grades of eighty feet per mile, ascending easterly, and sixty-six feet per mile, ascending westerly.

2d. The proposed new line is nine miles longer than the above, and will have ruling grades of forty feet per mile, in both
directions. The total amount and minimum radius of curvature are assumed to be the same on each line.

The question to be decided is, with a due regard to all the interests concerned, Which of these lines should the Company adopt?

This question necessarily involves the discussion of the value of high grades between fixed points, and a given distance, as compared with low grades between the same points, with increased distance; or, in other words, to what extent should a line of railroad, with a given or assumed traffic, be lengthened, in order to avoid certain or assumed objectionable grades.

In discussing this question, I will assume the following data:

Weight of engine, 30 tons, or 60,000 lbs.
" tender, fuel, and water 40,000 "
" car, 7 tons, or 14,000 "
" car load, 10 tons, or 20,000 "
Friction of engine, 10 lbs. per ton, 300 lbs.
" tender, 6 " 420 lbs.
" car, 6 " 102 "
Gravity of engine and tender, for 10 feet inclination 189 "
" car and load 64 1/4 "
Weight on driving wheels of engine, 20 tons, or 40,000 "
Adhesion, 25 pr. ct., making tractive force of engine 10,000 "

This adhesion will be worked out by an effective pressure of 97 1/2 lbs. per square inch, with cylinders sixteen inches diameter, and twenty-four inches stroke, and with drivers five feet in diameter.

The maximum number of cars, loaded as assumed above, which this engine will move upon a level and ascending grades, will be as follows:

On a level 94 cars.
On a grade ascending 10 feet per mile 56 "
" 20 " 40 "
" 30 " 30 1/2 "
" 40 " 25 "
On a grade ascending 50 feet per mile .................. 20½ cars.
" " " 60 " " .................. 17 " "
" " " 66 " " .................. 16 " "
" " " 70 " " .................. 15 " "
" " " 80 " " .................. 13 " "
" " " 90 " " .................. 11½ " "
" " " 100 " " .................. 10 " "

The actual working expenses of the train will be very nearly the same per mile in each case, as the engine always works up to its full power.

The cost of transportation, exclusive of repairs to roadway, taxes, interest on outlay, etc., has been ascertained to be about sixty-two and one-half cents per mile run; we will call it sixty cents.

Assume that an engine brings down the Platte Valley to the Elkhorn, over grades, either level, or descending in an easterly direction, for several hundred miles, a train of ninety-four loaded cars. To transport this train from the Elkhorn to Omaha, a distance of twenty-three miles, over grades of eighty feet per mile, the same engine could take only thirteen of these cars; and without regard to return freight, it would therefore be obliged to traverse the road seven times with a load, and return six times without a load, or a distance of two hundred and ninety-nine miles, in order to transfer the same number of cars from the Elkhorn to Omaha.

Upon this extreme supposition, and not taking into account the transportation of return freight, or the cost and maintenance of roadway, buildings, etc., a road of two hundred and ninety-nine miles in length, with level grades, would be as useful for transportation purposes, with a given amount of tonnage in one direction, as one twenty-three miles in length, with eighty feet grades, for the reason that it would cost the same to move a given amount of freight over one as the other.

It has been shown that the same engine will haul about twice the number of loaded cars over a forty feet grade that it will over an eighty feet grade.

The above mode of reasoning shows, that an engine will be obliged to traverse the present line three times in order to trans-
port a given amount of tonnage from the Elkhorn to Omaha, over grades of eighty feet per mile, when, with a grade of forty feet per mile, she would only be obliged to traverse it once, thus making an additional distance of forty-six miles, or an additional expense of $27.60, chargeable to every train of twenty-five cars: and showing that, other things being equal, and without regard to return freight, the Company can always do the same amount of business as cheaply over a line sixty-nine miles in length, with ruling grades of forty feet per mile, as over a line twenty-three miles in length, with ruling grades of eighty feet per mile.

It has been stated that an engine that hauls twenty-five loaded cars over an ascending grade of forty feet per mile, will haul only sixteen cars over a grade ascending sixty-six feet per mile. Inasmuch, therefore, as the preponderance of tonnage over this road will probably be in a westerly direction, it may be proper to assume that the engine would be furnished with a load for every return trip; and therefore that, as a general rule, the distance actually travelled by the engine, and chargeable to transporting a given amount of freight over the maximum grades of sixty-six and eighty feet per mile, will be only twice the distance chargeable to hauling the same tonnage over a maximum grade of forty feet per mile.

Upon this assumption, therefore, which it must be admitted is a very favorable one for the high maximum grades, the Company would be justified in adding one hundred per cent. to the length of this portion of the road in order to secure a maximum of forty, instead of sixty-six, and eighty feet grades per mile. This conclusion is based upon the supposition that the cost of construction per mile, will be the same for each line, and that the tariff for freight and passengers will be the same per mile run in each case.

When, in addition to the above, it is taken into account, that in all probability the proposed line may be completed from six to twelve months earlier than the present one; and that the most experienced railroad managers in the country agree in recommending the reduction of grades by an increase both in cost of construction and distance; and that many railroad companies have already expended large amounts to accomplish this
result;* the argument in favor of the change, in my opinion, becomes conclusive.

The discussion might be continued almost indefinitely, by assuming that future competing lines may compel a departure from the rule of fixing tariffs at certain rates per mile, and that, consequently, the cost per mile of maintenance of way, etc., should be taken into the account; but this contingency seems almost too remote to deserve present notice; and even were it now assumed and embodied in the argument, it is believed that it would strengthen the conclusions at which we have already arrived.

The additional wear and tear to superstructure and machinery, chargeable to high grades, together with the increased liability to accidents and delays, from dividing and making-up trains, would also come legitimately within the limits of the discussion, and add greatly to the force of the argument; but it is believed that enough has already been said to enable you to arrive at correct conclusions, not only with reference to the location of the line in question, but as to the general principles that should govern the location of other portions of your road.

The Union Pacific Railroad is to be a great national thoroughfare for all time. The Government has endowed it most liberally. The people, both on the Atlantic and Pacific slopes of the continent, are anxiously waiting for its construction. The amount of its business will be limited only by its capacity; and it therefore seems of the greatest importance that all the facilities afforded by nature should be taken advantage of, both in the location and construction of the road; and that no mistake be made that will be calculated to impair its future usefulness, or disappoint the just expectations of the Government, the stockholders, or the public.

I have the honor to be,

Very respectfully, your obt. servt.,

SILAS SEYMOUR,
Consulting Engineer.

To Thomas C. Durant, Esq.,
Vice-Pres't Union Pacific R. R. Co.

* See Appendix.
APPENDIX.

Containing Opinions of Railroad Managers, Experiences of Railroad Companies, and Experiments upon Railroads, in justification of the Conclusions arrived at in the foregoing Report.

The following letter was addressed to some of the most successful and experienced managers of railroads in this country:

Union Pacific Railroad Company,
Engineer Department, 13 William street.


Dear Sir,—I am requested by Mr. T. C. Durant, the Vice-President and Acting Manager of the Union Pacific Railroad, to ask your opinion upon the following proposition.

The eastern terminus of the Union Pacific Railroad has been fixed by the President of the United States at Omaha City, Nebraska Territory. There is a choice of routes between Omaha and the point where the line reaches the valley of the Platte River. One of these routes is twenty-three miles in length, with maximum grades ascending, westerly, of sixty-six feet per mile, and ascending easterly of seventy-nine and one-half feet per mile.

The other route is assumed to be thirty-two miles in length, with maximum grades in both directions of forty feet per mile, and will cost three hundred thousand dollars less to prepare it for the superstructure than the first-named route.

The line through the Platte Valley, for a distance of several hundred miles west of where the line enters it at the point above mentioned, will be characterized by grades not exceeding ten feet per mile, ascending westerly, and by grades either level or descending in an easterly direction.

The question upon which your opinion, as a practical and experienced
manager of railroads is solicited, is, whether it will be good policy for the Company, and for the best interests of the Government and the public, to increase the length of the eastern portion of the road, nine miles, in order to attain the difference in maximum grades as above specified.

Very respectfully, your ob't servt.,

S. SEYMOUR,
Consulting Engineer, U. P. R. R.

To which the following replies have been received:

WAR DEPARTMENT,
Office of Director and General Manager of Military Railroads, U. S.

WASHINGTON, Dec'r 27th, 1864.

Col. Silas Seymour.
Consulting Eng'r, U. P. R. R'd:

Dear Sir,—Your communication of the 24th inst., relating to the Union Pacific Railroad is received. You request my opinion in regard to the adoption of one of two routes between Omaha City and the point where the line reaches the Platte River. One of these routes being twenty-three (23) miles in length, with maximum grades of sixty-six (66) feet per mile, ascending westerly, and seventy-nine and one-half (79½) feet per mile, ascending easterly.

The other route is stated to be thirty-two (32) miles in length, with maximum grades in both directions of forty (40) feet per mile.

In answer I would state, that upon a close examination and comparison as between length of lines and grades of the same, I am clearly of the opinion, that the adoption of the longest line with ruling grades of forty (40) feet per mile, will best subserve the interests of the Government, the public, and the Railroad Company. The question being considered regardless of any difference there may be in the cost of the construction of either line, and independent of any subsidy from the Government.

I am,

Very respectfully
Your obedient servant,

Director and General Manager

M. R. R. U. S.
Dear Sir,—I am in receipt of yours of the 24th inst., requesting my opinion in regard to one of two lines to be adopted for the location of the Union Pacific Railroad between Omaha City and a point where the line reaches the Platte River. One of said routes being twenty-three (23) miles in length with maximum grades ascending westerly of sixty-six (66) feet per mile, and ascending easterly seventy-nine and one-half (791/2) feet per mile. The other is assumed to be thirty-two (32) miles in length, with maximum grades in both directions of forty (40) feet per mile.

In reply, I beg to say I have no doubt, assuming the curvatures of the two lines to be about the same, that the longest line, with grades of forty feet per mile, is clearly the one to be adopted, both for the interest of the Company and the public.

Yours very truly,

C. WIBBARD,
Gen'l Supt. N. Y. Central R. R.

To Col. SILAS SEYMOUR,
Con. Eng'r, U. P. R. R. Co.,
New York.

NEW YORK, December 28th, 1864.

SILAS SEYMOUR, Esq.,
Consulting Engineer, U. P. R. R.:

Dear Sir,—In reply to yours of the 24th inst., just received, I can only answer briefly, that it will, in my opinion, be sound policy to increase the length of line in the case stated; especially if the high grades are of considerable extent either in length or number, and if, in so doing, the curvature be not very materially increased.

The portion of the line in question will, it is true, be extended about thirty-nine (39) per cent; but it is, comparatively, a very small part of the whole road. The interest on the difference of cost, including that of the superstructure, will pay the extra running expenses of three trains each way daily on the longer line; while it may be worked easier with its forty (40) feet grades, than the shorter line with its sixty-six (66) and seventy-nine and a half (791/2) feet grades.
The highest ascending grade upon any section or division of the road will fix a limit to the load that can be hauled continuously over that division; and any separation of trains into parts, for the purpose of overcoming the elevations, will invariably be attended with vexatious delays, and often with positive danger. For every one hundred (100) tons that can be hauled up a forty (40) feet grade, only sixty-five (65) tons can be hauled up a sixty-six (66) feet grade, and but fifty-four (54) tons can be hauled up a seventy-nine and a half \( (79\frac{1}{2}) \) feet grade. Practically, for heavy freight trains, a road twenty-three (23) miles long, ruled by grades of seventy-nine and a half \( (79\frac{1}{2}) \) feet, will be equivalent to a road of forty-three (43) miles long, ruled by grades of forty (40) feet. So, also, a road twenty-three (23) miles long, ruled by grades of sixty-six (66) feet, will be equivalent to a road thirty-five and a half \( (35\frac{1}{2}) \) miles long, ruled by forty (40) feet grades.

Light trains, say a locomotive and tender, one baggage, one mail, and four passenger cars, with their loads, will be able to ascend any of these grades, but with varying speed. The resistance on the sixty-six (66) feet grades will be about forty-five (45) per cent. greater than on the forty (40) feet grades, and the resistance on seventy-nine and a half \( (79\frac{1}{2}) \) feet grades will be about eighty-eight (88) per cent. more than on the forty (40) feet grades.

Without going into any nice calculations, and neglecting atmospheric resistance, it may be assumed that any train that can just make a speed of twenty (20) miles per hour on a forty (40) feet grade will have that speed reduced to fourteen (14) miles per hour on sixty-six (66) feet grades, and to twelve (12) miles per hour on seventy-nine and a half \( (79\frac{1}{2}) \) feet grades. As regards speed, then, a road twenty-three (23) miles long, of seventy-nine and a half \( (79\frac{1}{2}) \) feet grades, will be equivalent to a road thirty-eight (38) miles long of forty (40) feet grades; and a road twenty-three (23) miles long of sixty-six (66) feet grades will be equivalent to a road thirty-three (33) miles long of forty (40) feet grades, and so in proportion as the lengths of these grades are to the actual length of road.

I am of the opinion, that where the locomotive is well proportioned for working out its whole adhesion, it is unsafe for a train to descend a heavy grade at much greater speed than it will ascend the same grade, and, as a rule, that speed lost on heavy up grades should not be regained on similar down grades.

On roads having a light traffic, the effects of heavy grades are not of a very formidable nature; but on a road of national importance, designed as a great thoroughfare of travel, and for the transit of immense quantities of goods and produce, it will be found, at no very distant day, that grades
of eighty (80) feet, and even of sixty-six (66) feet per mile are quite serious obstacles.

Respectfully yours, &c.,

S. S. POST,
Civil Engineer.

M A S T E R O F T R A N S P O R T A T I O N ' S O F F I C E ,
B A L T I M O R E A N D O H I O R A I L R A D O C O M P A N Y,
B A L T I M O R E , J A N U A R Y 2 , 1 8 6 4 .

S. SEYMOUR, Esq.,
Engineer, Union Pacific R. R. Co.,
No. 13 William Street,
New York City:

Sir,—Your letter of the 24th Dec., relative to the proposed routes of your road for a short distance west of Omaha, was duly received.

It does not need much consideration at my hands, with the special experience of our company, regarding the relative advantages of level lines as against heavy grades, to enable me to promptly answer your question.

I advise, unhesitatingly, that it is "unquestionably good policy for the company and for the best interests of the government and the public to increase the length of the eastern portion of the road nine (9) miles, in order to attain the difference in maximum grades," as specified.

I might cite, in illustration, the fact that, between Piedmont and Grafton, on our road, we have a series of grades ranging from 90 to 116 feet to the mile, the distance being 72 miles.

From Piedmont to Martinsburg, eastwardly, the distance is 106 miles but there is no grade exceeding 50 feet, and yet the latter-named division, though of one-third greater length, is worked at far less cost in every respect than the division embracing the heavy grades first named.

Between Piedmont and Martinsburg an engine carries with facility from 25 to 30 loaded cars, while between Piedmont and Grafton the load is from 8 to 9 cars only.

This illustration is not minutely applicable to your case, but serves in a general way to sustain the position I have assumed in this letter.

In the case stated by you, with the circumstances named, it is very clear in my mind that the longer lines and lower grades should be adopted.

Very resp'y,

Your obd'lt serv't,

W. P. SMITH,
Master of Transportation.

**EXPERIMENTS FOR DETERMINING EFFECT OF GRADES AND CURVATURE.**

Experiments were made in September last with the view of determining the relative power required upon the several Divisions of the road for the transportation of heavy freight, by ascertaining the maximum load any given engine can haul over those portions of each Division which limit the load.

For this purpose a single locomotive engine was run the entire distance from Dunkirk to Piermont, with trains varying to suit the ruling grades of the respective Divisions. As these experiments were not intended to set at rest questions of a purely scientific character, the accuracy necessary to that end was not observed. It is believed, however, that they have been made with sufficient care to determine the practical objects more immediately in view, and show the capacity of the road and its machinery to be adequate to the movement of an immense tonnage, and at a less cost per ton, for a large traffic, than can be attained on any road of less gauge, and of equal grades and curvature.

The engine selected for this purpose was of the following proportions: Total weight, 66,050 lbs.; Weight on driving wheels, 40,050 lbs.; Cylinders, 17 inches diameter; Length of stroke, 24 inches; Driving wheels, 5 feet diameter; Maximum pressure of steam on cylinders without slipping the wheels, 140 lbs.; or, deducting the atmospheric pressure, 125.35 lbs. effective pressure per square inch.

The traction of the engine, that is, its power applied at the circumference of the wheels, and by which it is impelled, neglecting its friction, may be stated thus:

\[
\frac{125.35 \times 17 \times 17 \times 24}{60} = 14,485 \text{ lbs.}
\]

This is the total resistance, consisting, principally, of the friction of the
engine and tender, of the cars, the gravity of the train on ascending grades, and the resistance of curves, which this engine, under an effective pressure of $125\tfrac{1}{2}$ lbs. per square inch upon its pistons, can overcome.

The engine and tender were moved with slightly accelerated motion, on a level, under an effective pressure of 3 lbs. Their friction, therefore, without any load attached, is $3 \times \frac{17 \times 17 \times 24}{60} = 347$ lbs.

It has been customary to estimate the friction of cars, with wheels of 30 inches and journals of 3 inches diameter, at about 7 lbs. per ton; or, 8 lbs. per ton for wheels 33 inches and journals 3$\frac{1}{2}$ inches diameter—the dimensions of those in use on this road: but the experiments made, show conclusively that the friction of the loaded cars did not exceed 4$\frac{1}{2}$ to 5 lbs. per ton.

It has also been usual to estimate the additional friction of the engine in consequence of its load, at one pound per ton of its load on a level. This item will of course be reduced as the friction of the cars is reduced.

After a careful examination and comparison of the loads moved upon the ruling grades and curves of various sections of the road, it is assumed that the friction of the cars is 4$\frac{1}{2}$ lbs. per ton of 2,000 lbs. The resistance of curves $\frac{1}{3}$ lb. per ton per degree of curvature per 100 feet; and the additional friction of the engine $\frac{1}{2}$ lb. per ton of load on a level and straight line, or its equivalent.

The weight of the engine on its drivers being 40,050 lbs., and the traction 14,485 lbs., the adhesion was, therefore, $\frac{14485}{40050} = \frac{7}{20}$, or not less than 36 per cent. of the insistant weight. This has heretofore been variously estimated at from 12$\frac{1}{2}$ to 25 per cent.

The tender, with its complement of wood and water, weighed 40,240 pounds.

A train consisting of 100 loaded cars, weighed 3,423,150 lbs., making the total weight of engine, tender, and cars 3,529,440 lbs., or 1,765 tons, very nearly, was taken over a mile of road, on an ascent of 6'14 feet, and a curve of 1$^\circ$ or 5,730 feet radius, in 11$\frac{1}{2}$ minutes. The preceding mile being on an uniform grade of 6 feet, ascending also, no advantage could have been taken of momentum previously acquired by the train.

The resistances overcome in this case are estimated as follows:
Friction of engine and tender, 347 lbs.  
  cars 1,711\(\frac{3}{10} \times \frac{3}{10}\) tons at 4\(\frac{1}{2}\) lbs., 7,702 "  
Gravity of engine and train 3,529,440 \times 6.14 4,104 "  
Resistance of curve 1,765 x 4\(\frac{1}{2}\) lb., 882 "  
Additional friction, \(\frac{1}{3} \left(\frac{4,104 + 882}{4\frac{1}{2}} + 1,711 \frac{3}{10}\right)\) 1,410 "  
Total resistance, 14,445 lbs.

A train of 22 cars, weighing 753,082 lbs., or 376\(\frac{3}{10}\) tons, and with engine and tender weighing 859,372 lbs., or 420\(\frac{5}{10}\) tons, was taken up a mile of 60 feet ascending grade, through a curve of 5\(\frac{1}{2}\) or 1,146 feet radius, in 6\(\frac{1}{2}\) minutes.

Friction of engine and tender, 347 lbs.  
  cars 376\(\frac{1}{2}\) tons at 4\(\frac{1}{2}\) lbs., 1,694 "  
Gravity of engine and train 859,372 \times 60.5 9,847 "  
Resistance of curve 420\(\frac{5}{10}\) \times \frac{2}{3} 1,074 "  
Additional friction \(\frac{1}{3} \left(\frac{9,847 + 1,074}{4\frac{1}{2}} + 376\frac{1}{2}\right)\) 1,401 "  
Total resistance, 14,363 lbs.

or 122 lbs. less than the maximum traction or power of the engine under an effective steam pressure of 125\(\frac{1}{10}\) lbs. per square inch.

On a mile of 52 feet ascending grade and a curve of 5\(\frac{1}{2}\) per 100 feet, or 1,146 feet radius, a train of 25 loaded cars, weighing 870,250 lbs., or 435\(\frac{1}{2}\) tons, and with engine and tender 976,540 lbs., or 488\(\frac{7}{10}\) tons, was taken up in 9 minutes.

Friction of engine and tender, 347 lbs.  
  cars 435\(\frac{1}{2}\) at 4\(\frac{1}{2}\) lbs., 1,958 "  
Gravity of engine and train, 976,540 \times 52 9,618 "  
Resistance of curve 488\(\frac{7}{10}\) \times \frac{2}{3} 1,220 "  
Additional friction \(\frac{1}{3} \left(\frac{9,618 + 1,220}{4\frac{1}{2}} + 435\frac{1}{2}\right)\) 1,422 "  
Total, 14,565 lbs.

being an over estimate of resistances, or an under estimate of traction of 80 lbs.

On a mile of 60 feet ascending grade, through 2,900 feet of curve 3\(\frac{3}{4}\) or 1,637 feet radius, a train of 23 loaded cars, weighing 800,330 lbs., or 400\(\frac{5}{10}\) tons, and including engine and tender, a total weight of 906,620 lbs., or 453\(\frac{1}{10}\) tons, was taken up in 5 minutes.
Friction of engine and tender, .......................... 347 lbs.
    " cars, 400½ tons at 4½ lbs., .......................... 1,800 "
Gravity of engine and train, \(\frac{906,620 \times 60}{5,280}\) .......... 10,302 "
Resistance of curve, \(453\frac{31}{100} \times 1\frac{3}{4}\) .......... 793 "
Additional friction \(\frac{1}{2} \left(\frac{10,302 + 793}{4\frac{3}{2}} + 400\right)\) .......... 1,433 "
Total .................................................. 14,675 lbs.
or 190 lbs. over estimate of resistance.

A train of 24 cars, weighing 821,544 lbs. or 410,773½ tons, total weight including engine, 927,834 lbs. or 463,997½ tons, was taken up a mile of 60 feet grade, without curvature, in 5½ minutes.

Friction of engine and tender, ................................ 347 lbs.
    " cars, 410\frac{8}{10} x 4\frac{1}{2} .................................. 1,848 "
Gravity \(\frac{927,834 \times 60}{5,280}\) .................................. 10,543 "
Additional friction \(\frac{1}{2} \left(\frac{10,543}{4\frac{3}{2}} + 410\frac{8}{10}\right)\) .......... 1,377 "
Total .................................................. 14,675 lbs.
Resistance less than traction 370 lbs.

The same train was taken the next mile on a grade of 58 feet, through a curve of 3\(\frac{3}{4}\)° per 100 feet, for 1,500 feet, in 8½ minutes.

Friction of engine and tender, ................................ 347 lbs.
    " cars, 410\frac{8}{10} x 4\frac{1}{2} .................................. 1,848 "
Gravity, \(\frac{927,834 \times 58}{5,280}\) .................................. 10,102 "
Resistance of curve, \(463\frac{9}{10} \times 1\frac{3}{4}\) .......... 812 "
Additional friction \(\frac{1}{2} \left(\frac{10,102 + 812}{4\frac{3}{2}} + 410\frac{8}{10}\right)\) .......... 1428 "
Total .................................................. 14,627 lbs.
or over estimate of resistances of 142 lbs.

The average of these six experiments shows an estimated resistance of 14,465 lbs., or 20 lbs. less than the traction or computed maximum power of the engine with the steam gauge indicating 140 lbs. pressure.

The ultimate power of a well proportioned engine may be most easily and correctly determined from the weight on its driving wheels. From the experiments made we are able to deduce practical rules for ascertaining the gross weight of cars and useful load which an engine should take behind its tender.
The preponderance of trade on this road being eastward, it is desirable to know the maximum load any given engine can haul in that direction, upon the grades and curves which limit the road upon each Division, and is very nearly as follows:

**NUMBER OF TONS OF CARS AND LOAD FOR EACH TON OF WEIGHT ON DRIVING WHEELS.**

- **Western Division,** Dunkirk to Hornellsville, 28 tons
- **Susquehanna Division,** Hornellsville to Susquehanna, 80 "
- **Delaware Division,** Susquehanna to Deposit, 18½ "
  Deposit to Port Jervis, 85 "
- **Eastern Division,** Port Jervis to Suffern, 20 "
  Suffern to Piermont, 20½ "

**Note.**—The ruling grades ascending easterly on the above portions of road are as follows:

- Dunkirk to Hornellsville, 40 feet.
- Hornellsville to Susquehanna, 5 "
- Susquehanna to Deposit, 61 "
- Deposit to Port Jervis, Level.
- Port Jervis to Suffern, 61 "
- Suffern to Piermont, 57 "

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**MEMORANDUM.**—In relation to the location and construction of the Western Division of the New York and Erie Railroad.

The following brief history of the successive steps, from the first surveys to the final location and construction of the Western Division of the New York and Erie Railroad, extending from Hornellsville to Dunkirk, a distance of one hundred and twenty-eight miles, will perhaps furnish as instructive an example as can be referred to, for the purpose of illustrating the great importance attached to, as well as the large expenditure incurred in securing the lowest grades practicable upon the great trunk lines of railroad in this country.

The first surveys were made in 1834 by Mr. Charles Ellet, Jr., under the direction of Judge Benjamin Wright. Mr. Ellet reported that an inclined plane would be necessary in overcoming the ascent eastward from Lake Erie; and several pages of his report were devoted to the subject of the value of inclined planes worked by stationary power, as compared with grades that could be worked by locomotives.

In 1836, the Railroad Company appointed Captain Talcott and Major Courtenay, of the United States Topographical Engineers, to make further
examinations, with a view, if possible, to reducing the grades within the limits of locomotive power. After spending one season in making elaborate surveys, they reported the practicability of obtaining a line with maximum grades of sixty-eight feet per mile, ascending from Lake Erie, at Dunkirk, to the head waters of a branch of the Connewango Creek at Mud Lake Summit.

In 1838, it became necessary for the Company to locate and place under contract ten miles at each end of the road, in order to avail themselves of certain aid granted by the Legislature. Major T. S. Brown, of the United States Engineers, was appointed to make the location at the western end; and Mr. Edwin F. Johnson was appointed consulting engineer. It had been ascertained that the maximum grades ascending easterly upon all other portions of the road, could be brought down to a maximum of sixty feet per mile; and it was therefore considered very important to reduce the grade on the western end to the same maximum. This result was finally accomplished, at considerable increase in cost, by an elongation of the line between the initial points; and the work was placed under contract, and the grading completed for a double track.

The location was extended eastward to Hornellsville in 1839 and 1840 with a grade descending easterly of sixty-eight feet per mile, immediately west of Hornellsville; and a large proportion of the grading was completed. About this time the Company became insolvent; and the work of construction upon this portion of the road was suspended until 1850.

In 1849 and 1850, the undersigned was instructed by Mr. Benjamin Loder, the president of the Company, to revise the location of the Western Division, and prepare it for immediate completion. The ruling grades, as before stated, were sixty feet per mile ascending easterly, and sixty-eight feet ascending westerly. After several months spent in surveys and investigation, a report and estimate were submitted to the Company, in which it was recommended that about sixty miles of road, either wholly or partially graded, should be abandoned, and new routes adopted with ruling grades of forty feet per mile ascending easterly, and fifty feet ascending westerly. This change involved an abandonment of work previously done, amounting to not less than one million dollars; and an additional expenditure of at least another million, more than would have been required to prepare the road-bed on the old location for the superstructure. The line, however, between the Allegany river and Lake Erie, was shortened about five miles by the change proposed.

The recommendation was fully concurred in, by Mr. Horatio Allen, the consulting engineer of the road, and adopted by the Railroad Company.
And the road was finally constructed, and is now in operation upon the routes then recommended.

New York, Dec. 29, 1864.

S. SEYMOUR.

Extract from the Report made by a Commission appointed by the Legislature of the State of New York to locate certain portions of the New York and Erie Railroad.

In 1840, the question of locating a portion of the New York and Erie Railroad through the counties of Sullivan and Broome, in this State, was referred, by the Legislature, to a Commission for final decision. The rival routes were surveyed under the direction of the Commission; and, after a very full investigation, a report and decision were made by a majority of the Commission in favor of the routes having the lowest ruling grades. It has been found almost impossible to make extracts from the conclusions arrived at in the Report, without, to some extent, weakening the argument, or mystifying the case. The following extract is therefore given entire:

"General Description of the Routes Surveyed under the direction of the Commissioners.

"Commencing at a point about one mile westerly of the village of Binghamton, and extending easterly to Deposit; there are two routes; which, for distinction, are called, one the Nineveh, or Interior Route, and the other, the Susquehanna, or River Route.

"The Nineveh Route passes up the Chenango Valley to Port Crane, near the mouth of Page Brook, where the heavy grade commences, then follows Page Brook valley, and reaches the summit between the Chenango and Susquehanna rivers, called the New Ohio Summit. To reach this summit, a grade of 65 feet to the mile is encountered. The line then descends and reaches the valley of the Susquehanna at Nineveh. The line then ascends by a maximum grade of 65 feet per mile to the Bettsburgh summit, which is the summit between the Susquehanna at Nineveh, and the Delaware at Deposit. The line then descends to Deposit. The total length is 43 5/6 miles.

"The Susquehanna route passes through the village of Binghamton, and continues up the valley of the Susquehanna to near Lanesboro, in the State of Pennsylvania. To this point the maximum grade is 20 feet to the mile. It then leaves the valley of the Susquehanna and reaches the Gulf summit, or the summit between the Susquehanna at Lanesboro, and the Delaware, at Deposit. The maximum grade to reach this summit is 68 feet per
mile. The line then descends to Deposit. The total length is 39 \(\frac{2}{100}\) miles.

"The following tabular statements show the essential character of the two routes:—

<table>
<thead>
<tr>
<th></th>
<th>Susquehanna, or River Route.</th>
<th>Nineveh, or Interior Route.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum grade going East</td>
<td>68 ft. per mile,</td>
<td>65 ft. per mile.</td>
</tr>
<tr>
<td>&quot; &quot; West</td>
<td>67 &quot;</td>
<td>74 &quot;</td>
</tr>
<tr>
<td>Number of summits</td>
<td>1 summit,</td>
<td>2 summits</td>
</tr>
<tr>
<td>Length of line on which maximum grade rules</td>
<td>15 (\frac{5}{100}) miles,</td>
<td>35 (\frac{8}{100}) miles.</td>
</tr>
<tr>
<td>Total ascent going East</td>
<td>540 feet,</td>
<td>1087 feet.</td>
</tr>
<tr>
<td>&quot; &quot; West</td>
<td>395 &quot;</td>
<td>936 &quot;</td>
</tr>
<tr>
<td>Total rise and fall</td>
<td>935 &quot;</td>
<td>2023 &quot;</td>
</tr>
<tr>
<td>Minimum radius of curves,</td>
<td>1000 &quot;</td>
<td>1056 &quot;</td>
</tr>
<tr>
<td>Total curvature, in degrees</td>
<td>2371 degrees,</td>
<td>3253 degrees.</td>
</tr>
<tr>
<td>Length of lines</td>
<td>39 (\frac{2}{100}) miles,</td>
<td>43 (\frac{8}{100}) miles.</td>
</tr>
<tr>
<td>Total estimated cost of grading, with superstructure on extra length</td>
<td>$746,900</td>
<td>$628,600</td>
</tr>
</tbody>
</table>

"The maximum grades for loads moving eastward are three feet per mile greater on the Susquehanna route than on the Nineveh route. The length of line on which maximum grade rules is nearly 20 miles less on the Susquehanna than on the Nineveh route. The total rise eastward is 547 feet greatest on the Nineveh route. The total ascent for both east and west is 1088 feet greatest on the Nineveh route. The radius of minimum curvature is the most favorable by 56 feet in 1000 for the Nineveh route. The total curvature is 882 degrees, or 2.45 circles, most favorable for the Susquehanna route. From Deposit the line proceeds down the valley of the Delaware river about 40 miles, to the mouth of the Callicoon creek. To this point it is common to the two routes between the mouth of the Callicoon creek and the summit of the Shawangunk ridge in Orange county.

"The two routes between the points last mentioned, for the purpose of distinction, we call one the Sullivan County or Interior route, and the other the Delaware River or Southern route.

"The Sullivan County, or Interior route, follows up the valley of the Callicoon creek, thence crossing to the Mongaup and Neversink rivers, and over the dividing ridge, between the latter and the headwaters of the Sandbag creek, which it follows several miles and thence by the Maksating valley to the village of Wurtsboro. The distance from the mouth of the Callicoon to Wurtsboro is 52 \(\frac{5}{100}\) miles. There are several different rates of ascending grade going eastward, the maximum of which is 45 feet per mile. From Wurtsboro the line begins to ascend the northwestern slope
of the Shawangunk mountain, and reaches the point of junction at the
summit gap in a distance of $8 \frac{5}{15}$ miles, with a maximum grade of 45
feet per mile.

The Delaware river route continues down the valley of the Delaware
river, from the point of divergence at the mouth of Callicoone Creek. It
occupies the New York side of the Delaware river, for $20 \frac{3}{15}$ miles, and
then crosses it to the Pennsylvania side, and follows that side about 27
miles, where it recrosses, and thence continues on the New York side to
Port Jervis. The distance from the mouth of the Callicoone creek to this
place is $48 \frac{5}{15}$ miles; the line then leaves the valley of the Delaware,
crosses the table land and the valley of the Neversink and ascends the
northwestern slope of the Shawangunk mountain, reaching the summit gap
in a distance of $9 \frac{5}{10}$ miles. The grade going east from the Callicoone
to Port Jervis, is either level or descending, and from Port Jervis to the
summit of the Shawangunk, the maximum grade is 50 feet per mile.

The following tabular statement shows the essential character of the two
routes:

<table>
<thead>
<tr>
<th></th>
<th>Delaware River Route</th>
<th>Sullivan County or Interior Route</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum grade ascending east.</td>
<td>50 feet per mile.</td>
<td>45 feet per mile.</td>
</tr>
<tr>
<td>&quot; &quot; ascending west.</td>
<td>15 &quot; &quot;</td>
<td>157 &quot; &quot;</td>
</tr>
<tr>
<td>Number of summits</td>
<td>one.</td>
<td>5.</td>
</tr>
<tr>
<td>Total ascent, east.</td>
<td>454 feet.</td>
<td>1187 feet.</td>
</tr>
<tr>
<td>&quot; &quot; west.</td>
<td>316 &quot;</td>
<td>1040 &quot;</td>
</tr>
<tr>
<td>&quot; ascent and descent.</td>
<td>770 &quot;</td>
<td>2236 &quot;</td>
</tr>
<tr>
<td>&quot; length of line on which maximum grade rules.</td>
<td>9 $\frac{5}{10}$ miles.</td>
<td>61 $\frac{1}{10}$ miles.</td>
</tr>
<tr>
<td>Minimum radius of curves.</td>
<td>1200 feet.</td>
<td>955 feet.</td>
</tr>
<tr>
<td>Total curvature.</td>
<td>4588 degrees.</td>
<td>7609 degrees.</td>
</tr>
<tr>
<td>Length of lines.</td>
<td>58 $\frac{1}{10}$ miles.</td>
<td>61 $\frac{1}{9}$ miles.</td>
</tr>
<tr>
<td>Estimated cost of grading.</td>
<td>$1,496,430.</td>
<td>$1,994,950.</td>
</tr>
<tr>
<td>Length from the mouth of the Callicoone.</td>
<td>48 $\frac{2}{10}$ miles to Port Jervis.</td>
<td>52 $\frac{5}{10}$ miles to Wurtsboro.</td>
</tr>
</tbody>
</table>

* This applies only to the line from Port Jervis, 9 56-100 miles to the Shawan-
gunk summit, and the engineer, Mr. Tracy, states this may be reduced to 45 feet
per mile.

† The engineer, Mr. Tracy, says this may be reduced to 48 feet per mile.
The maximum grade of 45 feet per mile, rules for \(61 \frac{1}{4}\) miles on the interior route; and at 50 feet per mile for \(9 \frac{5}{10}\) miles on the river route. The total rise and fall is 1466 feet more on the interior than on the river route; the minimum radius of curvature 245 feet less favorable; and the total curvature is 3021 degrees, (equal to \(8 \frac{3}{5}\) circles,) less favorable on the interior than on the river route.

In considering the question of motive power on the routes in question it becomes necessary to understand the influence of the adjacent parts of the road.

Commencing at the point near Binghamton, the road westward of that place, for more than 100 miles, has no grade descending eastward, of more than 20 feet per mile. Consequently the trains will come to this point from the West, with loads adapted to a ruling grade of 20 feet per mile. With this load they would continue on the Nineveh route about eight miles to near Port Crane, and on the Susquehanna route, 23 \(1^a\) miles, to near Lanesboro, in Pennsylvania.

The extra power will therefore be, the amount required above that necessary for a grade of 20 feet per mile. The two routes unite again at Deposit, on the Delaware. The line then runs down the valley of the Delaware, as before observed, 40 miles, to the mouth of Callicoon Creek, and is level, or slightly descending eastward.

Between the Shawangunk summit and the Hudson river, at Piermont, grades of 60 feet occur.

If the Nineveh and Sullivan county lines were adopted, it would be a question of some practical importance to decide whether it would not be best to make up the trains moving East, (the direction of greatest load,) to go through to the Hudson without extra power. This course would render the level grade, of 40 miles on the Delaware, of little importance: but the inconvenience of changing the arrangement of trains for this distance, would probably counterbalance the advantage of doing so. If the system of extra power at the heavy grades be adopted, for these routes, then, extra power must be provided to take a train due to a 20 feet grade, at Port Crane, (near the mouth of Page Brook,) and carry it over grades of 65 feet per mile, for a distance of 35 \(\frac{1}{10}\) miles to Deposit. At this place a train due to a road nearly level, will proceed to the Callicoon, where extra power must be provided to carry it (over grades of 45 feet to the Shawangunk summit)—the entire length of this route. The same, or nearly the same power would be required to proceed on to Goshen, and increased so as to adapt it to a 60 feet grade, before the train leaves Orange county. Frequent changes of trains, or motive power, will be attended with inconvenience and extra expense, and in practice the trains and power will be regu-
lated to avoid changes as much as possible, especially if the road has only a single track.

It will be a near approximation, and simplify the comparison, to consider the routes for computation of motive power, to terminate for the Sullivan county, at Wurtsboro', and for the Delaware river, at Port Jervis. Considering the ascent from both these places to the Shawangunk summit as nearly the same, one 45, and the other 50 feet per mile, (and, as suggested by the engineer, the latter could be reduced to 45 feet,) the trains may be made up at these places respectively, to proceed over the ruling grades to the Hudson river, which are higher than either of the above. The train is then made up at Deposit for a level road and for the interior line, extra power is provided to carry it over the heavy grades between the mouth of the Callicoon and Wurtsboro', or for a distance of 40 miles; leaving the extra length of the line to Wurtsboro' over that to Port Jarvis for a separate estimate.

This arrangement, for a basis of comparative computation, will be as favorable for the interior lines as can be adopted; and it is proper to remark that, in any practical arrangement of business, the Commissioners are of the opinion it would be found most simple, efficient, and not less economical, to make up the train at Port Crane, in Broome county, to proceed to Deposit, and there adapt it to a ruling grade of 45 feet per mile, to be thence carried to the Shawangunk summit, and probably to Goshen. This mode of computation, however, would present a less favorable result, as no benefit would appear from the 40 miles of level grade on the Delaware, above the Callicoon creek.

It is important to this investigation to know the power and the cost of working locomotive engines.

The Commissioners have devoted their attention to this subject; and though it is one on which there is some conflict of opinion, the results arrived at in the following statement, are believed to be sustained by the most extensive experience, where detailed accounts have been kept.

**Cost of Motive Power on Railroads, per train, per mile.**

1st.—Engine-men, Firemen and Station Men:
- Baltimore and Ohio Railroad, 5 cents.
- Utica and Schenectady 8 "
- Reading 4.55
- Boston and Worcester 5.50
- Fitchburgh 7.00
- New York and Erie 7.485

\[30.05 \div 5 = 6.01 \text{ cents.}\]
### 2d.—Fuel:

<table>
<thead>
<tr>
<th>Location</th>
<th>Description</th>
<th>Cost</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading</td>
<td>Railroad, wood</td>
<td>$3.50</td>
<td>23.70</td>
</tr>
<tr>
<td>Boston and Worcester</td>
<td>“</td>
<td>$4.00</td>
<td>22.20</td>
</tr>
<tr>
<td>Fitchburgh</td>
<td>“</td>
<td>$4.25</td>
<td>14.17</td>
</tr>
<tr>
<td>*Baltimore and Ohio</td>
<td>Coal</td>
<td>$2.00</td>
<td>8.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New York and Erie</td>
<td>“</td>
<td></td>
<td>18.09</td>
</tr>
</tbody>
</table>

\[68.07 \div 4 = 17.02 \text{ cents.}\]

### 3d.—Repairs of Engines and Tenders:

<table>
<thead>
<tr>
<th>Location</th>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading</td>
<td>Railroad</td>
<td>4.90</td>
</tr>
<tr>
<td>Boston and Worcester</td>
<td>“</td>
<td>9.05</td>
</tr>
<tr>
<td>Utica and Schenectady</td>
<td>“</td>
<td>7.93</td>
</tr>
<tr>
<td>Fitchburgh</td>
<td>“</td>
<td>5.20</td>
</tr>
<tr>
<td>Western (Mass.)</td>
<td>“</td>
<td>6.50</td>
</tr>
<tr>
<td>*Baltimore and Ohio</td>
<td>“</td>
<td>9.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New York and Erie</td>
<td>“</td>
<td>8.75</td>
</tr>
</tbody>
</table>

\[42.55 \div 6 = 7.09\]

### 4th.—Oil and Cotton Waste:

<table>
<thead>
<tr>
<th>Location</th>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading</td>
<td>Railroad</td>
<td>1.74</td>
</tr>
<tr>
<td>Boston and Worcester</td>
<td>“</td>
<td>1.24</td>
</tr>
<tr>
<td>Fitchburgh</td>
<td>“</td>
<td>1.30</td>
</tr>
<tr>
<td>*Baltimore and Ohio</td>
<td>“</td>
<td>1.46</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New York and Erie</td>
<td>“</td>
<td>2.94</td>
</tr>
</tbody>
</table>

\[5.74 \div 4 = 1.43\]

### 5th.—Interest on Cost of Engines:

<table>
<thead>
<tr>
<th>Location</th>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baltimore and Ohio</td>
<td></td>
<td>3.01</td>
</tr>
</tbody>
</table>

\[= 3.01\]

### 6th.—Conductors and Brakemen:

- Reading Railroad: 4.11
- Fitchburgh: 6.20

\[10.31 \div 2 = 5.15\]

Take 63 per cent. for brakemen (which is the ratio on Reading road), as conductors should not be included, and the expense for brakemen is...

\[5.15 \div 63 = 3.14\]
Do. Baltimore and Ohio Railroad as per estimate for coal trade............. 2.40

New York and Erie Railroad............. 0.52

5.54 ÷ 2 = 2.77

7th.—Repairs of Railroad, chargeable to Locomotive and Tender:

1st. Ordinary repairs; of these one-fifth is regarded as chargeable to motive power.

Reading Railroad.............. 13.66
Boston and Worcester " ........ 18.00
Boston and Lowell " ........ 13.50
Western (Mass.) " ........ 13.75
Baltimore and Ohio " ........ 18.30

and 15.44 ÷ 5

77.21 ÷ 5 = 15.44

= 3.09

2d. Deterioration of iron, not yet settled by experience. Half of this wear is believed to be chargeable to locomotives and tenders, on account of their greater weight. Suppose rail cost $7,000 per mile, and will bear transport of 20,000,000 tons on a level road, average say 250 tons freight per train, equal to 80,000 trains. The cost per train will be $8.75; and half of this is............. 4.37

7.46

44.79

The weight of engines in the cases above detailed is not known, but is supposed to average less than fifteen tons on their driving wheels; to provide cost for an engine of 20 tons on driving wheels, would require an additional expense; but the fuel on the line of road under consideration, would be less expensive by about 7 cents, than the average for the same size of engine. In view of both
considerations, it is believed a reduction should be made from the preceding result of, say, ........................................ 4.79

And the estimate for a 20 ton engine is $40.00

* Estimate of coal trade in 1844.

Forty cents per mile run, for motive power with an engine of twenty tons on the driving wheels, appears to be about the cost as indicated by the experience of the roads above quoted from.

It is difficult to obtain the items of expense, as very few railroad reports present the items separately; and where they are given, they frequently include expenses for both freight and passengers. The weight of trains has an influence on the cost per mile, and in providing for power, reference should be had to this circumstance. The range for a cord of wood is from fifteen miles to forty miles run, according to the weight of train and size of engine.

From the data above presented, with due consideration of the circumstances, we have come to the conclusion, that forty cents per mile run with a twenty ton engine, is about the actual cost of motive power, including interest, and renewal of engines and tenders, and their proportion (according to the influence of their action on the road) for repairs and maintenance of way.

CALCULATION OF MOTIVE POWER REQUIRED ON RAILROADS.

Some difference of opinion exists as to the proper data for this calculation. It is generally considered that an engine in good order will work up to the adhesion of its driving wheels. The main question therefore is, as to the ratio of this adhesion. In the most favorable state of the rails, this ratio may be taken at one-sixth the weight; but in many instances, slightly unfavorable circumstances in the rails, and the condition of the engine, will occur in the ordinary business of the road; and for general purposes a ratio of one-eighth of the insistent weight is regarded as most favorable data for calculating motive power.

The friction of the cars is another element, and will depend on their condition. For general use 8 ½ pounds per gross ton of car and load is considered a proper basis.

The ratio of the weight of freight to the gross weight of car and freight must be considered. Two-thirds is a common rule for a trade that admits of regularity, as coal, &c. For a general business it is believed the freight will be about six-tenths (6/10) of the gross load of the cars and freight.
An engine of 20 tons gross weight, all resting on the driving wheels, is assumed as the basis of the estimate—tender 10 tons. The elements will therefore be—

Engine, 20 tons (44,800 pounds), all on the drivers.
Adhesion, one-eighth the insistent weight.
Friction, 8½ pounds per ton—this is, essentially, equal to the resistance of gravitation on a rise of 20 feet to the mile.

Of course, for every 20 feet rise per mile, there must be added the power required to move the train on a level.

Ratio of freight to gross load, as 6 is to 10—$44,800 \div 8 = 5600$ lbs = tractile power of engine, $5600 \div 8 \frac{1}{2} = 658$ tons gross load, exclusive of engine.

The freight the engine will carry on different planes will be as follows:—

On a level, $658.10$ (the tender) \times 6 = gross tons, 389
Ascent 20 feet per mile, $658.20 \div 20 - 10 \times 6 = 185.4$
" 30 " " $658.30 \div 2 \frac{1}{2} - 10 \times 6 = 144.7$
" 45 " " $658.45 \div 3 \frac{1}{2} - 10 \times 6 = 107.16$
" 48 " " $658.48 \div 3, 4 - 10 \times 6 = 103.64$
" 50 " " $658.50 \div 3, 5 - 10 \times 6 = 98.22$
" 60 " " $658.60 \div 4 - 10 \times 6 = 83.7$
" 65 " " $658.65 \div 4, 25 - 10 \times 6 = 77.7$
" 68 " " $658.68 \div 4, 4 - 10 \times 6 = 74.42$
" 74 " " $658.74 \div 4, 7 - 10 \times 6 = 68.55$

The following table shows the ratio of freight carried by the same engine on different gradients, and also the multiplier, or number of engines required on different inclinations to carry the same load—the unit being a lever:—

<table>
<thead>
<tr>
<th>Grade of Road</th>
<th>Ratio</th>
<th>Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level</td>
<td>1,000</td>
<td></td>
</tr>
<tr>
<td>Ascending 20 feet per mile</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot; 30 &quot;</td>
<td>.576</td>
<td>2.093</td>
</tr>
<tr>
<td>&quot; 45 &quot;</td>
<td>.372</td>
<td>2.689</td>
</tr>
<tr>
<td>&quot; 50 &quot;</td>
<td>.276</td>
<td>3.680</td>
</tr>
<tr>
<td>&quot; 60 &quot;</td>
<td>.252</td>
<td>3.900</td>
</tr>
<tr>
<td>&quot; 65 &quot;</td>
<td>.215</td>
<td>4.647</td>
</tr>
<tr>
<td>&quot; 68 &quot;</td>
<td>.197</td>
<td>5.000</td>
</tr>
</tbody>
</table>

It is necessary to consider the ratio of freight moving in different or opposite directions. No certainty can be arrived at as to this ratio. It will no doubt vary at different times.
Probably an average of three tons will move east to one ton west, and there can be no doubt that the freight moving east will control the question of power, except on that portion which is in the valley of the Delaware river, where the return load of one-third the freight with the whole number of cars will require greater power than the full load moving east.

The grade going eastward on the Delaware river has a maximum descent of 15 feet per mile, and assuming the ratio of freight to be three to one, the result as to the greatest load that can be carried on it, will be as follows:—

The engine assumed has been shown to be capable of carrying on a level a gross load of 648 tons, exclusive of engine and tender; or, 389 tons of freight. The gross load the engine will carry up an ascent of 15 feet per mile, exclusive of engine and tender, is 357 tons. If the freight be 358 tons, the gross load of cars and freight will be 596 tons. The cars for this load will be 238 tons. To return with one-third the freight and all the cars, the load will be \(358 + \frac{1}{3} + 238 = 357\) tons. It has been shown that 357 tons is the capacity of the engine on this ascent; consequently the load moving east can only be 358 tons of freight. The load moving east is therefore restricted by the load moving west.

The gross load due on an ascending grade of 20 feet is 309 tons; the freight 185.4 tons. The weight of cars required for this road is 124 tons; one-third the freight is 62 tons; together, 186 tons. To return up a 74 feet grade will require 63 per cent. additional power. It therefore appears that the train engine with a load due to a grade of 20 feet per mile, (this would be train from Hornellsville to Port Crane,) moving east, would require extra power to return on the interior route from Deposit to Port Crane, equal to 65 per cent.

The investigation, as applied to the line between Deposit and Wurtsboro', shows the following result: Down the Delaware it has been shown the load is 358 tons of freight. That portion of the interior line embraced in this section has a return grade of say 48 feet per mile. [In the table it is given at 57 feet, but, as there noted, the engineer states it may be reduced to 48 feet.] To return with cars and one-third freight over the interior portion of the section, gives a gross load of cars and freight of \(358 + \frac{1}{3} + 238 = 357\) tons. The engine will carry 169.4 tons up this ascent, consequently 2.10 engines, or 1.10 extra engines will be required to carry the return load.

From Wurtsboro' to the Shawangunk summit, the line has a ruling grade of 45 feet to the mile. From Port Jervis to the same point, the ruling grade is given in the table at 50 feet, but the engineer states this may be reduced to 45 feet, in which case they may be regarded as the
same. It will not be very material whether the latter is 45 or 50 feet, as
the trains would, in practice, most probably be made up at either point, so
as to encounter the heavier grades that occur towards the eastern terri-
mination of the road. This being about 70 miles, it is not probable there
would be a second change of train for this distance. There will, there-
fore, be no material difference whether the computation for the purpose of
comparison be made to the Shawangunk summit, or stop on one line at
Wurtsboro', and on the other at Port Jervis.

For the computation of extra power, it is proposed to take the Hornells-
ville train, which will be loaded for a 20 feet grade, and by extra power
carry it over the heavy grades to Deposit. At this place make up a train
that will be suitable for the Delaware river section, and provide extra
power sufficient to carry it over the heavy grades between the mouth of
Callicoon Creek and Wurtsboro'; leaving the trains to be there made up
either at Wurtsboro' or Port Jervis for the heavy grades between those
places and Piermont. This method will require but two changes of trains
between Binghampton and Piermont, and, in view of the whole subject, is
regarded as presenting a fair basis for comparing the two lines. It gives
the interior route the full benefit of the favorable grade on the Delaware
between Deposit and the mouth of the Callicoon, which may not be, and
probably will not be wholly available in practice; and the river route has
some additional elevation between Port Jervis and the Shawangunk sum-
mit, which may be regarded as a partial offset.

It has been shown that extra power will be required mainly as aid to
the train moving eastward; and that a portion of this power will be re-
quired for the return train. A part of the extra power required to move
the train eastward, might be dispensed with when it reached the last
summit of the ruling grade. There will, however be practical difficulties
in this. It will cause too much change in arranging the power, and tend
to confusion in conducting the business of the road; and it will deprive
the heavy trains of the power that is sometimes quite necessary, and
generally a convenience, in regulating their descent on the heavy grades.
There are times when the state of the rails is such that it is impossible to
control the trains on a heavy descending grade by means of the friction
brake alone—where the power of the engine is indispensable; and even
that is not always sufficient. In view of all the circumstances, there can
be no doubt, the most judicious business arrangement would be, to run
the extra power over the whole section affected by the ruling grade, both
ascending and descending in the direction of the greatest trade. As the
extra power must run in both directions over the section requiring its aid,
it will always be competent to carry the return load; and as the load east-
ward will determine the amount of extra power necessary to be provided, the computation will be simplified by considering it charged wholly to the freight moving in this direction. The engines must return; and though partially loaded with the train moving westward, the expense or comparison will not be affected, whether it be charged in this manner, or divided between the freight in both directions. The total cost of extra power will be therefore charged on freight moving eastward.

It has been shown that the cost of running an engine weighing 20 tons, and capable of carrying a train of 389 tons freight on a level, will be 40 cents per mile run. It is, however, well known, that extra power kept in readiness for running at intervals, and for short distances, cannot be maintained at the same expense per mile run as a regular train engine. The extra power must be adapted to the load, and this may require more than one and less than two engines, consequently two must be employed. Two or three engines coupled to the same train will not perform as much in proportion to their power as if worked separately, and if the train is separated and made up into several smaller ones, delay and expense is incurred. The power must be provided for a full load; but a general trade will be more or less irregular, and as the trains working on a long road must move at regular times, they will not always be full loaded, and the average will fall considerably below the capacity of the engines. This remark applies to the question of power generally, and is not peculiar to the provision for extra power. We are of the opinion that this extra power, for the reasons above given, will cost not less than 50 per cent. per ton of freight per mile more than that of engines in regular work, and carrying loads equal to their full capacity. The ratio of increase in cost, from the considerations above stated, cannot be arrived at with certainty, and though we think it will exceed the regular computation more than 50 per cent., this ratio will be assumed in the following estimates.

Collecting the data that have been presented, we now proceed to give the expense of extra power, and make a comparison of the several routes, on the basis that has been submitted.

**Nineveh, or Interior Route.**

The extra power to carry a train due to an ascending grade of 20 feet per mile, up a grade of 65 feet per mile (the ruling grade on this route), is $$= 1.386$$, or nearly, $$1\frac{1}{7}$$ engines. We have then, $$40 \times 2 \times 1.386 \times 1.5 = 166.32$$ cents per mile run with a load of 185 tons; $$166.32 \div 185 = 0.9$$ cents per ton per mile.

This route is 4.29 miles longer than the Susquehanna or Southern route.
For this distance, the whole cost of transportation, exclusive of depot expenses, is chargeable to the interior route. This, on a ruling grade of 20 feet per mile, ascending in the direction of the greatest trade, is estimated at one cent per ton per mile on the freight carried in both directions. The freight going westward is estimated at $\frac{1}{3}$ of that going eastward, and hence a charge of 1 ½ cents per ton per mile on that moving eastward, will cover the cost on freight in both directions.

The extra expense all computed on freight going eastward, will be, per ton as follows:

On 35 6-10 miles (length that heavy grade rules) at the rate of 0.9 cents... 32.04 cents.

On 4 29-100 miles, extra length of line, and to cover freight in both directions, though only chargeable on that moving east, at the rate of 1 ½ cents... 5.72 "

Per ton of freight... 37.76 "

Susquehanna, or River Route.

The extra power to carry a train due to an ascending grade of 20 feet per mile, up a grade of 68 feet per mile (the ruling grade on this route), is 1.491, nearly 1 ½ engines; computed on the basis above adopted is, 40x2x1.491x1.5 = 118.92 cents per mile, run with a load of 185 tons. 178.92 - 185 = 0.7 cents per ton per mile.

The length on which ruling grade prevails is 15.66 miles, at 0.97 cents per mile = 15.19 cents.

Comparison of the two routes:

Nineveh route... 37.76 cents.
Susquehanna route... 15.19 "

Difference in favor of Susquehanna route... 22.57 "

Sullivan County, or Interior Route.

It has been shown, that the train will proceed from Deposit to the mouth of Calicoon Creek, with a load due to a level, or a grade descending 15 feet per mile, the load being restricted by the return load to 258 tons freight. The extra power required to carry this load up a grade of 45 feet per mile, is 2.34 or 2 1/3 engines of equal power. We have then, 40x2x2.34x1.7 = 280.8 tons, 280.8 cents per mile, run with a load of 358 tons, 280.8 - 358 = 0.78 cents per ton per mile.
The distance on which this grade rules, as before remarked, between the mouth of the Callicoon and Wurtsboro' is 52.58 miles; but, as it is to be compared with the Delaware river line from the mouth of the Callicoon to Port Jervis, it should be taken for extra power, for no greater distance than that between the two latter points, or 48 97-100 miles. The extra power will therefore be taken for this distance.

This route is $2 \frac{1}{10}$ miles longer than the Delaware river route.

The extra length will be estimated the same as that for extra length of the Nineveh route, viz., at one cent per ton per mile on freight each way; or charging wholly on freight moving eastward, $1 \frac{1}{4}$ cents per ton per mile.

Summary of extra cost of transportation on Sullivan County route, charging the whole cost on freight moving east,

48.97 miles, at 0.78 cents per ton per mile........... 38.10 cts. per ton.
2.61 do. extra length at 1\%....................... 3.48 "
Total extra cost per ton, over the Delaware river route... 41.67 cents.
Extra cost on Nineveh route, as before shown........... 22.57 "

T. tal extra cost on the interior routes.................. 04.24 cents.

Having determined the extra cost of transportation per ton, caused by the heavy grades and extra lengths, it becomes necessary to ascertain what will be the total tonnage annually transported over the road. The calculations are all based on changing the whole expense of extra power on freight moving eastward; that moving westward being provided for by the method adopted to determine the question. It is, therefore, the tonnage moving eastward that we want to ascertain the amount of.

The officers of the New York and Erie Railroad Company, in presenting their views of this question to the Commissioners, assumed that 500,000 tons per annum would be transported eastward over the railroad. This position was not controverted by any person interested in the northern or other routes.

It is not possible to arrive at accuracy on this point; and the Commissioners are not willing to say the road will not eventually reach this estimate; but this would be a very large business for a general trade, and much beyond the capacity of a single track road. The question to be determined is, what amount of trade will pass over the section between the Shawangunk river and Port Crane, in Broome county.

An estimate of this kind should look to some future period, when the business of the road might reach, not its full capacity, but such as would form an average with the past and the future.
The Baltimore and Ohio Railroad, as now, and for several years past, has been worked about 180 miles. For the year ending September 30th, 1864, there was transported on it, to and from the different points, 193,016 tons (including the trade in both directions), equivalent to about 84,030 tons carried over the whole road.

The New York and Erie Railroad, when completed, will extend about 260 miles beyond Port Crane, in Broome county. Now, if we suppose three tons carried to Baltimore, to one ton in the opposite direction, there must have been about 145,000 tons moved towards Baltimore. This proportion applied to the New York and Erie Railroad, for equal distances, would show about 210,000 tons arriving at the western end of the routes under consideration. Whether the two roads should be regarded as presenting a fair parallel for amounts of trade, is however, a question which may admit of a difference of opinion.

The tonnage on the Western Railroad, from Albany to Worcester, 156 miles, for the year 1845, was equal to 93,392 tons carried over the whole road. This includes freight in both directions. On this road the freights in opposite directions are more nearly equal than is usual. Judging from the amount received for freight, it appears to be not far from two to one. This would show a result about 13 per cent. greater for the tonnage towards tide-water, comparing the distances, than the Baltimore and Ohio Railroad. It is to be considered, however, that a considerable portion of this tonnage is from place to place, and forms no part of the through tonnage.

The route traversed by the New York and Erie Railroad, is understood to be in general a grazing district, that furnishes freight of greater value, but of less tonnage than a grain growing district.

The Commissioners have been much embarrassed in forming a satisfactory estimate on the amount of tonnage. It does not appear practicable, from any data in their possession, to reach any definite accuracy, and their estimate must be considered as in a great measure conjectural.

The amount assumed by the engineer of the Company is regarded as too high, to form the basis of comparison between the several routes. The Commissioners have assumed 200,000 tons as the annual amount of freight that may be expected to move eastward over that portion of the road embraced in this question of location; this they think as high an estimate as they are warranted to make for this comparison.

It has been shown, the cost of transportation will be 84.24 cents per ton (computed wholly on freight moving eastward,) greater on the interior routes than on the river routes.
This rate on 200,000 tons per annum is 200,000 tons at 64.24 cents per ton, = $128,480.

The passenger trade will feel the unfavorable influence of the heavy grades, and will require extra power; or the train must proceed over them at reduced velocity.

The excess of curvature on the Nineveh and the Sullivan, or interior routes, over that on the river routes, is 3,903 degrees, or equal to 10.84 (nearly eleven) entire circles. The excess of curvature is mostly on radii of less than 1,000 feet, and frequently occurs on the heavy grades.

It will, no doubt, increase the expense of power. The Commissioners are not aware of any definite data by which this question can be reduced to computation. Heavy curving on railroads is regarded to be the next unfavorable thing to heavy grades; and great expenses are often incurred to reduce the curves to large radii, or dispense with them altogether.

Not only is more power required to move the train, but the displacement and wear of rails, and the wear of cars and engines is much greater on sharp curves than on a straight line. On the Nineveh and Susquehanna lines, an allowance of 10 feet per mile, or 15 per cent., was made for the curve lines; whether this is sufficient for the extra power is doubtful. On the Sullivan County lines, no such allowance was made. If it had been, it would have increased the maximum grade in the same proportion. If the same rule be applied to this, it will raise the total cost of extra power to nearly 70 cents per ton.

Regarding the extra wear of rails, cars and engines, this great excess of curvature, though not susceptible of a definite reduction, must be considered as a very serious objection to the interior lines, when viewed only in connection with the freight business.

Its influence on the passenger trade, exposing the cars to leave the track, causing greater wear to the road and machinery, and restricting the speed of traveling is still more serious.

The interior routes will be more obstructed by heavy snows, (especially that in Sullivan County) than the River routes, which will increase the expense of running, and cause delays that will be prejudicial to the business of the road during the winter season.

Heavy grades cause extra wear on the rails, cars and engines, from the more frequent and severe application of the friction brake, to control the latter in their descent. The cars on the heavy grades would not stand still, without being secured, and consequently, any accident by which a car should get loose, would allow it to move off with great velocity, putting at hazard its own safety, and that of others that might be in its way.
Any circumstance that should disable an engine in ascending a heavy grade, such as the slipping of the wheels, or the machinery suddenly getting out of order, would put the whole train at hazard.

On a long line, where the passenger traffic will be important, the excess of heavy grades and curvature on the interior routes, will have a material influence on the economy and usefulness of the road.

The several points of disadvantage that appertain to the interior routes, as above considered, namely: The influence of the great excess of curvature on the freight traffic; together with that of the heavy grades on the passenger traffic; the greater exposure to heavy and drifting snows—extra wear of rails, cars and engines, on the excess of heavy grades and curvature with the greater hazard of accident and consequent damage, are of a character that does not admit of any definite computation.

They are however of such importance, that heavy expense, where a change of route is practicable, may well be incurred to avoid them. That they materially impair the value of a railroad, is beyond question. After careful consideration, the Commissioners have come to the conclusion, that collectively, they will not be less than half the amount before stated, as the excess on the freight traffic caused by the excess of heavy grades.

The total amount of excess chargeable, as before presented, to the interior routes, is:

On freight arising from heavy grades, ........................................... $128,480
On items above enumerated, collectively assumed at 50 per cent.

of the above, ................................................................. 64,240

................................................................. $192,720

From this there must be deducted;

First—The extra cost of constructing and maintaining the Southern line.

Second. The annual tax imposed by the State of Pennsylvania.

In relation to the first, the estimates of the Engineers show the extra costs to be $519,821; to this must be added the interest that will accrue on the expenditure until the road is in operation, and receiving income from its business. This will, of course, depend on the vigor with which the work is prosecuted, and the facility with which its traffic may be advantageously commenced. It is supposed ten per cent., on the whole sum, would provide for all the accruing interest, making the capital invested for this item $571,808. The river routes, more particularly that along the Delaware, from the heavy bridges that must be maintained, and from the exposure of the work to the floods of this river, will be more expensive to keep in
repair than the interior routes. This item is estimated at $15,000 per annum.

The second item, the tax imposed by the State of Pennsylvania, is chargeable when the whole road is completed to Dunkirk, or connected with some road leading to Lake Erie.

This annual bonus will not, therefore, be chargeable until the road is in full operation.

The annual charge will be as follows:

Interest on $571,803 at 6 per cent. .......... $34,308
Annual repairs—excess. ................. 15,000
Bonus to Pennsylvania. .................. 10,000

$59,308

Summary of Excess:

On the interior routes ..................... $192,720
On the river routes ....................... 59,308

$133,412

Showing that the annual expenses on the interior routes will be $133,412 greater than those on the river routes. This result has been reached, after carefully considering and yielding every advantage to the interior routes which can be regarded as belonging to them. The mode of working on which the calculation is based, is the most favorable to them, involving the most careful attention to the economy of motive power; and the Commissioners feel constrained to say, that they have serious doubts whether a more expensive arrangement in relation to motive power, would not, on account of greater simplicity, be found more expedient in practice.

Herewith are submitted a map and profile marked A, of the Nineveh and Susquehanna line; a map and profile marked B, of the Sullivan county and Delaware river line; a profile, marked C, of the several routes from Binghamton to the Shawangunk summit; and a profile, marked D, of the whole line of the New York and Erie Railroad, from Piermont to Dunkirk. These have all been prepared under the directions of the Commissioners, and from surveys, also under their directions, except the general profile, which is from such surveys only on those portions that have come under the examinations of the Commissioners. From these maps and profiles, a good idea of the general features of the several routes may be obtained.
Tabular statements of the results of the surveys by Henry Tracy and James O. Morse, Esqrs., the engineers employed by the Commissioners, are also herewith submitted.

The Commissioners are required to take into consideration "the terms, conditions," &c., of the act of Pennsylvania, authorizing the New York and Erie Railroad Company to construct a portion of their road in that State.

There are several conditions in the act of the Legislature of Pennsylvania that are peculiar, and require the notice of the Commissioners.

First.—The railroad, if constructed along the Delaware river, is required to "be so constructed as not to obstruct the rafting navigation, nor contract the natural flow (and expansion) of the said Delaware river (at high floods), nor injure the works," &c., of the Delaware and Hudson Canal Company; and in relation to the point of crossing the Delaware river. Similar provisions are contained in the act of this State, which constituted this Commission.

On all these points, the engineer employed by the Commissioners was instructed to conduct his surveys and make his estimates with a view to a full compliance with these provisions.

Second.—The third section of the act of Pennsylvania requires certain laws to be passed by the Legislature of this State; it also requires from the New York and Erie Railroad Company, conditions in relation to the conduct of their business, which have been considered matters for said Company to look to, before they could legally locate their road in that State; but not requiring the attention of this Commission.

Third.—The fifth section of said act requires that after the said railroad is completed to Dunkirk, or connects at its western termination with any improvement extending to Lake Erie, said Company shall pay to the State of Pennsylvania ten thousand dollars per annum. This is presumed to be the main condition to which the attention of the Commissioners was called, and they have placed it, as an annual charge, against the routes in that State. It is certainly an onerous and extraordinary burden to be imposed on a Company, for the privilege of constructing a work that in its results must be a great benefit to a large portion of the citizens of that State; but it is a condition, and the Commissioners can do no less than place it to the debit of those routes.

By the act of May, 1846, the Commissioners are directed to take into consideration "a comparison of the grades, or elevations, and depressions
and curvatures, in the line or track of said railroad in the other counties east and west of Sullivan county.”

The Commissioners have no means of judging of the curvatures east and west of Sullivan county, except on the routes surveyed under their directions, which present no curvatures so unfavorable in degree, nor much exceeding half the amount, as compared with equal distances.

There are grades both east and west more unfavorable than occur in Sullivan county, and it was contended by the friends of the interior route in that county that this was sufficient, under the act, to settle the location on that route. Now, (as stated in the preliminary remarks of this report,) it was a matter of public notoriety, before the act was passed, that grades equally heavy as those in Sullivan county existed both east and west of it; but, as this question has been discussed, and the views of the Commissioners given in the preliminary part of this report, it is not deemed necessary to enter into further detail here on this point.

If the heavy grades in this county were so situated, in relation to the heavy grades east and west of it, that no material benefit could be obtained by avoiding them, then the construction of the act above given by the friends of the Sullivan county route would, no doubt, be in accordance with the intention of the Legislature. But, inasmuch as they are so situated that heavy extra expense would be incurred in conducting the traffic of the road over them, such construction would be equivalent to the position that serious obstacles on one part of the line were sufficient reasons that others of the same kind constitute no impediment to the enterprise, which position is considered as inadmissible in view of the general object of the act.

It is well known that the heavy grades which occur on several parts of the route of the New York and Erie Railroad have been great impediments to the progress of that enterprise, and consequently its friends have endeavored to reduce such obstacles as much as possible. The application for the law establishing this Commission had its origin in this effort, and the original law, of which the present is an amendment, had a reference to the same object, namely, to remove some of the impediments (of this character) to the progress of the improvement. The Commissioners are, therefore, fully of the opinion that the construction they have given to the act is the proper one, namely, that “this fact is to be candidly considered, and to have its due influence on their decision, but cannot control, irrespective of all other facts that bear on the question, and especially cannot do away with the main object of the act, which was, to determine whether those grades could be adopted ‘without great prejudice to the public interest,’”

The Commissioners are further required to take into consideration “the several acts of the Legislature of this State in granting aid to the said Com-
pany, and especially the provisions of the act mentioned in the first section of this act."

The act incorporating the New York and Erie Railroad Company was passed in 1832. It authorized the construction of a railroad through the southern tier of counties, and forbids any connection with railroads in the States of Pennsylvania and New Jersey without the consent of the Legislature of this State. Stock sufficient to organize the Company not being obtained, a subsequent act was passed authorizing an organization when one million of dollars was subscribed to the stock. No progress having been made in 1834, the Legislature authorized a survey of the route for said railroad at the expense of the State. In 1835 an act was passed authorizing the Company to construct and put in operation such sections of the road as they might deem eligible.

The powers and privileges granted by the several acts of the Legislature and the prospects of remuneration from the business of the road having failed to command private capital sufficient for the work, "an act to expedite the construction of a railroad from New York to Lake Erie," was passed in 1836. This act authorized a loan of the State credit for three millions of dollars, to be advanced in several sums on the completion of certain sections of the said railroad.

This act did not secure much progress in the construction of the road. Private capital could not be obtained sufficient to complete the "first section" of road necessary to obtain any portion of the loan of the State credit.

In 1838, the Legislature passed an act to amend the act of 1836, above mentioned. This act authorized the loan of the State credit to be made, in equal sums with, and after the expenditure of private subscription, to commence after the Company should expend three hundred thousand dollars. In 1840, an act was passed to amend previous acts, authorizing a six per cent. State Stock to be loaned to the Company, and the Stock to be issued on the expenditure, by the Company, from their own means, of half the amount of the same.

Under this act the Company proceeded with the work until the loan on the credit of the State was issued, to the amount of three millions of dollars, as authorized by the several acts above mentioned.

Failing to command the requisite means to carry forward the enterprise from subscriptions to the stock of the Company, after the State loan was exhausted, they were unable to proceed with the work, and early in 1842, notified the State authorities that they were unable to pay the interest on the State loan. This circumstance authorized the Comptroller of the State to sell the road and its appurtenances after six months notice. The sale was
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postponed by the authority of the Legislature. At this time, the Company were practically insolvent, and had no more than a nominal existence. But the Legislature did not seem disposed to abandon the project, and in 1843, passed a law authorizing the said Railroad Company to issue bonds to the amount of three millions of dollars, and giving these bonds priority to the State lien; also, providing, that the State may take the road on certain conditions, when finished, and if the State should not elect to take the road on such conditions, then, the said Company to be released from all liability for the payment of the State Stock heretofore issued to them, and amounting to three millions of dollars. After the passage of this law, a new Board of Directors were elected, composed of highly intelligent, honorable, and influential citizens, who made vigorous efforts to raise the funds necessary to carry forward and complete the enterprise. Capitalists, however, did not feel sufficient confidence in the success and productiveness of the enterprise to furnish the necessary funds, and the Board who had taken the direction, finding they were not sustained in their efforts, yielded the administration of the affairs of the Company to others. Nothing, however, in the way of progress was accomplished, and the work remained stationary until 1845. At that time, it became obvious that no further progress could be made by private enterprise, unless inducements could be presented that would secure a large addition of subscriptions to the stock of the Company, under which a new organization could be effected, and a new impulse given to the project. This was the condition of the enterprise, when the Act of 1845 was passed—the Act we are called upon particularly to consider.

This Act, passed May 14th, 1845, provided that a new subscription to the Stock of the Company should be obtained to the amount of three millions of dollars, and under certain restrictions, bonds were authorized for a like amount. It provides for a release of the lien of the State on account of the loan of its credit for three millions of dollars, provided, a single track road be completed within six years from the passage of the act. It established a Commission of three persons, who were authorized to survey and examine the routes between the summit of the Shawangunk and Deposit, and decide whether a practicable route did exist, and one that could be adopted "without great prejudice to the public interest;" but did not authorize any location out of the State as a substitute for that through Sullivan county.

The same Commission was authorized to examine the routes between Deposit and a point one mile westerly of Binghamton, with power, under certain circumstances, to locate on the route by the Great Bend of the Sus-
quahanna, passing so far in the State of Pennsylvania as might be necessary for that route.

At the time this act was passed an act had been passed by the State of Pennsylvania, authorizing the said Company to construct a portion of their road in that State, so far as necessary to occupy the route by the Great Bend of the Susquehanna; but they had not authorized the Company to occupy any portion of that State in the valley of the Delaware river.

To induce the subscription of three millions, and thereby secure the completion of the railroad, the Legislature of 1845, by the act above mentioned, prospectively gave up the lien of the State for the three million loan on the conditions above mentioned. They authorized, under certain restrictions, the railroad to pass through a portion of Pennsylvania, and thereby secure a more favorable line; also to consolidate the old Stock.

Under this act the company and its friends undertook to revive the affairs of the enterprise. The first proceeding was to obtain the subscription of three millions of dollars to the stock of the company; without this nothing could be done. The steps taken to procure it showed that many persons were more ready to advocate the project than to furnish funds to carry it forward; and (notwithstanding that the State prospectively released its lien on the road, the old stockholders submitting to a loss of half their stock, having the prospect of being allowed an improved route for an unfavorable portion of the line) they did not succeed in accomplishing this preliminary step without great efforts, continued for months together; and their final success may be attributed far more to the general influence the road was expected to produce in the trade of New York than to the dividends that would be made from its earnings.

The Commissioners can regard the law of 1845 in no other light than as emanating from a desire on the part of the Legislature to offer such further inducements to private capital as would be sufficient to secure the early accomplishment of this great improvement, and thereby afford to a large district of the State, now very much secluded, the means of easy communication to and from our great commercial centre. Subsequent events have proved that the inducements offered were barely sufficient to obtain the requisite subscription upon which the new organization has been established. To show the slender hold the new subscription had on the stockholders, it is only necessary to mention that before, and at the time the decision of the Commissioners was made on the question of location, shares of stock, on which twenty dollars had been paid, could be purchased in the market for two dollars. In this state of the affairs of the company, they were not in a condition to encounter difficulties, which they
regarded as onerous and unnecessary, and from which they had indulged the hope of being relieved.

The Commissioners cannot say the work would have been abandoned if their decision had confined the line to this State; but under the circumstances that existed, they were of the opinion that such a decision would have put in jeopardy the progress of the enterprise.

It was clearly the intention of the Legislature to confine the route to this State, unless it should be found there were urgent considerations for carrying some portion of it through Pennsylvania, and the commissioners were, without exception, extremely desirous of confining the location to this State. It was an unpleasant duty to carry the line into another State, that demanded compensation for the benefits that would be conferred on her citizens, while a portion of our own, that had contributed their exertions to secure its benefits, were thus deprived wholly, or in part, of the anticipated advantages. The law, however, under which this commission was established, contemplated the contingency of such decision. It was doubtless framed in view of the necessity that might be found to exist to abridge the benefits to a comparatively small number, in order to make it more beneficial to the public, and to secure the accomplishment of a great work, that would confer its benefits on a large portion of the population of this State.

To illustrate the views of the Commissioners as to the influence the extra cost of conducting the traffic will have on the prosperity of the project, they remark:

First.—It cannot be expected that an enterprise of this magnitude will be undertaken by private capital, without a fair prospect of reasonable remuneration for the outlay required.

Second.—If the road be constructed in such a manner as to involve large expenses in conducting a given traffic, such expenses must be charged to those interested in the traffic, and, consequently, the value of the improvement to the community, who use it, depends on the economy with which its business may be conducted.

Third.—Whatever tends to increase the cost of conducting the traffic of a road, reduces its power of competing with other roads, or other modes of conveyance, and, consequently, diminishes its prospects of business, and the inducements to prosecute the enterprise.

Fourth.—The facts and computations before presented, show that the interior routes would involve, annually, a heavy extra expense; materially
affecting the prospects of the enterprise, and, consequently, hazard its success.

The legislation of this State is a full demonstration of the difficulty that has attended every effort to obtain from private sources the funds necessary to carry forward this work, and the necessity of relieving it from every natural impediment, in order to accomplish the main object for which it has been undertaken: and although, in the origin of the enterprise, the Legislature was disposed to confine the line strictly to this State, in the progress of the undertaking, subsequent Legislatures have found it expedient, in order to secure to a large portion of the State its benefits, to recognize the possible necessity of some departure from the original design; and hence the establishment of this commission to ascertain the facts, and make such decision as the exigencies of the case should require.

That the river routes, when contrasted with the interior, routes, have the decided advantage, cannot admit of a doubt; and with that fact established, the only remaining question which presented itself, was, whether the Commissioners were authorized by the act, to sanction those routes.

The Commissioners were required to adopt the interior routes provided it can be done "without great prejudice to the public interest," &c. In arriving at this conclusion, they are required to consider, First,—"The public interest of this State." The public interest is doubtless promoted by the adoption of the route that will be most likely to secure the early construction of the railroad, and render the improvement most beneficial when completed. From the considerations and comparisons presented in the preceding pages, the Commissioners believe the interior routes, if adopted, would be greatly prejudicial "to the public interest of this State." Second.—"The interest of the citizens of this State, who in their (the Commissioners) judgment will be affected by the construction and location of said railroad, collectively considered." In examining this branch of the question, the Commissioners do not propose to notice remote interests.

There is no doubt a considerable number of citizens of this State that will be affected by the road, beyond the limits that are considered as specifically demanding consideration; but as these will have about the same relative bearing on the question, with those more directly interested, it is not considered necessary to refer more particularly to them.

It can hardly be said that any portion of the citizens of the Southern tier of counties, will be injured by the construction of the railroad on either route. Some portion will be less benefitted by the adoption of one route than by the adoption of the other; and comparatively a very small
number on either route may not be benefitted at all, except the road be constructed on the particular route in which they may be interested. The latter can only be those, who are so situated, that they would only use the road in the event of its being constructed in the route nearest to them.

The great mass of the citizens in the Southern tier of counties must be benefitted by the construction of the road on either of the proposed routes, and consequently are interested in such measures as will secure its early completion.

The total number of citizens residing on the routes affected by the question of location, or so near, that their trade after the construction of the railroad, would seek it as their avenue to markets, is estimated by the census of 1845 at 294,599. Of this number, 45,592 will be less benefitted by the adoption of the river routes, than by the adoption of the interior routes; and 249,007 will be more benefitted by the adoption of the river routes, than by the adoption of the interior routes; or the ratio is nearly as 16 is to 84. Of those who will be less benefitted by the adoption of the river routes, about 72 per cent. will have the benefit of the river route on the Delaware, which will be common to them with citizens west of Binghamton, and will materially lessen their dimunition of benefits. The amount of dimunition of benefits, compared with equal diminiution, appears on the average to be about the same, whichever route be adopted.

There is another portion of the citizens of this State who are directly interested in this question of location, namely, those resident in the city of New York.

This city has an interest in enlarging and securing the trade of the district that will be affected by the construction of the railroad, and it looks not only to that portion in this State, but also to that which will come from the northern part of Pennsylvania, (numbering about 100,000 people, by the census of 1840,) and from Lake Erie. The citizens of New York city cannot be overlooked in considering this question; they are a portion of this State, and have an equal right to be considered under the act, so far as their interests are involved; they are chargeable in all cases of State tax, in which they contribute about one-third of the total amount collected by the State. That their interest is peculiarly important in this enterprise is manifest from the fact that almost the entire reliance, so far as individual means are required, must depend on them. Whatever risk of private capital the undertaking involves, it must fall on them. The road may be a great benefit to the district through which it may be constructed, and yet afford a very inadequate return to the private capital invested in its construction. A due regard to this interest is not only important and proper in itself, but also as affecting the entire success of the project, as may be inferred from remarks
in a preceding part of this report. The interest of the city of New York, whether regard be had to the benefit its trade will derive from the operation of the railroad, or the remuneration the traffic will afford for the capital invested in its construction, will be best promoted by the adoption of those routes that will secure the best and most expeditious means of communication. This city, therefore, will be most benefitted by the adoption of the river routes.

The adoption of the river routes greatly improves the general prospects of the railroad, and presents very fair prospects for its early completion. The adoption of the interior routes would materially diminish its usefulness and value if constructed, and moreover, by the discouragement it would throw on the stockholders, would hazard the success of the enterprise. The latter remark cannot be regarded as unimportant when it is considered that the new stock of the Company can now be purchased in the market at 20 per cent. discount, though only 25 per cent. has yet been paid in.

In view of the facts that have been presented, and the reasoning based on those facts, after careful deliberation, in full board, a majority of the Commissioners decided that the interior routes through Sullivan and Broome counties could not be adopted for that portion of the said railroad "without great prejudice to the public interest of this State, and the interest of the citizens of this State, who, in their judgment, will be affected by the construction and location of said railroad, collectively considered." And in accordance with the requirements of the act, they have filed such decision in the office of the Secretary of this State.

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