STEAM ON THE CANALS.

SECOND ANNUAL

Report of the Commission

With Compliments of

DAVID M. GREENE.

TRANSMITTED TO THE LEGISLATURE FEBRUARY 25, 1873.

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1873.

STATE OF NEW YORK.

COMMISSION APPOINTED BY CHAPTER 868, LAWS OF 1871.

GEORGE B. McCLELLAN.
DAVID DOWS.
VAN R. RICHMOND.
GEORGE W. CHAPMAN.
JOHN D. FAY.
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GEORGE GEDDES.
WILLIS S. NELSON.
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VAN R. RICHMOND, CHAIRMAN.

DAVID M. GREENE, ENGINEER, TROY, N. Y.
HENRY A. PETRIE, SECRETARY, ALBANY, N. Y.

STATE OF NEW YORK.

No. 71.

IN SENATE,

February 25, 1873.

REPORT

OF THE COMMISSION APPOINTED BY CHAPTER 868, LAWS OF 1871, ENTITLED "AN ACT TO FOSTER AND DEVELOP THE INTERNAL COMMERCE OF THE STATE BY INVITING AND REWARDING THE PRACTICAL AND PROFITABLE INTRODUCTION UPON THE CANALS, OF STEAM, CALORIC, ELECTRICITY, OR ANY MOTOR OTHER THAN ANIMAL POWER, FOR THE PROPULSION OF BOATS," FOR THE YEAR 1872.

ALBANY, *February 24th*, 1873.

Hon. JOHN C. ROBINSON,

President of the Senate:

SIR.—I have the honor to transmit herewith the report of the Commission appointed by chapter 868, Laws of 1871, entitled "An act to foster and develop the internal commerce of the State by inviting and rewarding the practical and profitable introduction upon the canals, of steam, caloric, electricity, or any motor other than animal power, for the propulsion of boats," for the year 1872.

Yours, very respectfully,

VAN R. RICHMOND,

Chairman.

REPORT

ALBANY, *February* 20, 1873.

To the Legislature of the State of New York:

The Commission appointed by chapter 868, Laws of 1871, entitled "An act to foster and develop the internal commerce of the State, by inviting and rewarding the practical and profitable introduction upon the canals, of steam, caloric, electricity, or any motor other than animal power for the propulsion of boats," submit for the consideration of the Legislature the following

REPORT

Of the action of said Commission during the period that has elapsed since the date of their last report, together with a full account of all the experiments providing for the introduction of steam or any motor other than animal power for the propulsion of boats, made during the season of 1872, that have come to their knowledge and the conclusions to which they have arrived, from their investigation of the subject-matter committed to them.

At the first meeting of the Commission, held in 1871, the following resolutions were adopted:

Resolved, That for the purpose of carrying out the intent of the law, this Commission will require, among the tests to be made, that the several competitors shall make not less than three round trips, from New York and Buffalo or Oswego; each boat to be loaded with not less than 200 tons of cargo each way; the trips to be commenced as soon as any party is ready, and all completed in the least practicable time. For the purpose of determining the time consumed by each and all the trips, the clearance must show the day of the month and time of day that the boat passes each collector's office; certified copies thereof to be furnished to the Commission. In order to obtain information in regard to the practical working of the several devices in competition, as soon as practicable, the engineer of the Commission, Mr. David M. Greene, of Troy, will inspect the same from time to time, as in his judgment may be necessary, and report the facts obtained to this Commission.

Resolved, That competitors are hereby notified that for the purpose of carrying out the intent of the law, though it is desirable that the

three consecutive round trips from Buffalo or Oswego to New York be made at the earliest time practicable, the whole of the year 1872 will be allowed to such persons as may desire so much time, and the awards will not be made until the close of navigation in that year.

At a meeting of the Commission held at Albany on the 7th day of August, 1872, the foregoing resolutions were modified by the passage of the following resolution:

Resolved, That boats making the three round trips from Buffalo or Oswego to the Hudson river and return, as heretofore required by this Commission for the purpose of determining the rate of speed of said boats, will not be required to continue the trips to New York city, nor to carry more than 100 tons of cargo going west, and that deductions from the time consumed in navigating the canals will be made for passing the locks, equal to twenty hours for each round trip from Buffalo, and proportional allowance will be made if the trial is from Oswego. In case of delays growing out of obstructions to navigation, that are caused by breaks in the canals or injuries to the structures, or sunken boats, such as detain boats drawn by horses, the time lost will also be allowed for in computing speed.

At a meeting of the Commission held at Syracuse on the 1st day of October, 1872, the following resolution was adopted:

Resolved, That Commissioners Geddes and Chapman, together with the engineer, Mr. Greene, are requested to make a personal examination of the canals of New Jersey and Pennsylvania, or any other large canal, where steam is in use for the propulsion of boats, and to procure for the information of this Commission such facts as may bear upon the subject-matter intrusted to it by the Legislature.

The committee so appointed performed the duty assigned them, and have made a report of their observations and the information obtained, which is hereunto annexed. Attention is invited to this report, as giving much information in regard to the most important canals in the States visited, and to the whole subject of steam navigation.

The Delaware and Raritan canal, as it appears from this report of the committee, has a width of water surface of eighty feet, and an average depth of nine feet, except over some culverts where it is only eight feet four inches deep. The locks are 220 feet long and twenty-four feet wide.

These dimensions admit of the use of vessels that will carry 600 tons of cargo, and at various times larger boats have been constructed and used on this canal, but the committee were informed by John S. Hillis, Esq., of Philadelphia, formerly superintendent of this canal, that the result of his experience was, that a boat 110 feet long and twenty-three feet wide was as large as could be used with the greatest

economy. Boats of 140 feet in length and carrying 500 tons have been tried; but on account of the extra expense of crew to meet the increased difficulty of management, were not found to be economical.

The committee say that "the largest horse-boats plying upon this canal can carry 450 tons; but the average cargo that they do carry is about 210 tons."

These facts in regard to the best manner of using the Delaware and Raritan canal have an important bearing upon the feasibility and necessity of lengthening the locks of the Erie canal to 150 or 200 feet. While the locks on the Delaware and Raritan canal allow the use of boats of 600 tons carrying capacity, the boats on that canal do not in fact average as many tons cargo as the boats navigating the Erie canal.

With locks 220 feet in length and twenty-four feet in width, those best informed on the subject advise that boats should be built 110 feet in length and twenty-three feet wide, thus showing that greater width rather than greater length, is the form that boats would take upon the canals of this State, if the locks were enlarged and the prism of the canal widened.

It follows, therefore, that nothing would be gained by materially lengthening the locks, unless they were doubled in length, so as to allow two boats to be locked at once.

This Commission has received a full and able report from David M. Greene, Esq., civil engineer, appointed by this board, of all the trial trips of the several steamboats that have thus far competed for the prize, and, in addition thereto, he has given a very full statement of the facts relating to the navigation of the canals of Great Britain and the continent by the use of steam power. This report also embraces a large mass of important facts bearing upon the question of steam on the canals.

The Commission herewith submit Mr. Greene's report in the confident expectation that the information contained in it will be of great public interest, and may materially aid competitors in their future efforts to solve the problem that has so long engaged the attention of persons interested in the use and prosperity of our canals.

When this Commission entered upon the duties assigned it by the Legislature, its members were aware of the importance of the questions involved and the work to be done. They, therefore, adopted the resolutions hereinbefore recited, for the purpose of establishing a plan of preliminary trials of the several devices that might come before the Commission for consideration, which would practically test

their merits in many respects, and justify the Commission in undertaking still more critical and thorough trials before coming to a final decision.

Doubtless the plan of operations adopted by the Commission was a disappointment to all parties who supposed that the award would be made upon theories, models or plans, or at most upon a trial between competing boats, for a few days, under the most favorable circumstances.

But the Commission were of the opinion that the question was one involving many elements and demanding a practical solution. Before any award can be made the law provides "that the Commissioners shall be fully satisfied that the invention or device will lessen the cost of canal transportation and increase the capacity of the canals."

This offer made by the State has attracted great attention throughout the country, and has greatly stimulated invention. Many devices have been projected, and large sums of money have been expended in the construction of boats and machinery to compete for the award.

It will be seen by the engineer's report that a number of boats have actually entered for the contest, and that a portion of them have accomplished very gratifying results, which seem to indicate that great progress has been and can be made toward solving the problem of cheap steam navigation.

The talent, industry and enterprise already shown in the direction of cheaper transportation of freights, will prove of great value as well as a source of just pride to the people of this State.

But the report of the engineer will show that the boats that have made the best records did not finish the preliminary trial trips required until the month of November, near the close of navigation, which terminated the 28th of November, leaving no time or opportunity for the further tests and trials under the personal supervision of the commissioners, which were considered absolutely necessary to justify a decision.

Thus it appears that the time allowed by the law to practically test and examine the inventions or devices offered, has not been sufficient to enable the Commission to complete the duty prescribed, by coming to a final decision upon the matters before them. In accordance with these views the Commission, at a meeting at Albany, held on the 18th of February, 1873, adopted the following preamble and resolution:

Whereas, The preliminary trial trips, required by this Commission, of the several boats competing for the prize of $100,000 offered by

the State of New York, in chapter 868, Laws of 1871, were not completed in time, before the close of navigation in the year 1872, to allow such further tests and examinations as are necessary to enable the Commission to determine whether one or more boats had complied with the conditions of the offer made by said law, therefore be it

Resolved, That the Commission do not make any award or grant any certificates upon the facts and information now before said Commission.

Many of the competitors are anxious for more time to be given them, and the Commission is strongly urged by them, and others interested in the matters involved, to recommend to the Legislature that the rewards offered be continued, and that further time be given by the State for the examination and decision of the claims presented under the law.

In the opinion of this Commission, the conclusions arrived at by the engineer in his report, herewith submitted, not only justify further investigation, but present strong reasons why the State should not now abandon the effort to make steam the principal power used on our canals.

This Commission would, therefore, recommend that the reward offered by chapter 868, Laws of 1871, be continued, under such form or Commission as the Legislature may deem proper, and in case it is so continued, that an appropriation be made, sufficient to defray the probable cost of time and expenses necessarily incurred in discharging the duties prescribed.

Respectfully submitted.

VAN R. RICHMOND,	GEORGE W CHAPMAN,
DAVID DOWS,	WILLIAM W. WRIGHT,
GEORGE GEDDES,	JOHN D. FAY,
WILLIS S. NELSON,	DANIEL CROUSE,

Commissioners appointed by chapter 868, *Laws of* 1871.

REPORT OF COMMITTEE

APPOINTED TO

MAKE PERSONAL EXAMINATION OF THE CANALS OF NEW JERSEY, DELAWARE, PENNSYLVANIA, VIRGINIA AND NORTH CAROLINA, WHERE STEAM IS IN USE FOR THE PROPULSION OF BOATS.

HON. VAN R. RICHMOND, *Chairman.*

SIR.—The committee, which was appointed at the meeting of the Commission, held October 1st, at Syracuse, and directed to make personal observations upon several of the canals of New Jersey, Delaware, Pennsylvania, Virginia and North Carolina, for the purpose of ascertaining to what extent steam has been and is being used, together with the economy and efficiency of the same, having performed the duty assigned them, present the following

REPORT:

The committee left Albany on the 17th of October and returned on the 1st of November, having spent about two weeks in making the examinations and investigations directed to be made by the Commission.

The observations of the committee extended to the following named canals:

Delaware and Raritan, of New Jersey; Chesapeake and Delamare, of Delaware; Pennsylvania canal, of Pennsylvania; Schuylkill Navigation, of Pennsylvania; Chesapeake and Ohio, of Virginia; Albemarle and Chesapeake, of Virginia and North Carolina.

These will be reported upon, in the order in which they are named.

THE DELAWARE AND RARITAN.

This canal, which forms a part of an interior line from New York to Philadelphia, extends from the city of New Brunswick on the Raritan river, to Bordentown on the Delaware, a distance of forty-

four miles. The distance from New York to Philadelphia, by this route, is one hundred and twelve miles, and is made up as follows:

New York to New Brunswick	40 miles.
New Brunswick to the Delaware river	44 "
Bordentown to Philadelphia	28 "
Total	112 miles.

The actual distance run is, however, about 120 miles.

This canal is eighty feet wide at the water surface, thirty-eight feet wide at a depth of six and a half feet, and has an average depth of nine feet, except on several culverts, where the depth is only eight feet four inches. The locks are fourteen in number, including a double outlet lock at New Brunswick, and are two hundred and twenty feet long by twenty-four feet wide.

There are six lines of steamers plying regularly between New York and Philadelphia, and passing through this canal. The dimensions and capacities of the largest of these steamers are as follows:

Length.	Beam.	Depth.	Custom-house measurement.	Real tonnage.
153 feet...	22 feet, 9 inches.....	8 feet.....	341 tons	375,000 lbs.
175 feet....	23 feet.....	8 feet, 3 inches.....	353 tons	430,000 lbs.
149 feet....	23 feet.....	7 feet.....	287 tons	400,000 lbs.
155 feet....	23 feet.....	8 feet.....	393 tons	400,000 lbs.

To the above is to be added 100,000 pounds for machinery and coal.

In open water these boats can make thirteen miles per hour; but, in the canal, they are limited to four and a half miles per hour, and will pass through the forty-four miles of canal and the thirteen locks in fifteen hours; making an average speed through the canal, including lockages, of three miles per hour. This limit imposed upon the speed, we were informed, was removed last spring. We were also informed by gentlemen engaged in the transportation of freight over this line, that the speed now varies from four miles on the canal proper, to five miles on the pools or wider parts of the canal. These speeds do not, so far as we could learn, injure the canal or its structures.

There are also smaller steamers navigating this canal and carrying about 120 tons. Among these are five steamers, which were orginally built for service on the Erie canal and Hudson river, by the Rome, Watertown and Ogdensburgh Railroad Company, in 1861. These steamers are ninty-seven feet long and seventeen feet beam. Their

limited carrying capacity is due to their model, which is that of the ordinary river and lake propellers.

All of these steamers are driven by the ordinary single screw. The smaller ones make the round trip in about fifty hours—the entire distance run being about 240 miles, on a coal consumption of five tons. The larger steamers burn about seven and a half tons, and all of them occasionally make a single trip in twenty to twenty-one hours. The crews comprise a captain, mate, two engineers and two men.

A large steamer carrying 200 tons, consuming seven and a half tons of coal during the round trip, and making a single trip in twenty-three to twenty-seven hours, will, with an additional consumption of three tons of coal, tow a barge carrying 300 tons. In this case, however, the time of a single trip is increased to from twenty-seven to thirty-three hours, three hours of the additional time being consumed in locking. The time consumed in locking the single steamer is one and a half hours; that consumed in locking the steamer and barge is four and a half hours. These facts, obtained from an intelligent gentleman of large experience in connection with this canal, have an important bearing upon the question of the economy of towing a number of boats at the same time, by a single steamer or tug.

The largest horse-boats plying upon this canal can carry 450 tons; but the average actual cargo is about 210 tons. They are 144½ feet long, twenty-two and eight-tenths feet wide and eight feet deep.

There are a number of barges carrying 320 tons of coal; and one which carries 430 tons. These boats, loaded, and carrying from 200 to 350 tons, are towed at an average speed of two miles per hour. When light, the speed between locks is about three miles per hour. The charge for towing, in the case of horse-boats, is three and three-tenths mills per ton per mile, and the cost of maintaining, manning and equipping the mules is one dollar per day, per head. Boats carrying under 250 tons are towed by four mules; those carrying over 250 tons, by eight mules.

If we take a boat carrying 200 tons, towed by four mules, at an average speed of two miles per hour between locks, it may be assumed that the entire length of the canal will, as an average, be made in twenty-four hours. The charge for towing will be $3\frac{3}{10} \times 200 \times 44 =$ $29.04, or sixty-six cents per mile. If the animals be worked half the time, the *cost* of towing this boat will be cost of eight mules, with their drivers, for one day, or eight dollars. The cost per ton per mile will therefore be $\frac{8000}{200 \times 44} = \frac{9}{10}$ of a mill.

The precise cost of the movement of freight by steam on this canal cannot be estimated, as none of the steamers are confined to the canal. However, gentlemen abundantly qualified to judge give it, as their opinion, that the relative economy of steam and animal power is at least as two to one.

The committee are indebted to Mr. John S. Hillis, of the firm of W P. Clyde & Co., of Philadelphia, formerly superintendent of the Raritan and Delaware canal, and to Mr. C. B. Rossell, the present superintendent, for most of the foregoing information. The first named gentleman stated, as the result of his experience, that the most economical boat or barge for this canal is 110 feet long by twenty-three feet three inches wide, carrying 300 tons. Boats 140 feet long and carrying 500 tons have been tried; but, on account of extra expense of crew to meet the increased difficulty of management, were not found to be economical.

CHESAPEAKE AND DELAWARE CANAL.

This canal extends from Delaware city, on the Delaware river, to Chesapeake city, on the Chesapeake bay, a distance of thirteen and one-half miles. There are three locks; two at the termini, and one, of twenty feet lift, at St. George's, four miles from Delaware city. These locks are 220 feet long and twenty-four feet wide.

The northern level consists of three miles of canal proper, and one mile of pool; while on the southern level there are six and one-half miles of canal and three miles of pool. The canal proper is nine feet deep and about ninety feet wide, except through the deep cut, where, for about three miles, it is only sixty feet wide. Along the pools the width varies from that of the canal to 250 or 300 feet.

Steamers, carrying both passengers and freight, plying between New York and Baltimore, and between Philadelphia and Baltimore, pass through this canal. Towing is performed by both steam and animal power, and is in the hands of Messrs. G. F. Brady & Co., who own three steam tugs and the requisite number of mules. Steam has been in use for towing for about nineteen years, and is found to be more economical than animal power. The latter is, however, found to be convenient, if not necessary, as an auxiliary, especially in assisting at the locks.

The tugs are driven by single upright cylinders, 18x18 and 17x17, which are rated at forty-five horse power, and are able to tow a train of six boats, each carrying 250 tons of cargo, making an aggregate of 1,500 tons. The average speed attained is two miles per hour, though

a speed of two and one-half miles is maintained between locks. Teams are employed to assist the boats in their passage through the locks, and the time expended in locking a train of six boats and the tug is an hour and a half, or about thirteen minutes per boat. The coal consumption of the tugs varies from two to three tons in twenty-four hours, depending upon the service. The crew consists of six men, and the average daily running expense is estimated by Mr. Brady at twenty dollars per tug, exclusive of interest upon investment and maintenance of boats.

The charge for steam towing, for boats about the size of our Erie canal boats, is eleven dollars per trip, which includes the towing of the empty boats on the return trip. The charge per boat per mile is therefore $\frac{1100}{13.5}=81\frac{1}{2}$ cents, including the return of the light boat, while the charge per ton per mile amounts to $\frac{11000}{1500}=7\frac{3}{10}$ mills. Were the boats loaded both ways, the charge would not differ much from five mills per ton per mile.

The *cost* of this movement per ton per mile may be estimated approximately as follows: Taking the cost of the tug at $16,000, its lifetime at fifteen years, and assuming the season of navigation to be 300 days, the daily cost for maintenance and interest may be put at $7 47
Coal, oil and waste 13 53
Wages of crew 9 00
Board of crew 3 00

Total $33 00

The full daily duty of a tug and its crew may be put at two round trips, equivalent to the movement of 3,000 tons thirteen and one-half miles, and the return of the empty boats. The cost per ton per mile of such movement will therefore be $\frac{33000}{3000\times 13\frac{1}{2}}=0.815$ of a mill.

This estimate assumes, of course, that the tugs are continually worked to their full capacity. In fact, they are not worked to full capacity, and for that reason the daily expense, except for coal, being a constant quantity, the actual cost of movement, under the conditions which obtain on this canal, must be somewhat greater.

Boats of 210 tons, towed by three mules or horses, make about two miles per hour, and make the trip in about seven hours. The charge for this service is $5.25 for a single team of three mules, or $7.25 for a double team of six mules. The empty boats returning within thirty

days are towed without charge. The charge, therefore, per ton per mile, for mule towing, with a single team, is $\frac{5250}{210 \times 13\frac{1}{2}} = 1.85$ mills and for a double team $\frac{7250}{210 \times 13\frac{1}{2}} = 2.56$ mills.

The cost of this movement can only be estimated approximately. It is no doubt entirely fair to put the daily duty of a team of three mules at a single round trip, or the movement of 210 tons thirteen and one-half miles, and the return of the empty boats, and the daily cost at three dollars, or one dollar per day per mule. The daily duty of a double team may be put at one and one-half round trips, or 315 tons moved thirteen and one-half miles, at a cost of six dollars. Upon these assumptions the cost per ton per mile will be:

$$\text{For single team, } \frac{3000}{210 \times 13\frac{1}{2}} = 1.05 \text{ mills.}$$

$$\text{For double team, } \frac{6000}{315 \times 13\frac{1}{2}} = 1.41 \text{ mills.}$$

The duty of a double team has obviously been over estimated, as, other things being equal, the cost will vary as the square of the speed.

It is to be remembered that, in these estimates, we have been considering merely the question of *towing*, and that the total cost of transporting freight, made up as it is of this, together with other elements, must be quite a different matter.

Our estimate indicates that steam towing on this canal is $\frac{1.05 - 0.815}{1.05} \times 100 = 22$ per cent cheaper than animal towing. Mr. Brady gives it as his opinion that steam is *one-third* cheaper than animal power. The measure of economy will, of course, differ under different conditions.

No effort is made to estimate the total cost of freight movement, under the actual conditions of traffic, upon this canal. Forming, as it does, part of a route made up very largely of river and bay navigation, over which the business is of a mixed and variable character, it would be very difficult to arrive even at an approximation to the cost over the entire route, and still more difficult to estimate the cost over the canal alone.

An opportunity having been afforded here, through the courtesy of Mr. Brady, who placed a tug at our disposal, experiments were made for the purpose of ascertaining the effects of different speeds upon the water. The tug, which was of large size, drew about seven

feet of water. It was run about thirty-five feet from the towing path, so that, upon one side, the conditions would be nearly the same as in the case of a boat moving at the same rate of speed on the Erie canal. Mile posts upon the towing path served to indicate the speed.

The boat was first run at a speed of five miles per hour. The disturbance of the water, caused by a strong north-east wind which was blowing at the time, was not sensibly increased by the passage of the boat.

The speed was next increased to six miles per hour. At this speed the water along the towing path rose and fell about five inches, without, however, being attended by any violent action or wash.

Finally, the speed was increased to seven and one-fourth miles, when a wave or swell twenty inches high was formed, rising nearly to the top of the bank.

These results indicate that, upon this canal, the proper limit of speed is about six miles per hour. This speed is found to be necessary during the passage of boats or tows exposing a large surface to the action of a strong wind blowing athwart the canal. During the prevalence of such winds, boats running light, or having extensive upper works, are found to be unmanageable at a lower rate of speed.

PENNSYLVANIA CANALS.

The main line of the Pennsylvania Canal Company's canals extends from Havre-de-Grace to Wilkesbarre, a distance of 196 miles. The old canal was forty feet wide at the water line, twenty-eight feet wide at the bottom and four feet deep. The locks are thirty-six in number, and are seventeen feet by ninety feet.

This line is being gradually enlarged to a width of fifty-five feet on top, thirty-four feet at the bottom, and to a depth of six feet three inches. The enlarged locks are seventeen feet wide by 182 feet long, and are provided with a pair of gates midway between the end gates. The object of this last arrangement is to provide for locking two boats at a time whenever occasion requires, and to avoid an unnecessary expenditure of water when a single boat is locked.

Wiconisco Branch—Extends from Clark's Ferry dam to Millersport, twelve miles; surface width forty feet; bottom, twenty-eight feet; depth, four and a half feet; locks, six in number, seventeen by ninety feet. This branch leads directly to the coal fields.

Juniata—One hundred and twenty-seven miles long; width at surface of water, thirty-eight feet; at bottom, twenty-eight feet;

depth, four feet; locks, six in number, seventeen feet by ninety feet.

West Branch of the Susquehanna—Extends from Northumberland to Queen's Run, a distance of seventy-three miles; width at surface of water, forty feet; at bottom, twenty-eight feet; locks, twenty-six in number, seventeen feet by ninety feet.

Steam has been in use on these canals since 1861, in which year a steamer was built to transport materials to be used upon repairs and in the enlargement. This steamer carries seventy-five tons, and tows a barge carrying ninety-five tons, making a speed of two and a half miles per hour on the canal. The machinery of this boat consists of two upright cylinders, ten by twelve, driving each a screw of three feet diameter and about six feet pitch. The boiler has fourteen square feet of grate, and the coal consumption is from three-quarters of a ton to one ton in twelve hours. The boat has been in constant use ever since it was built, and is thought, by the canal officers, to possess decided advantage over horse-boats for its purpose.

A second steamer, called the "New Era," was built in 1864, and has continued to run until the past season, 1872. The "New Era" is eighty-four feet long, fifteen feet four inches wide, and carries eighty tons, besides towing a barge carrying 110 tons, at a speed of two and a half miles per hour. She has two cylinders, ten by fifteen, and two screws of four feet diameter and eight feet pitch. Five or six men are required to man the steamer and barge. From July, 1865, to the close of November of the same year, the net earnings of the "New Era" amounted to $900. There were no return freights. From 1864 to 1869, the annual net earnings of this steamer ranged from $600 to $1,200.

Both these boats are owned and run by the Canal Company, and an accurate account has been kept with each.

On the Juniata canal a steamer has been running for six years, and is represented by her owner to be a profitable boat. She is eighty-four feet long, fourteen feet wide, carries sixty tons, and tows a barge carrying seventy-five tons at a speed of two and a half to three miles per hour. This boat has a single engine, with cylinder fourteen by fifteen, and a screw of five feet diameter. Grate surface about fourteen square feet.

The steamer "A. G. Nichols" is eighty-four feet long, fifteen feet and four inches wide, carries eighty tons, and tows a barge carrying 100 tons, at a speed of three miles per hour. This average speed is that over 175 miles of canal and sixty miles of bay and river navigation,

including thirty-five locks. Her machinery consists of two vertical engines, having cylinders eight by twelve, which drive two screws three and a half feet diameter.

The steamer "Admiral," built in 1868, was supplied with a single engine sixteen by sixteen, and a screw five feet in diameter. The boiler has fourteen square feet of grate and consumes three-quarters of a ton of coal in twelve hours when towing a barge. The net earnings of the "Admiral," for a single season, have reached $1,800. No return freights.

None of these boats disturb or injure the banks of the canal.

Messrs. Thomas F. Wierman, Chief Engineer, and A. J. Whitney, principal assistant, to whose courtesy we are indebted for the foregoing information, expressed the opinion that all these steamers would be found to be permanently profitable if cargoes could be secured for them and competent men found to run them. It was found impracticable to procure information more in detail than that which Messrs. Wierman and Whitney furnished us. Indeed, it was scarcely necessary, as the information obtained covers all the vital questions involved. For example, we have learned that, on the narrow and shallow canals of Pennsylvania, at a moderate expense, and with the ordinary means, steamers have attained the speed we require upon the Erie canal while carrying and towing a paying cargo. The details of the machinery by which this has been and is done are of minor importance.

SCHUYLKILL NAVIGATION.

This line follows the Schuylkill river from Philadelphia to Port Carbon, a distance of about 102 miles. One-half the distance is canal proper, and one-half river-pools. In the canal the width is sixty feet at the water surface, and the depth six and one-half feet. In the pools the width is in some places 300 feet. The bottom width of the canal is from forty to forty-five feet. The locks are fifty-eight in number, and are 110 feet long by eighteen feet wide. Boats draw five feet three inches of water and carry 180 to 190 tons.

Towing is done by mules, and the time required to tow a loaded boat down, over 102 miles, is about three days. This indicates an average speed of 1.41 miles per hour, or about the speed habitually made by horse-boats on the Erie canal.

To accomplish this movement of 190 tons 102 miles, six mules are required for three days, at a cost of eighteen dollars. The cost per boat per mile is, therefore $\frac{1800}{102}$=18 cents, and the cost per ton per

mile $=\frac{18000}{19290}=0.93$ of a mill. In consequence of the boats having to be towed up—for the greater part—empty, the actual cost of towing must be considerably greater.

Steam has never been used on this line, except in a single instance, where a tug was employed in towing upon the principal pools. This canal is now leased by the Philadelphia and Reading R. R. Co., and the early introduction of steam is contemplated by that corporation.

CHESAPEAKE AND OHIO CANAL.

The committee visited this canal at Georgetown, D. C., but were unable to learn that steam has ever been used, except upon small passenger boats plying between Georgetown and Point of Rocks (?) a distance of about forty miles. These steamers are limited to a speed of four miles per hour; but they sometimes make six miles. This canal is of about the same width and depth as the canals of Pennsylvania. No information was gathered as to the cost of freight movement on this canal.

ALBEMARLE AND CHESAPEAKE CANAL.

This canal is part of an inland route between Norfolk, Virginia, and points on Albemarle sound. The total length of canal proper is fourteen miles; of this, eight and one-half miles, extending from the head of Elizabeth river to the head of North Landing river, lying in Virginia, and five and one-half miles, extending from Currituck sound to the head of North river, lying in North Carolina. The prism of the canal is seventy feet wide at the top and seven feet deep. It has one lock 220 feet long and forty feet wide.

The banks of the canal are entirely without protection, except such as is afforded by vegetation. It was designed and built expressly for steam navigation, and all boats passing through it are either propelled or towed by steam power.

The canal has been in use ten years, and during that time over 35,000 vessels have passed through it. Fifty-two different steamers have passed through this canal during the last year.

The canal company have had three tugs in use for towing purposes. These tugs are able to tow 1,000 tons at a speed of four miles per hour. The speed attained by steamers varies from three to six miles per hour.

Towing has not, as yet, proved remunerative, for the reason that

the tonnage of the canal requiring towage, is not yet sufficient to afford constant employment for the tugs.

Bushes and other vegetation growing on the banks are found to afford a tolerable protection against the abrasion or wash resulting from the slight disturbance of the water caused by passing boats.

The committee take pleasure in acknowledging the polite attentions shown them by the Hon. Marshall Parks, President of the Canal Company, who offered every facility for the prosecution of their investigations; also to President Franklin Gowen, of the Philadelphia and Reading Railroad; to C. W. Wharton, Superintendent, and to Chief-engineer Smith, of the Schuylkill navigation, who extended every desired courtesy.

Respectfully submitted.

GEORGE W. CHAPMAN,
GEORGE GEDDES,
D. M. GREENE, *Engineer*,
Committee.

SECOND ANNUAL REPORT

OF

ENGINEER OF COMMISSION APPOINTED BY ACT CHAP. 1868, LAWS OF 1871, OF THE STATE OF NEW YORK, FEBRUARY 18, 1872.

Hon. Van R. Richmond, *Chairman:*

Sir.—I have the honor to report the results of my observations upon and deductions from the performances of the several steamers competing, during the past season, for the reward offered by the State of New York for the successful and economical introduction of steam, as a motive power, upon our canals.

At the date of my last report it was hoped and expected that, upon the opening of navigation in the spring of 1872, several steamers would be ready to enter promptly upon the three trial trips, required by the resolution adopted by the Commission at its meeting at Syracuse, on the 14th of August, 1871.

It was supposed that competitors having had a full year in which to mature their plans and to make the necessary arrangements for their trial, and knowing that a single season only remained during which such trial could be had, would make every effort to avail themselves of the entire season, for the purpose of satisfying the Commission of the relative merits of their several inventions, plans or devices.

For a variety of reasons, however, among which may be mentioned the difficulty experienced by some of those desiring to compete, in procuring the requisite means with which to develop their plans, the delays incident to the construction of special machinery for a novel application, and the very general desire to first make private experiments and tests; for these, and other reasons, no boats, with a single exception, were formally reported ready for trial until late in August.

At this time, only three months of the season of navigation remained; and therefore it could not reasonably be expected, in view of the contingencies likely to arise in the use of new and untried machinery, and in view of the general inexperience of the competitors in canal

navigation, that the three preliminary trips would be accomplished much before the close of navigation, if, indeed, they could be accomplished at all.

Thus it has happened that only three steamers have succeeded in fully completing the three round trips between Buffalo and Troy. These are the "Port Byron," of Rochester; the "William Newman," of Watkins; and the "William Baxter," of New York.

The "Port Byron" left West Troy on her first trip on the 3d of July, and completed her third trip, at the same point, on the 19th of November; having occupied about three and a half months in making the three trips.

The "Newman" began and ended her three trips at Buffalo, on the 31st of August and 7th of November respectively; accomplishing the three round trips in two months and seven days.

The "Baxter" began and ended her trips at West Troy, on the 29th day of August and 14th of November, respectively; occupying two and a half months.

Besides the boats already named, the "Charles Hemje," "Fountain City," Excelsior," "Eureka," "Central City," "Montana," "Geo. A. Feeter" and "Success," each undertook to accomplish the required preliminary trips. All of these failed; most of them for want of sufficient time, and the others, for reasons which will appear in their proper places. The "Dawson," which commenced her trips during the season of 1871, has also been running during the past season; but, so far as I am informed, she has not made the required three round trips. She has, however, done what the Commission may regard as an equivalent to the required trips.

Before presenting the detailed statements of the performances of these several steamers, I desire to call the attention of the Commission to the circumstances under which the trial trips had to be undertaken; and to certain causes of delay, which, it seems to me, should be kept constantly in view by the Commission, while considering and passing judgment upon the results which have been accomplished.

In the first place, the full depth of water—seven feet—has not been maintained through the season. Many detentions have occurred in consequence of boats grounding while drawing only six feet of water. Some of these have been due to accumulations in the bottom of the canal and some have resulted from excessively low water on some of the shorter levels. The relative navigability of the several sections of the canal, will appear upon examination of the tabulated speeds of the competing boats over them.

Again, the steamer, making an average speed of three miles an hour, or double that of the horse-boat, must, in making a trip from Buffalo to West Troy, overtake and pass one-half the number of loaded horse-boats that may be bound east at the time of her departure from Buffalo. I estimate that at least 360 boats had to be thus passed on each trip. The steersmen of the horse-boats, either from not being able to judge correctly of the speed of the steamers, or from a disposition to hinder their progress as much as possible, would, in almost every instance, neglect or refuse to make way for the steamers to pass. This rendered it necessary to slacken the speed of the steamers, whenever approaching such boats, and, in very many instances, to entirely arrest it. Whenever a steamer undertook to pass a horse-boat, and the captain of the latter refused to halt his team, and this happened very often, the two boats would be drawn together; after which they could only be separated by stopping the team, or by the steamer forcing the horse-boat upon the bank. There was no necessary difficulty in passing the horse-boats, except at points where the horse-boats met. One minute is, in my opinion, a very moderate estimate of the average delay experienced in the passage of horse-boats. The passage of 360 boats would, therefore, involve a delay, in the aggregate, of six hours per trip. No account has been taken of these delays in the deductions which have been made; nor have they been claimed, so far as I am aware, by any of the competitors.* They are, of course, wholly chargeable to the horse-boats, and will disappear whenever steam shall have been substituted for animal power.

Serious complaints have been made, by all of the competitors, of the indisposition of superintendents and lock-tenders to recognize the right of the steamers to precedence at the locks. Capt. Small, of the "Newman," suggests, as a partial remedy for these difficulties and delays at locks, that steamers have precedence at the locks upon the *berme* side of the canal only. Such an arrangement, he thinks, would be quite acceptable to all parties, and would inure to the advantage of both steamer and horse-boat.

Finally, it will be remembered that, during the latter part of the season, the movement of boats was seriously interrupted in consequence of the horse disease. Some have supposed that on this account those steamers which made trips during such interruption met with less delay than they would have encountered had canal traffic remained in its normal condition. Such, however, was not the

* Except in aggravated cases.

case. The difficulties to be overcome by the steamers were in fact increased; for boats that were compelled to lay up invariably did so in the cities and small villages and at the canal groceries. At such places the canal was often found so full of boats that it was utterly impossible for boats to pass each other in opposite directions, and the steamer would be compelled to await, at each blockade, the slow movement of any horse-boat that might have stopped to change horses, or gained the narrow channel from the opposite direction. Many boats ran only during the day time; laying up at night as above stated, and in the morning moving on in schools, which the steamers experienced much delay in passing.

The detailed statements which are presented have been made up from sworn statements furnished by the competitors. These have been accompanied, in most cases, by certified copies of all clearances, and in all cases by copies of a sufficient number of clearances to enable me to judge as to the probable accuracy of the statements furnished. Satisfactory reasons have been given for the failures to present full copies of all clearances. In some cases, slight and immaterial discrepancies exist between the clearances and the statements of the competitors; these, also, have been satisfactorily explained.

In a few instances, there are obvious errors, as well as omissions, in the clearances; but, in most cases, corrections have been made without difficulty. The indorsements upon the clearances of the several collectors, or their clerks, have served to check the accuracy of the logs of the different boats; and as, upon careful comparison of both, I have been unable to discover any inconsistencies in the latter, I am led to the belief that the statements of the competitors thus checked, and the deductions therefrom, may be confidently relied upon as practically correct. My own personal observations, while on board such boats as I have been able to visit, lead to the same conclusion.

PERFORMANCES OF THE COMPETING BOATS.

I. *Description and Performance of the Steamer "A. H. H. Dawson."*

The "Dawson" is an old, full-modeled boat, rebuilt in 1871, and fitted with machinery in accordance with the patent of Messrs. Main and McMillan, of Pierpont, New York. Her weight, with her machinery, is seventy-four and a half tons, and her carrying capacity, with six feet draught of water, 205 tons.

The peculiar feature of this boat consists in the location of the propelling instrument, the ordinary screw, in a cavity at the bow.

This cavity, which is located at the center of the bow, is just large enough to admit the screw, slopes aft, and terminates at a distance of twenty feet from the stem.

She is furnished with a simple upright engine, high pressure, with cylinder twelve inches in diameter, and twelve-inch stroke of piston.

The boiler is upright, cylindrical, and has eight and one-half square feet of grate surface. The feed-water is heated by the exhaust steam, which is afterward discharged into the air or into the uptake, as may be desirable or necessary.

The propeller is a true screw, four bladed, four and one-half feet diameter and six feet pitch.

My own observations upon the performance of the "Dawson" are limited to a trip from Schenectady to Port Jackson, a distance of sixteen miles, made on the 20th of August last. The boat left the collector's office at Schenectady at 8.56 A. M., and reached Port Jackson at 8 P. M., having passed through five locks and having been detained by a jam about fifteen minutes. Deducting all detentions, the average speed during this day was 1.57 miles per hour.

The coal consumption, as near as I was able to ascertain it, averaged ninety-one pounds per hour, or at the rate of 2,184 pounds per day. Consumption of coal per mile, 62.6 pounds.

The average steam pressure was 68.9 pounds; revolutions of the screw, 89.4 per minute; horse-power, 38.6.

The data from which the former has been estimated were determined by observations taken at intervals of fifteen minutes, for the entire run of sixteen miles, and are, therefore, reliable; but in regard to the coal consumption I am not so certain. Having ascertained the weight of a bucket of coal, the engineer was requested to report the number of buckets expended, and the statement above is based upon his report. Although I gave such attention to the record of coal consumed as I was able to give, it is possible, and I think probable, that more coal was used than was reported to me. The fact that the quantity of coal per horse power per hour, as deduced from the foregoing data, is only 2.36 pounds, seems to justify such a conclusion. It is but just to say, however, that the quantity of coal reported as having been consumed is in perfect harmony with the representations of Mr. Main, previously made, that the coal consumption had averaged about one ton in twenty-four hours.

Several observations were made for the purpose of ascertaining the rate of the current, against which the "Dawson" was at that time

running. These observations indicated an average velocity of current equal to about thirty feet per minute, or one-third of a mile per hour.

The run from the collector's office at Schenectady to lock twenty-three, a distance of two and three-quarter miles, was made, without detention, in one hour and fourteen minutes, or at the rate of 2.22 miles per hour, over the ground. Adding to this the volocity of the current in the opposite direction, we get for the speed of the boat through the water, 2.55 miles per hour, or 224.4 feet per minute.

The average number of revolutions of the screw, while running this two and three-quarters miles, was 95.2 per minute. The pitch of the screw being six feet, it follows that the speed due the revolutions was 571.2 feet per minute, or 6.49 miles per hour. The "slip" of the screw was therefore

$$\frac{571.2-224.4}{571.2}\times 100 = 60.7 \text{ per cent.}$$

Upon this portion of the canal, the water is, as is well known, of the full width, and more than the ordinary depth. The excessive slip of the "Dawson's" screw is due, in my judgment, to three causes: First. To insufficient size. Second. To the manner in which it is compelled to act, and to the absence of a free escape for the water in the rear of it. Third. To the want of a proper adjustment of the pitch to the peculiar service required of it.

Thus far I am not aware that any competitor has adopted the proper form of screw for canal service. I have given no advice in this direction, for the reason that I have not conceived it to be just to the competitors to do so. A knowledge of the proper form and proportions of the screw may not be essential to the accomplishment of all that is required by the law; but it is, nevertheless, true that better results might have been obtained, had attention been given to this important matter.

In order to make the record of the "Dawson" as complete as practicable in this case, that portion of her performance which was reported last year is reproduced.

FIRST TRIP WEST.

Left the weigh lock at Albany at 9.45 A. M., August 4, 1871; cargo, 191$\frac{13}{20}$ tons coal; discharged 30 tons at Syracuse; weight of boat, as per clearance, 69$\frac{7}{20}$ tons; arrived at Buffalo at 9.20 A. M., August 22d.

	Days.	Hours.	Min.
Total time from Albany	17	23	45
Detentions reported	9	8	53
Add for lockage	..	10	..
	9	18	53
Running time	8	4	52

or $196\frac{52}{60}$ hours; distance 352 miles; average speed 1.79 miles per hour.

FIRST TRIP EAST.

Left Buffalo at 4.30 P. M., August 28, 1871; cargo, 6,400 bushels of corn; weight, $179\frac{1}{3}$ tons; arrived at West Troy weigh lock at 12.30 A. M., September 7th.

	Days.	Hours.	Min.
Total time from Buffalo	9	8	..
Detentions reported	2	6	30
Add for lockage	..	10	..
	2	16	30
Running time	6	15	30

or $159\frac{1}{2}$ hours; distance 345 miles; average speed 2.16 miles per hour.

SECOND TRIP WEST.

Left West Troy at 3.25 P. M., September 23d, 1871. Cargo, $169\frac{1}{3}$ tons coal for Syracuse, and 155 tons railroad iron, from Syracuse to Buffalo. Arrived at Buffalo at 3.30 A. M., October 10th. Total time from West Troy, sixteen days, twelve hours and five minutes.

Detentions not fully reported. The indorsements on the clearance, at the collector's offices between Troy and Syracuse, are so imperfect as to be quite useless. They are as follows: Schenectady, 24th September, at 12.30; Fultonville, 27th September, at 12.50; Little Falls, 28th September, at 8.07; Utica, 28th September, at 10 o'clock.

Montezuma, arrived 7 A. M., October 4th.

Montezuma, left 11 A. M., October 4th.

Palmyra, arrived $10\frac{1}{4}$ A. M., October 6th.

Palmyra, left $12\frac{1}{2}$ P. M., October 6th.

Rochester, arrived 8.40 A. M., October 7th.

Rochester, left 4.40 P. M., October 7th.

Brockport, arrived 3.30 A. M., October 9th.

Albion, arrived 11.30 A. M., October 9th.

Tonawanda, arrived 1.45 P. M., October 10th.

Buffalo, arrived 3.30 A. M., October 10th.

There is obviously an error in one or the other of the last two indorsements; and it is difficult to reconcile the discrepancy with any probable or practicable speeds between Brighton and Buffalo. It is impossible to reach any satisfactory conclusion as to times and speeds on this trip, and for that reason the record is submitted as it stands.

SECOND TRIP EAST.

Left Buffalo at 3.45 P. M., October 16th, 1871. Cargo, 6,603$\frac{5}{6}\frac{6}{0}$ bushels of wheat; weight, 199$\frac{3}{1}\frac{}{0}$ tons. Boat drew five feet ten inches of water.

				DETENTIONS. Hours.	Min.
Arrived at Tonawanda	at 7	P. M.,	16th.	..	..
Left	at 7.15	"	16th.	..	15
Passed Pendleton	at 10.45	"	16th.	..	..
Arrived at Lockport	at 1	A. M.,	17th.	..	..
Left Lockport	at 1.30	"	17th.	..	30
Passed Medina	at 7	"	17th.	..	..
Arrived at Albion	at 10.50	"	17th.	..	..
Left Albion	at 11.30	"	17th.	..	40
Passed Brockport	at 4.30	P. M.,	17th.	..	..
Arrived at *Rochester*	at 11.30	"	17th.	..	..
Left Rochester	at 3	A. M.,	18th.	3	30
Delayed by a sunken boat and by weighing.					
Left Brighton locks	at 6.30	A. M.,	18th.	..	..
Passed Palmyra	at 6.15	P. M.,	18th.	..	..
Passed E. Arcadia	at 1	A. M.,	19th.	..	..
Arrived at Montezuma	at 2.10	P. M.,	19th.	..	..
Left Montezuma	at 3.35	"	19th.	1	25
Arrived at Geddes	at 11.30	A. M.,	20th.	..	..
Left, after coaling	at 2	P. M.,	20th.	2	30
Passed *Syracuse*	at 3	"	20th.	..	
Left Lodi locks	at 4.30	"	20th.	..	..
Passed Rome	at 2.30	"	21st.	..	..
Delayed west of Rome by picking up a lost tow-line from the bottom of the canal				2	..
Arrived at *Utica*	at 10.30	P. M.,	21st.	..	..
Laid up over Sunday.					
Left Utica	at 12.30	A. M.,	23d.	26	..
Passed Little Falls	at 12	M.,	23d.	..	..
Passed Fultonville	at 2.45	A. M.,	24th.	..	..
Passed Schenectady	at 3	P. M.,	24th.	..	..
Arrived at Cohoes	at 12	M.,	24th.	..	..
Arrived at West Troy	at 5	A. M.,	25th.	..	..
Total detentions				36	50

Deductions.

	Days.	Hours.	Min.
Total time from Buffalo	8	13	15
Detentions	1	12	50
Add for lockage	..	10	..
	1	22	50
Running time	6	14	25

or $158\frac{5}{12}$ hours; distance 345 miles; average speed 2.18 miles per hour.

The following table shows the average speeds between the more prominent points, or over special sections of the canal. A deduction of eight minutes is made for each lock passed.

	Miles.	Running time. Hours.	Min.	Aver. speeds.
Buffalo to Rochester	93	29	32	3.15
Rochester to Syracuse	93	53	57	1.72
Syracuse to Utica	56	28	58	1.93
Utica to Schenectady	80	35	26	2.26
Schenectady to Troy	23	11	20	2.03

THIRD TRIP WEST (TO SYRACUSE ONLY).

Left West Troy November 8th, 1871, with a cargo of 100 tons of water-lime, for Syracuse.

Passed Schenectady	at 10	P. M.,	Nov. 9th.
Passed Fultonville	at 10.30	"	Nov. 10th.
Passed Little Falls	at 11.30	"	Nov. 11th.
Passed Utica	at 7	"	Nov. 13th.
Passed Rome	at 8	"	Nov. 14th.

Arrived at Syracuse at 8 P. M., Nov. 15th.

Time, about seven days; distance 159 miles. As no statement of detentions has been made, we can arrive at no conclusion as to speed.

THIRD TRIP EAST.

Left Buffalo July 2d, 1872, with a cargo of $6{,}696\frac{24}{56}$ bushels of corn; weight $187\frac{1}{2}$ tons. Passed Schenectady, July 25th. The date of arrival at Troy is not given; nor is any other information contained in the clearance, by which an estimate of the speed can be made. It appears, however, that about eighteen days were consumed in making the run from Buffalo to Syracuse, and that about five days were consumed in making the run from Syracuse to Schenectady.

ADDITIONAL TRIPS OF THE "DAWSON."

On August 16th, 1872, cleared from West Troy for Rochester, laden with 184 tons coal. Arrived at Rochester September 10th; time, about twenty days.

On the 23d of September, cleared from Montezuma, with a cargo of 200 tons coal; bound from Ithaca to Rochester. Arrived at Rochester on the 28th of September.

On the 13th of October, cleared from Montezuma, with a cargo of 200 tons of coal; bound from Ithaca to Rochester. Arrived at Rochester on the 13th of October (so in the clearance).

On the 4th of November, cleared from Montezuma with a cargo of 200 tons of coal; bound from Ithaca to Albion. Passed Rochester on the 8th of November; date of arrival at Albion not given.

The foregoing comprises all of the information in my possession in regard to the performance of the "Dawson." It will be observed that there is no complete record of three entire round trips by this steamer. A single trip from Syracuse to Buffalo is wanting.

On the third trip east, between Buffalo and Rochester, an average speed of 3.15 miles per hour was attained. There is no evidence to show that a speed of three miles was attained during any other trip, or upon any other part of the canal.

Mr. Dawson represents that the boat has done a profitable business during the past season, and that she has been returned in excellent condition, by the party to whom she had been chartered.

It is to be regretted that the data furnished are so incomplete as to render it impossible to deduce any reliable or satisfactory conclusion, as to the time, speed and coal consumption, or to judge of the economy of the boat, as compared with the horse-boat.

SUPPLEMENT.

After completing the foregoing report of the Dawson's performance, I received on the 11th of January, from Mr. Thomas Main, the following:

STATEMENT OF TRIPS OF S. C. B. "DAWSON."

	1871.		Cargo.
1.	August.	New York to Buffalo.....	185 tons coal.
2.	"	Buffalo to New York.....	200 tons corn.
3.	Sept.	Newburgh to Utica,.....	160 tons coal.
4.	"	Utica to Syracuse, ...	Light.
5.	"	Syracuse to Buffalo.....	160 tons railroad iron.
6.	October.	Buffalo to New York.....	200 tons wheat.
7.	Nov'r.	Rondout to Syracuse	120 tons cement.
8.	"	Syracuse to New York.....	201 tons salt.

	1872.		
9.	June.	New York to Utica	180 tons coal.
10.	"	Utica and Syracuse.....	Light.
11.	"	Syracuse to Buffalo	180 tons coal.
12.	July.	Buffalo to New York	200 tons corn.
13.	August.	New York to Rochester ...	180 tons coal.
14.	"	Ithaca to Rochester	201 tons coal.
15.	"	Ithaca to Rochester	201 tons coal.
16.	"	Ithaca to Albion.....	201 tons coal.
17.	Nov'r.	Albion to New York	Potatoes and apples.

From this statement it appears that while three complete round trips have not been made, the "Dawson" has run over the entire distance between Buffalo and Troy three times each way, loaded. It appears further that the total distance run by the "Dawson" since the commencement of her first trip, in August, 1871, is made up as follows:

	Miles.
On the Erie canal, loaded	3,058
On the Erie canal, light.....	292
On Cayuga lake, loaded.....	169½
On Cayuga lake, light	169½
Total distance run	3,689
Total tons moved one mile	572,876

The above movement was effected during the last half of the season of 1871, and the entire season of 1872.

The number of tons moved one mile on the canal by a horse-boat, making six round trips in a season, with cargoes of 226 tons east and 100 tons west is 674,820; while the number of miles run on the canal is 4,140.

It thus appears, finally, that the entire work of this steamer for a season and a half is not equal, either in freight movement or miles run, to the capacity of a successful horse-boat for a single season.

II. *Description and Performance of the Steamer "William Newman."*

The "William Newman," built at Watkins, New York, is a full-sized, double decked boat, of the following dimensions and capacity: Length of keel, ninety-two feet; over all, ninety-six feet; width, seventeen and a half feet; light weight, including machinery, seventy and three-quarter tons; carrying capacity, when drawing six feet of water, 214 tons.

The lines of the "Newman" are quite full forward, but aft are moderately fine, in order to allow the water to reach the screw.

The machinery of the "Newman" consists of a single upright engine, with cylinder twelve inches in diameter and twelve inches stroke of piston, together with a small auxiliary or "donkey" engine and pump for feeding the boiler.

The screw propeller is four bladed, five feet in diameter, and has a pitch of seven feet.

The boiler is horizontal, return tubular, eight feet long and four feet in diameter; fire-grate, thirty-nine inches long by forty inches wide; area, 10.83 square feet; it has an oval flue, thirty-one inches by fourteen inches, and thirty-three inches long; thirty-four return tubes, two and a half inches diameter, and six feet five inches long; heating surface about 191 square feet.

The engine-room, cabin and quarters of the "Newman" are large, conveniently arranged, and very comfortable for a canal boat.

Late in the season the machinery was inspected and found to be in excellent condition, and giving promise of as much endurance as is usually shown by machinery of that size and power. The behavior of the machinery was found to be all that could be desired, as also was the steaming capacity of the boiler, except for a short time after the fires had been cleaned. The boiler was, however, entirely without protection from loss of heat by radiation, and hence could not be as efficient as it would have been had it been felted or otherwise protected. Capt. Small states that he has expended during the season, for repairs to his machinery, the sum of twelve dollars.

The following "logs" of the three round trips of the "Newman" are made up from certified copies of her clearances, together with a sworn statement of Capt. Small.

FIRST TRIP EAST.

Left Buffalo at 5.30 A. M., August 31st, 1872. Cargo, 7,200 bushels of corn. Weight, $201\frac{6}{10}$ tons.

	DETENTIONS. Hours.	Min.
Detained at Buffalo on account of low water and boats aground	..	30
Detained at Black Rock by same cause	..	30
Detained at Lockport by a raft	..	40
Detained at Cataract Springs for water and stores	..	20
Arrived at *Rochester* at 1 P. M., September 1st.		
Detained at Rochester weigh-lock, weighing	..	30
Detained at Brighton by boat aground at waste-weir	..	20
Detained at Fairport, coaling	..	55
Detained at Perrington Strait, low water and boats aground	1	..

	Detentions. Hours.	Min.
Detained at Macedon lock, wedged by boat "Hoyt," captain claiming that steamer had no preference....	1	10
Detained at Clyde, coaling.....	1	..
Detained between Fairport and Syracuse by eel-grass, which fouled the screw; had to reverse engine to clear the screw	..	..
Passed Syracuse at 1.30 P. M., September 3d.		
Detained at Rome trying to coal; water so low could not get to dock	1	..
Arrived at *Utica* at 4.25 P. M., September 4th.		
Detained at Utica for coal.....	1	..
Passed Schenectady at 4.30 A. M., September 6th.		
Detained at head of the sixteen locks, getting line out of wheel.....	..	40
Arrived at *West Troy* at 6.45 P. M., September 6th.		
Total detentions claimed.....	9	35

Deductions.

	Days.	Hours.	Min.
Total time from Buffalo	6	13	15
	Hours.	Min.	
Detentions claimed.....	9	35	
Add for lockage	10	..	
	..	19	35
Running time	5	17	40

or 137⅔ hours. Distance, 345 miles.

Average speed..... 2.5 miles per hour.
Average speed, including time spent in coaling and clearing the screw..... 2.44 miles per hour.
Average speed, including all detentions..... 2.19 miles per hour.

Average speed over special sections of the canal, exclusive of all detentions claimed, and eight minutes for each lock passed:

	Distance. Miles.	Running Hours.	time. Min.	Aver. speed. Miles per hour.
Buffalo to Rochester.....	93	28	42	3.24
Rochester to Syracuse.....	93	41	27	2.24
Syracuse to Utica	56	25	23	2.20
Utica to Schenectady.....	80	32	1	2.50
Schenectady to West Troy	23	10	55	2.11

FIRST TRIP WEST.

Left West Troy at 6.40 A. M., September 12, 1872. Cargo, 114 tons of iron ore.

	DETENTIONS. Hours.	Min.
Detained between West Troy and Schenectady.....	1	..
Arrived at *Schenectady* at 6.50 P. M., September 12th.		
Detained at Schoharie creek locks, waiting for turn...	..	20
Detained at Fultonville, for water and stores.....	..	15
Detained at Phillips lock, lock-tender locked boat "David Ellis" on "Newman's" time.....	..	20
Detained at Little Falls lower lock, lock-tender locked boat "Lyman Clark" on "Newman's" time.....		20
Detained at Little Falls upper lock, wedged in lock by boat "Thomas Kearney;" lock-tender decided against "Newman," and held lock until superintendent could be found, when "Newman" was locked through....	1	10
Arrived at *Utica* at 5.30 A. M., September 14th.		
Detained at Whitesboro for water	..	8
Detained at Thompson's, dense fog, at night, no boats running	1	..
Detained at Lodi lock, waiting for lock.....	..	15
Arrived at *Syracuse* at 2.20 A. M., September 15th.		
Detained at Syracuse by boats wedged, could not pass,	..	30
Detained at Geddes, dense fog, could not see.....	1	..
Detained at Port Byron, wedged in lock by boat "Kilderhouse," lock-tender refusing to give the "Newman" the preference.....	..	30
Detained at Montezuma, Sunday; had difficulty in getting coal.....	2	..
Detained by eel-grass between Montezuma and Fairport, as on down trip.....	..	..
Arrived at *Rochester* at 6.20 P. M., September 16th.		
Detained at Brighton lower lock, boat drawn aground by waste-weir	..	20
Detained at Brighton upper lock, boat "John Vought" took "Newman's" turn.....	..	15
Detained at Cataract for water and stores.....	..	20
Arrived at *Buffalo* a 5 A. M., September 18th.		
Total detentions claimed	9	43

Deductions.

	Days.	Hours.	Min.
Total time from West Troy	5	22	20
	Hours.	Min.	
Detentions claimed.....	9	43	
Add for lockage	10	..	
	..	19	43
Running time	5	2	37

or $122\frac{37}{60}$ hours; distance 345 miles.

Average speed..... 2.81 miles per hour.
Average speed, including lockages only ..... 2.61 miles per hour.
Average speed, including all detentions ..... 2.42 miles per hour.

Average speeds over special sections of the canal, exclusive of all detentions claimed, and eight minutes for each lock passed:

	Distances. Miles.	Running time. Hours.	Min.	Aver. speeds. Miles per hour.
Troy to Schenectady	23	8	30	2.71
Schenectady to Utica.....	80	29	11	2.76
Utica to Syracuse	56	18	55	2.96
Syracuse to Rochester	93	33	52	2.75
Rochester to Buffalo	93	32	57	2.82

SECOND TRIP EAST.

Left Buffalo at 6.40 A. M., Sept. 21st. Cargo, 6,700 bushels of wheat; weight 201 tons.

	DETENTIONS. Hours.	Min.
Detained at Buffalo by low water	..	30
Detained at Black Rock by boats across the canal.....	..	40
Detained at Cataract Springs for stores.....	..	20
Arrived at at *Rochester* 12.30 P. M., Sept. 22.		
Detained at Rochester weigh lock	..	30
Detained at Brighton, low water and boats aground...	..	30
Detained between Fairport and Syracuse by eel-grass, low water and boats aground	..	..
Detained at Lyons by broken rudder-post.....	19	..
Detained at Port Byron, waiting for lock.....	..	20
Detained at Weedsport by boats aground	..	30
Arrived at *Syracuse* at 6.40 A. M., September 25th.		
Detained at Oneida for coal	..	40
Detained at Rome by boats aground.....	1	..
Detained at Whitesboro by dense fog	1	..
Arrived at *Utica* at 7.55 A. M., September 25th.		
Detained at Utica for coal.....	1	..
Detained from Utica to Frankfort by low water, water drawn down in order to let light boat pass bridge at Utica	..	..
Detained at Little Falls by raft	..	15
Detained at Schoharie creek, lock-tender refused to give steamer preference	..	40
Arrived at *Schenectady* at 6.40 P. M., September 27th.		
Detained at Upper Aqueduct, waiting for lock	..	10
Detained at Lower Aqueduct, taking line out of wheel,	..	30
Arrived at *West Troy* at 7 A. M., September 28th.		
Total detentions claimed	27	35

Deductions.

	Days.	Hours.	Min.
Total time from Buffalo	7	..	20
Detentions claimed	1	3	35
Add for lockage	..	10	..
	1	13	35
Running time	5	10	45

or 130¾ hours; distance 345 miles.

	Miles per hour.
Average speed	2.64
Average speed, including time spent in coaling and clearing wheel	2.58
Average speed, including all detentions	2.05

Average speed over special sections of the canal, exclusive of detentions, and eight minutes for each lock passed:

	Distance. Miles.	Running time. Hours.	Min.	Average speed. Miles per hour.
Buffalo to Rochester	93	27	32	3.38
Rochester to Syracuse	93	41	42	2.23
Syracuse to Utica	56	22	03	2.54
Utica to Schenectady	80	29	26	2.72
Schenectady to West Troy	23	9	20	2.46

SECOND TRIP WEST.

Left West Troy at 6.30 A. M., Oct. 4th, 1872. Cargo, 127¾ tons iron ore.

	Detentions. Hours.	Min.
Detained at lock 8; lock out of order	..	30
Detained at Upper Aqueduct, waiting for a lock	..	15
Arrived at *Schenectady* at 5.45 P. M., Oct. 4th.		
Detained at lock 23, waiting for lock	..	10
Detained at first lock below Port Jackson, waiting for lock	..	15
Detained at Port Jackson; dense fog; no boats running,	3	30
Detained at Fort Plain, waiting for lock	..	15
Detained at Mindenville, waiting for lock	..	10
Detained at Little Falls, lower lock; lock-tender refusing to give steamer the preference	..	10
Detained at third lock below Little Falls; same reason as above	..	20
Detained at Ilion; boats wedged	..	50
Detained at Frankfort, low water and lock broken	1	..
Arrived at *Utica* at 8.45 A. M., Oct. 6th.		
Detained at weigh-lock	..	45
Detained at York Mills, coaling	1	..
Detained at Lenox Basin, wind-bound; no boats running	1	20

	Detentions. Hours.	Min.
Detained at Lodi lock, waiting for lock	..	15
Arrived at *Syracuse* at 7 A. M., Oct. 7th.		
Detained at Jordan lock, waiting for lock	..	15
Detained at Port Byron, wedged in by boat "O. L. Nims;" captain claimed that steamer had no preference	..	40
Detained by eel-grass as on former trips.		
Arrived at *Rochester* at 9.45 P. M., Oct. 8th.		
Detained at May's Point, boats wedged	..	40
Detained at Cataract, for stores	..	20
Detained at Tonawanda, by rafts	..	20
Arrived at *Buffalo* at 10 A. M., Oct. 10th.		
Total detentions claimed	13	..

Deductions.

	Days.	Hours.	Min.
Total time from West Troy	6	3	30
	Hours.		
Detentions claimed	13		
Add for lockage	10		
	..	23	
Running time	5	4	30

or 124½ hours; distance 345 miles.

Average speed ..... 2.77 miles per hour.
Average speed, including lockages ..... 2.57 miles per hour.
Average speed, including all detentions ..... 2.34 miles per hour.

Average speeds over special sections of the canal, exclusive of all detentions, and eight minutes for each lock passed:

	Distance. Miles.	Running time. Hour.	Min.	Aver. speeds. Miles per hour.
West Troy to Schenectady	23	7	50	2.94
Schenectady to Utica	80	27	06	2.95
Utica to Syracuse	56	18	33	3.02
Syracuse to Rochester	93	35	42	2.60
Rochester to Buffalo	93	34	07	2.72

THIRD TRIP EAST.

Left *Buffalo* at 7 A. M., October 16, 1872. Cargo, 7,300 bushels of corn; weight, 204$\frac{4}{10}$ tons.

	Detentions. Hours.	Min.
Detained at Tonawanda by raft	..	20
Detained at Cataract Springs for stores	..	25
Detained at Shelby's basin, boat and raft wedged	..	40
Arrived at *Rochester* at 12 noon, October 17th.		

	Detentions. Hours.	Min.
Detained at Rochester weigh lock	..	30
Detained at Brighton lower lock, waiting for lock	..	15
Detained at Fairport for coal	1	..
Detained at first lock west of Clyde, waiting for boats to lock	..	20
Detained at Port Byron, waiting for lock	..	20
Detained at Geddes, trying to get coal	..	30
Arrived at *Syracuse* at 11 A. M., October 19th.		
Detained at Syracuse for coal	3	20
Detained at New Boston, boats aground	..	40
Detained at Rome, boats aground	..	30
Arrived at *Utica* at 2.45 P. M., October 20th.		
Detained at Utica weigh lock, weighing	..	30
Detained at Frankfort by low water, and by boats aground	..	20
Detained at Fort Plain, dense fog, could not see to navigate	1	20
Detained at Schoharie creek, getting line out of wheel,	..	20
Arrived at *Schenectady* at 10.30 P. M., October 21st.		
Detained at Upper Aqueduct, boats wedged	1	..
Detained at Sixteen locks, by dense fog	1	
Arrived at *West Troy* at 11.15 A. M., October 22d.		
Total detentions claimed	13	20

Deductions.

	Days.	Hours.	Min.
Total time from Buffalo	6	4	15
	Hours.	Min.	
Detentions claimed	13	20	
Add for lockage	10	..	
	..	23	20
Running time	5	4	55

or 124$\frac{11}{12}$ hours; distance, 345 miles.

Average speed ..... 2.76 miles per hour.
Average speed, including lockages only ..... 2.56 miles per hour.
Average speed, including all detentions ..... 2.33 miles per hour.

Average speeds over special sections of the canal, exclusive of all detentions claimed, and eight minutes for each lock passed:

	Distance. Miles.	Running time. Hours.	Min.	Aver. speed. Miles per hour.
Buffalo to Rochester	93	26	47	3.47
Rochester to Syracuse	93	41	57	2.22
Syracuse to Utica	56	22	43	2.47
Utica to Schenectady	80	26	11	3.05
Schenectady to West Troy	23	8	5	2.85

Third Trip West.

Left *West Troy* at 12 o'clock noon, November 1, 1872. Cargo, merchandise; weight, $101\frac{9}{10}$ tons; sixteen tons merchandise to be delivered at Fairport and Rochester; balance for Buffalo.

	Detentions. Hours.	Min.
Arrived at *Schenectady* at 10.30 P. M., November 1st.		
Detained at Schenectady, wind-bound	1	30
Detained at Fultonville, wedged with raft	..	20
Detained at Cox's, coaling	..	50
Arrived at *Utica* at 7.30 A. M., November 3d.		
Detained at Whitesboro for stores	..	20
Arrived at *Syracuse* at 4 A. M., November 4th.		
Detained at Syracuse by raft	..	30
Detained at Geddes by raft	..	20
Detained at Weedsport for coal	1	20
Detained by eel-grass, as on former trips	..	..
Detained at Lyons by dense fog	4	..
Detained at Perrington by boats aground	..	30
Detained at Fairport by boats wedged	1	..
Arrived at *Rochester* at 10.50 P. M., November 5th.		
Detained at Middleport, coaling	..	30
Arrived at *Buffalo* at 9 A. M., November 7th.		
Total detentions claimed	11	10

Deductions.

	Days.	Hours	Min.
Total time from West Troy	5	21	..
	Hours.	Min.	
Detentions claimed	11	10	
Add for lockages	10	..	
	..	21	10
Running time	4	23	50

or $119\frac{5}{6}$ hours; distance 345 miles.

	Miles per hour.
Average speed	2.88
Average speed, including lockages only	2.63
Average speeds, including all detentions	2.45

Average speeds over special sections of the canal, exclusive of all detentions claimed and eight minutes for each lock passed:

	Distance. Miles.	Running time. Hours.	Min.	Average speed. Miles per hour.
West Troy to Schenectady	23	7	50	2.94
Schenectady to Utica	80	27	16	2.93
Utica to Syracuse	56	19	38	2.85
Syracuse to Rochester	93	33	2	2.82
Rochester to Buffalo	93	35	52	2.83

The foregoing comprise the three round trips between West Troy and Buffalo required by the Commission. After completing these trips, the "Newman" made an additional trip from Buffalo to West Troy, with two loaded boats in tow. The duration of this trip, the cargoes and speed are as follows:

Left Buffalo at 5 P. M., November 11th; arrived at West Troy at 11 P. M., November 23d.

	Days.	Hours.
Total time from Buffalo	12	6
Detentions claimed, including lockages	1	2
Running time	11	4

	Miles per hour.
Average speed	1.29
Average speed, including all detentions	1.17

Name of boat.	Cargo.	Tons.
"Newman"	7,300 bushels corn	204.4
"Everline"	7,500 bushels wheat	225.0
"Harrison"	8,250 bushels corn	231.0
Totals	23,050	660.4

In another place I shall take occasion to consider the economy of this last performance, as compared with those of the boat running alone.

POWER AND COAL CONSUMPTION.

The coal consumption of the "Newman," for each trip, has not been reported. A statement of the aggregate coal consumption for the entire season's work has, however, been furnished; and from this the consumption per mile or trip is deduced as follows:

The steamer commenced running on the 17th of May, 1872, and had, therefore, been running three and a half months when her first trial trip was commenced on the 31st of August. During the entire season she steamed 4,595 miles, and burned 161 tons of coal; costing, at $5.50 per ton, $885.50. This distance includes the final trip from Buffalo, upon which two loaded boats were towed. The duration of this trip having been about double that of the other trips, it is assumed that the coal consumption was also double that of the average for that of the other single trips; and that the result would have been the same, so far as fuel is concerned, had the boat made an additional *round* trip instead of making the final single trip with two boats in tow. The length of a single trip, 345 miles, is therefore

added to the actual distance steamed, making the equivalent run $4,595+345=4,940$ miles. We thus have for the average coal consumption, $\frac{161\times2000}{4,940}=65.2$ pounds per boat mile for the "Newman" alone, or 130.4 pounds per mile when towing two loaded boats.

On the 12th of September I joined the Newman at West Troy, and accompanied her as far as Schenectady. The time consumed in locking averaged, for the twenty locks between West Troy and Schenectady, about five minutes for each lock. This time is that which elapsed from the entrance of the bow of the boat at the lower gates to the passage of the stern from the upper gates; and hence includes the time expended in entering and leaving the lock. Again, on September fourteenth, I joined the Newman at Utica, and accompanied her as far as Durhamville. During these three days, the steam pressure varied from 42 to 85 pounds, and the revolutions from 58 to 90 per minute, and the power from 16 to 42½ horses. The development of the smaller power occurred only for short periods, when the cleaning of the fires had not been attended to at the proper time. The higher power was maintained only for short periods, after detentions at locks or elsewhere, during which the steam would, of course, run up. A fair average for the two days would be about as follows: Steam, 65 pounds; revolutions, 80 per minute; power, 30 to 35 horses, depending upon the cut-off and upon the extent to which the steam was throttled.

On the 12th, the run between locks 19 and 20—called three miles—was made in 53 minutes, against the current; the screw averaging 84 revolutions per minute, and the power expended being about 35 horses. The velocity of the current in that part of the canal was, on several occasions, found to be about half a mile per hour, or 44 feet per minute. Assuming then that the distance between the locks is in fact three miles, the speed of the Newman through the water was 3.9 miles per hour, or 343.2 feet per minute. The speed due to the pitch and revolutions of the screw was 6.68 miles per hour, or 588 feet per minute. The slip of the screw was, therefore, $\frac{588-343.2}{588}\times100=42$ per cent, nearly. It should be observed here, that, inasmuch as the "Newman's" cargo was at this time only 114 tons, and her draft about four feet, her screw was not wholly immersed. Under these conditions the "slip" of the screw was naturally greater than it would have been, had the screw been entirely submerged.

On the 14th, the run from Utica to Rome was made in six hours, including one lockage. The power varied from 16 to 42½ horses. At one point, the boat was observed to be making three and three-quarters miles per hour over the ground, against a very slight current; the screw making 84 turns per minute.

I was not able to intercept the Newman while bound east loaded, and hence am unable to make any specific statement as to her performance under such circumstances.

SUMMARY OF "NEWMAN'S" TRIPS.

TRIPS.	Cargoes, tons.	Times between Buffalo and Troy.									Average speed, miles per hour.
		Total.			Detentions, including lockage.			Running time.			
		D.	H.	M.	D.	H.	M.	D.	H.	M.	
First trip east	201.6	6	13	15	..	19	35	5	17	40	2.50
First trip west	114.0	5	22	20	..	19	43	5	2	37	2.81
Second trip east	201.0	7	0	20	1	13	35	5	10	45	2.64
Second trip west	127.75	6	3	30	..	23	0	5	4	30	2.77
Third trip east	204.4	6	4	15	..	23	30	5	4	55	2.76
Third trip west	101.9	5	21	0	..	21	10	4	23	50	2.88
Means	.....	6	6	46⅔	1	0	3 5-6	5	6	42 5-6	2.727

GENERAL DEDUCTIONS.

The work done, its cost, etc.

In the absence of all the "Newman's" clearances for the season, it will be impossible to indicate fully and in detail the entire season's work. For the three round trips, however, the work done will stand as follows:

Tons moved one mile, including boat	474,426
Tons moved one mile, cargo only	327,974
Boat, miles	2,070
Coal consumed, pounds	134,964
Cost of coal	$371 18
Power employed, horses (about)	32
Days occupied in making the three trips, including two trips to New York	69
Cost of engineer's wages	$184 00
Average length of round trip, days	23
Coal consumed per boat mile, pounds	65.2
Coal consumed per ton mile, including boat	0.284
Coal consumed per ton mile, cargo only	0.411
Cost of coal per boat mile, cents	14.67
Cost of coal per ton mile, cents (including boat)	0.078
Cost of coal per ton mile, cents, cargo	0.113
Cost of engineers per boat mile, cents	8.89

Cost of engineers per ton mile, cents (including boat) ...	0.039
Cost of engineers per ton mile, cents, cargo....	0.056
Cost of engineers and coal per boat mile, cents.....	23.56
Cost of engineers and coal per ton mile, cents (inc. boat).	0.117
Cost of engineers and coal per ton mile, cents, cargo....	0.169
Average pounds coal burned per hour.....	175.
Average pounds coal burned per day	4200.
Average pounds coal burned per horse-power per hour..	5.47
Average speed, exclusive of detentions, miles	2.727
Average speed, including detentions, miles	2.297
Slip of screw, per cent.....	40 to 44

AVERAGE SPEEDS OVER SPECIAL SECTIONS OF THE CANAL.

Trips East.

BETWEEN	Distance.	AVERAGE SPEED — MILES PER HOUR.			
		First trip.	Second trip.	Third trip.	Means.
Buffalo and Rochester	93	3.24	3.38	3.47	3.36
Rochester and Syracuse	93	2.24	2.23	2.22	2.23
Syracuse and Utica	56	2.30	2.54	2.47	2.40
Utica and Schenectady	80	2.50	2.72	3.05	2.76
Schenectady and Troy	23	2.11	2.46	2.85	2.47

Trips West.

BETWEEN	Distance.	AVERAGE SPEED — MILES PER HOUR.			
		First trip.	Second trip.	Third trip.	Means.
Buffalo and Rochester	93	2.82	2.72	2.83	2.79
Rochester and Syracuse	93	2.75	2.60	2.82	2.72
Syracuse and Utica	56	2.96	3.02	2.85	2.94
Utica and Schenectady	80	2.76	2.95	2.93	2.88
Schenectady and Troy	23	2.71	2.94	2.94	2.86

Trips East and West.

BETWEEN	Distance.	AVERAGE SPEED — MILES PER HOUR.		
		East.	West.	Means.
Buffalo and Rochester.....	93	3.36	2.79	3.07
Rochester and Syracuse.....	93	2.23	2.72	2.47
Syracuse and Utica.....	56	2.40	2.94	2.67
Utica and Schenectady	80	2.76	2.88	2.82
Schenectady and Troy.....	23	2.47	2.86	2.66

The preceding tables show that the average speeds east and west, over the entire canal, were 2.7 and 2.82 miles per hour respectively. This difference between the speeds eastward and westward is to be ascribed partly to the fact that the difference between the cargoes of the eastward and westward bound boats was more than sufficient to compensate for the effect of the prevailing eastward current, and partly by the fact that the westward bound boat, on account of its less draft of water, experienced less difficulty from the eel-grass and shoal water between Syracuse and Rochester than did the more heavily and deeply laden eastward bound boat. Had the cargoes been the same both ways, the effect of the currents upon the speeds over the different sections of the canal would have been entirely eliminated in the results contained in the final column of the last table; but, as the cargoes west were in fact only about half as large as those east, the numbers in this column must still be slightly affected by the currents. However, these numbers may be taken as the nearest attainable indices of the navigability of the several portions of the canal to which they apply. They show conclusively that the complaints which have been so general in regard to that portion of the canal between Syracuse and Rochester have not been wholly without cause. Had this part of the canal been in as good condition as that between Schenectady and Utica, the average speeds east and west over the entire canal would have been 2.85 and 2.87 miles per hour respectively.

At 2.7 miles per hour, the running time between Buffalo and Troy is 127.78 hours. If to this be added the ten hours which has been allowed for lockage, the time is 137.78 hours, or 5 days 17.78 hours; and the average speed, including lockages, 2.504 miles per hour. Adding again thirty hours for the run from Troy to New York, the total time from Buffalo to New York is 167.78 hours, or 6 days 23.78 hours; and the average speed, including lockages, for the entire distance of 495 miles, is 2.95 miles per hour.

We are justified in assuming the time from Troy to New York to be 30 hours, by the fact that the "Newman" has repeatedly made the run between Troy and Albany, 6 miles, in one hour. Capt. Small has never steamed down the river, for the reason, as he states, that he deemed it more economical to tow down than to hire a pilot, and that he did not choose to risk the loss of his insurance, in case of possible accident, in the absence of a licensed pilot.

From all the facts presented, it therefore appears that we are authorized to assume that, with the canal in proper condition, with horse-boats out of the way and steam generally introduced, the "Newman"

can be relied upon to maintain an average speed, between Buffalo and New York, of at least three miles per hour, and that the trip can be made inside of seven days.

III. *Description and Performance of the Steamer "William Baxter."*

The "Baxter" was designed and built expressly to compete for the reward offered by the State, and is, therefore, a purely experimental boat, entirely unlike the ordinary Erie canal boat. She was built during the spring and summer of 1872, at Fishkill-on-the-Hudson, by Samuel Sneden, Esq., an experienced ship-builder of New York, from a model designed by William Baxter, Esq., of Newark, N. J., whose name she bears.

Her dimensions and weight are as follows: Length 96 feet 2 inches; breadth 17 feet; depth of hold 9 feet; weight, including machinery and water in the boiler, $57\frac{2}{10}$ tons.

In model, the "Baxter" resembles the "log-bilge" boats of the New Jersey and Pennsylvania canals, being, however, somewhat sharper than those boats. Her bottom is perfectly flat, and her sides, stem and stern are vertical; so that she has a uniform horizontal section from her bottom up to $5\frac{1}{2}$ feet draft. Above this, the sides are carried out, forming an overhang at the stern, for the protection of the screw and to give deck room.

The form and dimensions of the immersed portion of the Baxter's hull are the same at bow and stern; so that, if a line be drawn athwart the plan, at right angles to the keel, and mid-way between the stem and the stern-post, such line would divide the plan into two equal and symmetrical parts. The sides converge from points distant twenty feet from both stem and stern, on curves of thirty feet radii. The area of the Baxter's bottom is 1,408.078 square feet. Her displacement, when drawing six feet of water, is therefore 8,048.468 cubic feet, or 264.015 tons, and her carrying capacity 206.815 tons. With a cargo of 200 tons, she should draw 5 feet 10 inches of water.* These results are deduced from the dimensions of the Baxter's plans. It is, however, stated that, as a matter of fact, when carrying 201 tons she draws only 5 feet $8\frac{1}{2}$ inches of water.

The machinery, which was built by the Fishkill Landing Machine Company, consist of a Baxter upright cylindrical boiler and a pair of Baxter compound condensing engines; these, together with the coal-

* Six inches immersion of the overhanging stern is not included.

bunker, engineers' berths and water-closet, occupy a space of 14 feet in length, at the stern.

The boiler is about 7 feet high and has an external diameter of 46½ inches; the fire-grate is 27 inches in diameter, and the combustion chamber about 2 feet high; from the upper portion of the latter, which is somewhat larger than the fire-grate, the products of combustion descend through 34 two-inch tubes 18½ inches long, after which they enter and ascend through an annular space about 3½ inches wide, to the smoke pipe, whence they escape into the air. Outside of the annular space just referred to is a second annular space ⅞ of an inch wide, through which the steam passes and is reheated on its way from the high to the low pressure cylinder.

The boiler was originally covered with felt, and thoroughly lagged with wood, but as the latter was found to be liable to take fire from the excessive heat to which it was exposed, it was removed, and the "salamander" felt substituted in its place. By this means, the loss of heat by radiation from the boiler, from which all the other boilers have suffered more or less, was effectually prevented. Altogether, the Baxter's boiler is remarkably economical for a power suited to its capacity. But it is too small for the duty required of it, and it has been found necessary to keep the small blower (a part of the original design) constantly running, in order to make the necessary amount of steam. The speed at which this blower—which was driven by a belt from one of the screw shafts—had to be run, in order to produce the desired result, was such that, especially at night, a stream of flame was seen frequently issuing from the top of the smoke pipe. In consequence of this loss of heat, the efficiency of the boiler was of course seriously impaired. The areas of the grate and heating surfaces are 4, and 160 square feet, respectively.

The cylinders, which are vertical, are attached to either side of the boiler, and are jacketed; the jackets being connected to the boiler by pipes at top and bottom, so as to insure a constant supply of live steam to the outside, as well as to the inside of the cylinders. The high and low pressure cylinders are 7 and 12 inches in diameter, respectively, and the stroke of the piston is 12 inches; the admission of steam to both is suppressed at three-fourths the stroke, by lap upon the slide valves, which are worked by the ordinary link motion.

The condenser, which is exceedingly cheap and simple, as well as moderately efficient, consists simply of an extension of the exhaust from the low pressure cylinder through the side of the boat, where it connects with a three-inch iron pipe which passes around the stern

and enters upon the opposite side, where a small air pump is located, and operated by a crank attached to the inboard end of the starboard shaft. The condensation is effected by the action of the water in the canal upon the exterior surface of the pipe outside the boat. The vacuum which is obtained by this means varies from 12 to 22 inches, depending upon the temperature of the water, quantity of steam used, etc. The water of condensation is, of course, returned directly to the boiler, and the necessity of supplying it from the muddy water of the canal entirely obviated. In the case of the "Baxter" the loss from leakage was a little more than replaced by a trifling leak in a joint of the condenser pipe, outside the boat, through which a very small quantity of water was forced inward by the excess of external pressure. This is an important feature of the Baxter plan, as by it the accumulation of mud in the boiler is almost, and may be, wholly prevented.

The Baxter is propelled by two three-bladed true screws, $4\frac{1}{2}$ feet in diameter and 4 feet pitch, placed on each side of the stern, and revolving toward each other at the bottom; uniform motion of the two being secured by a cross-shaft and mitre wheels. The disc area of the two screws is $14\frac{3}{10}$ square feet, or 14 per cent of the immersed midship section when the boat is loaded.

The reversing lever, throttle valve and steam whistle are all so arranged as to be within easy reach of the steersman, and the steam and vacuum gauges are so disposed as to be easily seen from the wheel, so that a single person may perform the duties of steersman and engineer at the same time; the fireman being thus free to give his whole attention and time to the fire, and to keeping the engines properly oiled.

The Baxter was launched about the 10th of August; made a preliminary trial trip on the 24th, and on the 27th of the same month left Newburgh for Buffalo on her first competitive trial trip.

Leaving West Troy at 1 P. M., August 29th, on her first trip west, and completing her third trip east at the same point, at 6.30 A. M., November 15th, she occupied, say 78 days in making the three round trips, taking one only of her eastern cargoes to New York during that time.

Mr. Baxter has furnished certified copies of all the clearances of his boat, and a detailed statement of detentions and their causes; together with the original bills of all the coal consumed by the "Baxter," from the time she was launched to the day of her arrival in New York with her third cargo from Buffalo. This statement is

accompanied by the affidavits of Mr. Baxter, Captain Runyon and Mr. Charles L. Sneden, who accompanied the "Baxter" during the greater part of her first round trip.

From these documents, and my own personal observations, the following "logs" of the "Baxter's" several trips are made up.

First Trip West.

Left *West Troy* at 1 P. M., August 29th, 1872; cargo 102¼ tons of plaster.

	Detentions. Hours.	Min.
Detained near Cohoes, waiting for locks	..	35
Detained east of Schenectady; machinery broken by log in one wheel	4	..
Arrived at *Schenectady* at 4.10 A. M., August 30th.		
Detained at Schenectady for repairs	12	25
Detained, running at two-thirds speed during two dark, foggy nights	5	..
Detained, repairing link motion	5	..
Arrived at *Utica* at 2 A. M., Sept 1st.		
Detained at Utica, discharging part of cargo	9	20
Detained, repairing machinery	2	30
Arrived at *Syracuse* at 9.45 A. M., September 2d.		
Detained at Syracuse to repair links	27	30
Detained at locks below Rochester by blockade of boats,	..	30
Arrived at *Rochester* at 5 A. M., September 5th. (?)		
Detained at Rochester for coal	1	..
Detained at Tonawanda to repair blower belt	1	30
Detained by boats aground	1	45
Detained at Black Rock by boats aground	1	30
Arrived at *Buffalo* at 11 P. M., September 6th.		
Total detentions claimed	72	35

Deductions.

	Days.	Hours.	Min.
Total time from West Troy	8	10	5
Detentions claimed	3	..	35
Add for lockage	..	10	..
	3	10	35
Running time	4	23	30

or 119½ hours; distance 345 miles.

	Miles per hour.
Average speed	2.89
Average speed, including ten hours for lockage	2.66
Average speed, including all detentions	1.65

Average speeds over special sections of the canal, exclusive of all detentions claimed except for running slow on account of fog and eel-grass, and eight minutes for each lock passed.

	Distance. Miles.	Running time. Hours.	Min.	Average speeds. Miles per hour.
West Troy to Schenectady	23	7	55	2.90
Schenectady to Utica.....	80	25	21	3.15
Utica to Syracuse.....	56	19	23	2.89
Syracuse to Rochester	93	37	7	2.51
Rochester to Buffalo.....	93	35	27	2.62

I joined the "Baxter" at West Troy, and accompanied her as far as Crescent. My notes are as follows: Left the weigh-lock at 12.53, P. M., and passed out of lock eighteen at 4.56, P. M. Time from West Troy, 4 hours and 3 minutes; time expended in passing through the sixteen locks, 92 minutes and 40 seconds; average time at each lock, 5 minutes and 45 seconds; maximum time of locking, 7 minutes; minimum time 5 minutes and 15 seconds; detentions, 35 minutes. Reached Crescent, 3 miles from lock eighteen, at 6 P. M; time from lock eighteen, one hour and four minutes. The performance of the machinery during this run, which was in the highest degree satisfactory, is sufficiently indicated by the following observed data:

Steam-pressure, high-pressure cylinder.....	74	pounds,
Steam-pressure, low-pressure cylinder.....	18.75	pounds,
Vacuum.....	15	inches,
Revolutions per minute.....	115	
Horse-power.....	32.23	

This run includes the passage of the Lower aqueduct, and for that reason the time was somewhat greater, and the speed less, than it would have been had no such obstructions been encountered.

FIRST TRIP EAST.

Left *Buffalo* at 3 P. M., Sept. 11th, 1872. Cargo, 7,200 bushels of corn; weight, $201\frac{6}{10}$ tons.

	Detentions. Hours.	Min.
Detained by boats aground at night.....	1	..
Detained at Black Rock, for stores.....	1	30
Detained running at $\frac{1}{2}$ speed, on account of low water,	4	..
Detained at Pendleton, aground, low water	5	15
Detained near Rochester by blockade of boats	..	30
Arrived at *Rochester* at 4.30 A. M., Sept. 13th.		
Detained east of Rochester by eel-grass, estimated....	25	15
Detained at Macedon by eel-grass	1	30
Detained by stone falling into canal from another boat,	8	..
Detained to adjust machinery.....		30

	Detentions. Hours.	Min.
Detained by blockade of boats	..	45
Detained at Montezuma on dry dock, to remove eel-grass from screws	6	..
Detained at Geddes for coal	1	30
Arrived at *Syracuse* at 7.30 P. M., Sept. 15th. (?)		
Detained at Syracuse by crowd of boats	..	30
Detained by running at ⅔ speed during a foggy night	3	..
Arrived at *Utica* at 9 A. M., Sept. 17th.		
Detained at Ilion for passengers	1	45
Detained running at ⅔ speed during a stormy and foggy night	2	..
Detained by a raft of logs	..	30
Detained by a blockade of boats	..	30
Detained at lock 23	6	..
Arrived at *Schenectady* at 9 P. M., Sept. 18th. (?)		
Detained above Cohoes by blockade of boats	2	..
Detained for drinking water	1	..
Detained adjusting machinery	..	30
Arrived at *West Troy* at 8.45 A. M., Sept. 19th.		
Total detentions claimed	73	30

Deductions.

	Days.	Hours.	Min.
Total time from Buffalo	7	17	45
Detentions claimed	3	1	30
Add for lockage	..	10	..
	3	11	30
Running time	4	6	15

or 102¼ hours; distance 345 miles.

Average speed ..... 3.38 miles per hour.
Average speed, including lockage ..... 3.07 miles per hour.
Average speed, including all detentions ..... 1.86 miles per hour.

Average speed over special sections of the canal, exclusive of all detentions claimed, except for running at part speed, and eight minutes for each lock passed:

	Distance. Miles.	Running time. Hours.	Min.	Aver. speed. Miles per hour.
Buffalo to Rochester	93	28	27	3.27
Rochester to Syracuse	93	44	45	2.08
Syracuse to Utica	56	36	28	1.54
Utica to Schenectady	80	24	11	3.31
Schenectady to Troy	23	5	35	4.11

The dates and hours of arrival at Rome and Fultonville are given in the clearance. The times from Rome to Utica, and from Fultonville to Schenectady, are estimated.

The detentions claimed for running at part speed, on account of eel-grass, darkness and fogs, no doubt occurred; but as they did not amount to actual stoppage, the precise effects could not be estimated. For this reason, these detentions have not been included with the other detentions, and will not be included in making up the speed over the special sections of the canal.

SECOND TRIP WEST.

Left *West Troy* at 3.30 P. M., September 30th, 1872. Cargo, 113⅛ tons of plaster.

	Detentions. Hours.	Min.
Detained at Cohoes by broken lock-gate	3	40
Arrived at *Schenectady* at 4.50 A. M., October 1st.		
Detained by lock out of order	..	15
Detained by blockade of boats	..	20
Detained above Fort Plain, to adjust rudder	..	30
Arrived at *Utica* at 9 A. M., October 2d.		
Detained at Utica	1	..
Arrived at *Rome* at 2.15 P. M.; distance 15 miles; time 4½ hours.		
Detained for castings	6	..
Detained by boat aground	3	..
Detained by two boats wedged at Eight-mile grocery,	3	..
Arrived at *Syracuse* at 9.30 A. M., October 3d.		
Detained by boats aground, and by low water between Lockport and Buffalo	9	..
Arrived at *Rochester* at ——, time not given.		
Arrived at *Buffalo* at 7 A. M., October 6.		
Total detentions claimed	26	45

Deductions.

	Days.	Hours.	Min.
Total time from West Troy	5	16	..
Detentions claimed	1	2	45
Add for lockage	..	10	..
	1	12	45
Running time	4	3	15

or 99¼ hours; distance 345 miles.

Average speed ..... 3.48 miles per hour.

Deducting from the detentions claimed, 9 hours (between Lockport and Buffalo), the average speed for the running time was ..... 3.19 miles per hour.

Including the 10 hours allowed for lockage, with the above detention, the running time was 118¼ hours, and the speed ..... 2.92 miles per hour.

Average speed, including all detentions ..... 2.53 miles per hour.

Average speeds over special sections of the canal, exclusive of all detentions claimed, with the exceptions already mentioned, and eight minutes for each lock passed:

	Distance. Miles.	Running time. Hours.	Min.	Aver. speeds. Miles per hour.
West Troy to Schenectady	23	7	30	3.07
Schenectady to Utica	80	24	41	3.24
Utica to Syracuse.....	56	17	58	3.12
Syracuse to Rochester	93	30	17	3.07
Rochester to Buffalo	93	30	17	3.07

I have here assumed that the speed was uniform between Syracuse and Buffalo, as the time of the arrival at Rochester has not been furnished. The actual speed, from Syracuse to Rochester, was undoubtedly less than that from Rochester to Buffalo; but just how much less, it is of course impossible to say.

SECOND TRIP EAST.

Left *Buffalo* at 12 o'clock noon, October 10, 1872. Cargo, 6,700 bushels of wheat; weight, 201 tons.

	Detentions. Hours.	Min.
Left *Lockport* at 8 P. M., October 10th.		
Detained at Brockport by crowd of boats.....	1	..
Arrived at *Rochester* at 1.30 P. M., October 11th.		
Detained by a boat tied up	1	..
Detained at Palmyra.	2	..
Detained at Jordan to clean and calk boat.....	12	..
Arrived at *Syracuse* at 2 P. M., October 13th.		
Detained at Syracuse by crowd of boats.....	1	..
Detained by block of wood in screw.....	1	..
Arrived at *Utica* at 3.50 P. M., October 14th.		
Detained at Frankfort, on dry dock, putting wearing strips on bilges, which had been badly worn by grounding and rubbing on the slope-walls	22	..
Detained at Schoharie creek by low water on short level, which had been drawn down in order to repair lock-gate.....	2	..
Arrived at *Schenectady* at 9.20 P. M., October 16th.		
Detained at Phillips' locks by crowd.....	1	15
Arrived at *West Troy* at 8 A. M., October 17th.		
Total detentions claimed.....	41	15

Deductions.

	Days.	Hours.	Min.
Total time from Buffalo	6	20	..
Detentions claimed	1	17	15
Add for lockage	..	10	..
	2	3	15
Running time	4	16	45

or 112¾ hours; distance 345 miles.

Average speed ..... 3.06 miles per hour.
Average speed, including lockages ..... 2.81 miles per hour.
Average speed, including all detentions ..... 2.10 miles per hour.

In making up the speeds over the special sections, no deduction is made from the detentions claimed. The necessity for the delay at Frankfort was due to the obstinacy of horse-boat captains, in refusing to afford facilities for passing, and in putting the steamer aground or upon the slope-walls unnecessarily. These speeds will then stand as follows:

	Distance. Miles.	Running time. Hours.	Min.	Aver. speeds. Miles per hour.
Buffalo to Rochester	93	23	42	3.92
Rochester to Syracuse	93	32	22	2.88
Syracuse to Utica	56	23	18	2.40
Utica to Schenectady	80	28	6	2.85
Schenectady to Troy	23	6	45	3.41

On the 16th I joined the Baxter at 11.15 P. M., just below lock 21, and accompanied her to Troy. The following notes were made during the run: Arrived at lock 20, at 12.20 A. M., 17th; left lock 20, at 12.25; arrived at lock 19, three miles, at 1.20; left lock 19, at 1.30; found level very low; arrived at lock 18, at 4.15 A. M., having made the run of nine miles, including the Lower Aqueduct, in 2¾ hours; left lock 3 at 8.10 A. M., time occupied in running from lock 18, to lock 3, including passage of both, 3 hours and 55 minutes. During the last four hours a very thick fog prevailed, and it was found necessary to move very slowly and with great caution between the locks.

THIRD TRIP WEST.

Left West Troy at 7 A. M., October 29th, 1872; cargo 114½ tons of iron ore.

	Detentions. Hours.	Min.
Detained, waiting for turn at lock	..	35
Detained by a boat across the canal	..	5
Detained at Upper Aqueduct locks, waiting for turn to lock	..	40

	DETENTIONS. Hours.	Min.
Detained at Phillips' lock, lock out of order	..	30
Arrived at *Schenectady* at 6 P. M., Oct. 29th.		
Detained at Schenectady, at collector's office.....	..	15
Detained, dark, foggy night, run very slow; no claim for detention.....	..	..
Detained at Fultonville, cause not stated	4	..
Detained at Little Falls to repair pump	4	15
Detained at Frankfort, lock out of order	1	..
Arrived at *Utica* at 8 A. M., October 31st.		
Detained west of Utica, lock out of order.....	..	15
Time from Utica to Rome 4½ hours.		
Detained by crowd of boats	..	20
Arrived at *Syracuse* at 2 A. M., November 21st.		
Detained at Port Byron by crowd of boats	1	..
Detained by boat across the canal	..	15
Detained at Lyons by crowd of boats, lock-tender refused to give steamer the preference	2	20
Detained, waiting for turn at lock.....	..	15
Detained, waiting for turn at lock during night	1	30
Detained at Fairport for coal	1	10
Arrived at *Rochester* at 2 P. M., November 2d.		
Detained, waiting for turn at lock	1	5
Detained at Tonawanda by crowd of boats.....		15
Arrived at *Buffalo* at 5 P. M., November 3d.		
Total detentions claimed.....	19	45

Deductions.

	Days.	Hours.	Min.
Total time from Troy	5	10	..
Detentions claimed..... ..	19	45	
Add for lockage	10	..	
	1	5	45
Running time	4	4	15

or 100¼ hours; distance 345 miles.

Average speed.... ..... 3.45 miles per hour.
Average speed, including lockages ..... 3.13 miles per hour.
Average speed, including all detentions ..... 2.65 miles per hour.

Average speed over special sections of the canal, exclusive of all detentions claimed, and eight minutes for each lock passed:

	Distance. Miles.	Running time Hours.	Min.	Average speeds. Miles per hour.
West Troy to Schenectady	23	7	30	3.07
Schenectady to Utica.....	80	25	26	3.15
Utica to Syracuse.....	56	16	53	3.32
Syracuse to Rochester	93	27	22	3.39
Rochester to Buffalo	93	24	52	3.74

THIRD TRIP EAST.

Left Buffalo at 12.30 P. M., November 9th, 1872; cargo 6,700 bushels of wheat; weight 201 tons.

	DETENTIONS. Hours.	Min.
Detained at Tonawanda by rafts	1	15
Detained near Lockport by boats across the canal	2	15
Detained below Lockport by same cause	1	50
Detained for provisions	..	15
Arrived at *Rochester* at 6.15 P. M., Nov. 10th.		
Detained by crowd of boats at Rochester	1	40
Detained at Brighton lock	..	30
Detained at Waynesport by boats aground	2	10
Detained at Macedon locks by crowd of boats	1	20
Detained at Port Gibson, passing boats	..	10
Detained at Newark for coal	2	..
Detained waiting turn at lock	..	20
Detained by raft of timber	..	25
Detained by boat aground	..	20
Detained by level below Lock Berlin, 18 inches low	..	35
Detained by passing boats near Clyde	..	10
Detained by crowd of boats	..	15
Detained at Montezuma, crowd of boats	1	30
Detained at Port Byron, passing boats	..	35
Detained at Centreport, crowd of boats	..	20
Detained at Weedsport, crowd of boats	..	20
Detained at Cold Spring, crowd of boats	..	15
Detained at Jordan, crowd of boats	..	30
Detained by lines across canal	..	20
Detained at Canton, crowd of boats	..	10
Detained below Canton, crowd of boats	..	10
Detained by crowd of boats	..	10
Arrived at *Syracuse* at 1.30 P. M., Nov. 12th.		
Detained at Syracuse, crowd of boats	1	30
Detained at Lodi lock, waiting for turn	..	15
Detained at Thompson's lock, waiting for turn	..	10
Detained by boats aground	..	10
Detained at Kirkville, crowd of boats	..	30
Detained at Durhamville, crowd of boats	1	..
Detained between Rome and Utica, passing boats	..	20
Arrived at *Utica* at 1.10 P. M., Nov. 13th.		
Detained at Utica weigh-lock removing old line and wire from screws	..	35
Detained waiting to pass boats between Utica and Ilion,	..	30
Detained at Canada creek, crowd of boats	1	30
Detained by tow-line in wheel	..	30
Detained at Fultonville for coal and stores	..	40
Detained in passing steam-tug "Noyes" with two boats in tow	..	20
Detained at Upper lock at Schoharie creek	..	15
Arrived at *Schenectady* at 7 P. M., Nov. 14th.		

	Detentions. Hours.	Min.
Detained at Schenectady by crowd of boats.....	..	20
Detained at Crescent, boat aground across canal	1	..
Arrived at *West Troy* at 6.30 A. M., Nov. 15th.		
Total detentions claimed	29	..

Deductions.

	Days.	Hours.	Min.
Total time from Buffalo	5	18	..
	Days.	Hours.	Min.
Detentions claimed.....	1	5	..
Add for lockage	..	10	..
	1	15	..
Running time	4	3	..

or ninety-nine hours; distance 345 miles.

Average speed	3.48 miles per hour.
Average speed, including lockage.....	3.16 miles per hour.
Average speed, including all detentions.....	2.50 miles per hour.

Average speeds over special sections of the canal, exclusive of all detentions claimed, and eight minutes for each lock passed:

	Distance. Miles.	Running time. Hours.	Min.	Aver. speed. Miles per hour.
Buffalo to Rochester	93	27	42	3.32
Rochester to Syracuse	93	27	12	3.45
Syracuse to Utica	56	20	43	2.70
Utica to Schenectady.....	80	22	41	3.52
Schenectady to Troy	23	7	30	3.07

On the 12th of November I joined the "Baxter" at Syracuse, and accompanied her as far as Schenectady. My own notes, taken during the run, so far as relates to speed, are as follows: Joined the Baxter at the Syracuse weigh-lock at 2.20 P. M. Left lock 47, at the west end of the long level, at 3.27 P. M.; arrived at Orville feeder, four miles, at 4.59; detained fifteen minutes by a boat across the canal; from 5 to 5.07 aground; arrived at Kirkville at 7.05; detained at Kirkville thirty minutes by a crowd of boats; arrived at Bolivar at 8.40; arrived at Canastota at 11.30; arrived at Rome collector's office at 7.55 A. M., Nov. 13th; detained at Rome twenty minutes by crowd of boats; arrived at Oriskany, eight miles from Rome, at 10.40; passed Whitesboro at 11.30 A. M.; and arrived at Utica at 1.10 P. M. Made the run from Rome to Utica, fifteen miles, in four hours and fifty-five minutes. Detained at Utica weigh-lock thirty-

five minutes to remove masses of old tow-line, wire fence and other rubbish, which had accumulated upon the screws. Left Utica at 1.45 P. M.; passed West Frankfort lock at 4.30; passed Ilion at 6, and arrived at Little Falls at 9.30 P. M. Time from Rome, including all detentions, thirteen hours and thirty-five minutes; distance thirty-eight miles; average speed, including all detention, 2.8 miles per hour. Passed Mindenville at 12.30 A. M., Nov. 15th; stopped in a jam at 1.10 A. M., and left at 2.35 A. M.; arrived at Fultonville at 9.05 A. M. Stopped at Fultonville forty minutes for coal and stores, and left at 9.45; arrived at Schoharie creek, five miles, at 11.23 A. M. The steam-tug "S. R. Noyes," with two boats in tow and burning three tons of coal per day, left Fultonville just as the "Baxter" arrived. At Schoharie creek lock, the "Noyes" was overtaken by the "Baxter," the former leaving the lock only one minute in advance of the latter. The "Noyes" left the lock, made up her tow and was just getting under way, when the "Baxter" attempted to pass. The "Noyes" refusing to stop, the "Baxter" went aground in her effort to pass. She was soon afloat again and renewed the attempt to pass the tow; after passing the rear boat, the captain of the forward boat peremptorily ordered the "Noyes" to stop, threatening to cut her lines if she persisted in refusing to do so. The "Noyes" then stopped and the "Baxter" passed, after having been detained about twenty minutes. Passed Port Jackson at 1.40 P. M.; passed Hoffman's Ferry at 3.50 P. M.; reached lock 23, at 6.07 and arrived at Schenectady at 7 P. M. The detention caused by a tow-line in the screw, and which is noted in Mr. Baxter's statement, actually occurred, but I neglected to note the time or place. It thus appears that my record agrees substantially with that portion of Mr. Baxter's statement which relates to this part of the trip. From the foregoing notes I make the following deductions: Total time from Syracuse to Schenectady, fifty-two hours and forty minutes; distance 136 miles; average speed, including all detentions, 2.33 miles per hour; average speed, exclusive of twenty-eight lockages, at eight minutes each, 2.78 miles per hour; average speed, exclusive of all detentions except those due to the passage of about 100 loaded boats, which could not be estimated, 3.06 miles per hour.

The engines worked smoothly and well during the entire run, as they did at all times when I was on board, and gave no trouble whatever, beyond the repairing of the blower-belt on a single occasion. The boiler also performed well, doing all that, and even more than I supposed it capable of doing. However, being driven beyond its

capacity, its endurance will very likely prove less than might be expected from a similar boiler of suitable size.

SUMMARY OF THE "BAXTER'S" TRIPS.

TRIPS.	Cargoes, tons.	Times between Buffalo and Troy.									Average speeds, miles per hour.
		Total.			Detentions, including lockages.			Running time.			
		D.	H.	M.	D.	H.	M.	D.	H.	M.	
First trip west	102.25	8	10	5	3	10	35	4	23	30	2.89
First trip east	201.60	7	17	45	3	11	30	4	6	15	3.38
Second trip west	113.13	5	16	0	1	12	45	4	3	15	3.48
Second trip east	201.0	6	20	0	2	3	15	4	16	45	3.06
Third trip west	114.5	5	10	0	1	5	45	4	4	15	3.45
Third trip east	201.0	5	18	0	1	15	0	4	3	0	3.48
Means	.....	6	15	18⅗	2	5	48⅗	4	9	30	3.29

The only uncertain element in the above is that of detention. How far the detentions claimed may be relied upon, as having actually occurred, of course I cannot undertake to say; except so far as my own personal observation has enabled me to judge of the probable reliability of the statements made. While I do not believe that those detentions, which resulted from the causes stated, exceeded in duration the time claimed, I am inclined to believe that any excessive claim for detention, which the competitor may possibly have made, will find an offset in other detentions, which, from their nature, could not be estimated,

POWER EXPENDED, AND "SLIP" OF SCREWS.

On the 29th of August, the "Baxter," laden with 102¼ tons, ran from the head of the 16 locks at Cohoes, to Crescent, including the passage of the Lower Aqueduct, in just one hour. The distance is called three miles. During the first half hour, the steam, revolutions and speed were better than they were during the last half hour. The speed, over the ground, during the first half hour, was estimated to be at the rate of 3½ miles per hour. This result was arrived at by observing the time required by the boat to move its own length over the ground; this time, observed several times, was found to vary from 18 to 20 seconds. A mean of four observations, made at the same time, gave the following data for the power which was being developed by the engines:

Steam, high-pressure cylinder	74	pounds.
Steam, low-pressure cylinder	18.75	pounds.
Vacuum	15	inches.
Revolutions per minute	115	
Cut-off in each cylinder	⅞	

With these data, an approximate estimate of the power is made thus:

Speed of pistons, feet per minute	230.
Area of high-pressure piston, square inch	38.48
Area of low-pressure piston, square inch	113.09
Mean pressure, per cent of initial	96.
Mean pressure on high-pressure piston, per square inch, pounds $(72+14.7)\,0.96=$	83.23
Deduct back pressure $(18.75+14.7)$	33.45
Mean effective pressure on high-pressure piston, pounds per square inch	49.78
Mean pressure on low-pressure piston, pounds per square inch $(18.75+14.7)\,0.96=$	32.11
Deduct back pressure, half atmosphere	7.35
Mean effective pressure on low-pressure piston, pounds per square inch	24.76
Total mean effective pressure on high-pressure piston, pounds $38.48\times 49.78=$	1915.53
Total mean effective pressure on low-pressure piston, pounds $113.09\times 24.76=$	2800.11

Therefore,

$$\text{H. P.} = \frac{(1915.53+2800.11)\times 230}{33000} = 32.87$$

Subsequent observations showed that in this part of the canal the velocity of the current was about half a mile an hour. It follows, then, that the steamer was running through the water at a speed of four miles per hour, and that the actual "slip" of the screws was $\frac{4\times 115-4\times 88}{4\times 115}\times 100=23\frac{1}{2}$ per cent, while the *apparent* slip was $\frac{1\times 115-3.5\times 88}{4\times 115}\times 100=33$ per cent. The boat at this time was drawing only three feet nine inches of water, and hence the screws were not fully immersed. For this reason, both the power and the slip were greater than they would have been had the same useful work been accomplished by the same screws wholly immersed.

On the 13th of November, while the "Baxter" was making her final trip east, observations were made between Oriskany and Utica, while the boat was running at a speed of three and one-half miles per hour over the ground. The results of these observations were as follows:

Steam pressure in high-pressure cylinder	65 pounds.
Steam pressure in low-pressure cylinder	12 pounds.
Vacuum	$17\frac{1}{2}$ inches.
Revolutions, per minute	88

From these data it appears that the power which was being developed at the time was 21.61 horses. At this point the speed of the current was small and uncertain; it was, however, in the direction in which the boat was moving. The apparent slip of the screws was $\frac{4\times88-3\frac{1}{2}\times88}{4\times88}\times100=12\frac{1}{2}$ per cent. If the current was half a mile an hour, the actual slip was twenty-five per cent.

Again, on the 15th of November, observations were made a short distance east of East Canada creek, with the following results:

Steam pressure in high-pressure cylinder	75 pounds.
Steam pressure in low-pressure cylinder	18 pounds.
Vacuum	16 inches.
Revolutions per minute	102

The power estimated from these data was 29.75 horses. No note was made of the speed, on account of the darkness, which prevented reliable observations for that purpose.

Finally, on the 15th of November, while the "Baxter" was overhauling the "Noyes," between Fultonville and Schoharie creek, observations were made with the following results:

Steam pressure in high pressure cylinder	60 pounds.
Steam pressure in low pressure cylinder	15 pounds.
Vacuum, about	20 inches.
Revolutions per minute	88

These data indicate a power of 22.8 horses. The speed was not noted; but as the run of five miles was made in one hour and thirty-eight minutes, without detention, it is safe to say that the speed was not less than three miles an hour over the ground. The velocity of the current was not known, nor were there any means by which it could be ascertained at the time of these observations. If, however, we assume it to have been half a mile an hour, the speed of the boat through the water was only two and one-half miles an hour; and the real slip of the screws thirty-seven and one half per cent, while the apparent slip was twenty-five per cent. It is probable that the real speed of the boat at this time was in fact three and one-half miles per hour; for the average speed for running time for the entire trip from Syracuse to Schenectady was over three miles, without taking account of the loss of time in passing boats, and in stopping and getting under way at locks. If the speed was three and a half miles over the ground, or three miles through the water, the real and apparent slips were twenty-five and twelve and a half per cent respectively.

On the 15th of November, the "Baxter" attained a speed of four

miles per hour on the canal in West Troy, and made the run from the Lower side-cut to a point in Albany below the new railroad bridge in fifty-five minutes.

The average of the four determinations of power is 26.76 horses; but as one of these results only was obtained when the steamer was running against the current, while three were obtained while she was running with the current, more weight should obviously be attached to the former than to the latter. Giving to the former *three times* the weight that is given to the latter, the average power is 28.8 horses. It is believed that twenty-eight horses and thirty per cent are fair averages for the power and "slip" respectively.

COAL CONSUMPTION AND DISTANCE STEAMED.

The coal consumption for each trip has not been reported; but all the coal bills have been furnished, showing that the total consumption of coal, both for steam and cooking, from the time the "Baxter" was launched until she was finally laid up at Fishkill, was 85,130 pounds, or about 42½ tons. The cost of this coal was $261.60, or at the rate of $6.15 per ton. The total distance steamed by the "Baxter" appears to have been as follows:

Six trips between Troy and Buffalo	2,070 miles.
Four trips between Troy and New York	600 miles.
Trial trips about Fishkill	40 miles.
One trip from Troy to Waterford and return	8 miles.
Trips about the harbors of New York and Buffalo	25 miles.
Total	2,743 miles.

The time occupied in making these runs extended from the 24th of August, on which day the first trial trip was made, to the 18th of November, on which day the "Baxter" arrived in New York with her third cargo from Buffalo. Of the eighty-six days thus occupied, twenty-six days were spent in New York, Troy and Buffalo, with fire in the furnace and steam up.

Applying the total coal consumption to the whole number of miles steamed, the average is 31.04 pounds per mile, and the cost per mile, for fuel alone, 9.545 cents. At three miles per hour, the hourly consumption of coal is 93.12 pounds.

For the actual running time, however, the consumption and cost must have been less, but just how much less, it is of course impossible to say. That the above results are not too small, seems to be proven

by the results of observations made for eighteen hours, beginning at 8.45 A. M., November 14th, and ending at 2.45 A. M., November 15th. During that time the hourly consumption of coal—which was checked every six hours—was very uniformly eighty pounds per hour, or 26⅔ pounds per mile. At this rate of consumption, the costs of fuel per hour and per mile were 24.6 and 8.2 cents respectively. Finally, as indicating the probable accuracy of the reported coal consumption, I refer to the very small grate surface of the "Baxter's" boiler.

GENERAL DEDUCTIONS.

Tons moved one mile on the canal, including boat	440,047
Tons moved one mile, cargo	322,057
Boat miles, on the canal	2,070
Coal consumed on the canals, pounds	64,253
Power employed, average, horses	28
Days occupied in making the three round trips, including one trip to New York	78
Average length of round trip, days	26
Coal consumption, per boat mile, pounds	31.04
Coal consumption, per hour, at three miles per hour	93.12
Coal consumption, per day, at three miles per hour	2234.88
Coal consumption, per ton mile, including boat	0.146
Coal consumption, per ton mile, cargo	0.1995
Cost of coal, per boat mile, cents	9.545
Cost of coal, per ton mile, including boat, cents	0.0449
Cost of coal, per ton mile, cargo, cents	0.0613
Average coal per horse power, per hour, pounds	3.33

AVERAGE SPEEDS OVER SPECIAL SECTIONS OF THE CANAL.

Trips East.

BETWEEN	Distance, miles.	AVERAGE SPEED—MILES PER HOUR. First trip.	Second trip.	Third trip.	Means.
Buffalo and Rochester	93	3.27	3.92	3.32	3.50
Rochester and Syracuse	93	2.08	2.88	3.45	2.80
Syracuse and Utica	56	1.54	2.40	2.70	2.21
Utica and Schenectady	80	3.31	2.85	3.52	3.23
Schenectady and Troy	23	4.11	3.41	3.07	3.53

Trips West.

BETWEEN	Distance, miles.	AVERAGE SPEED—MILES PER HOUR.			
		First trip.	Second trip.	Third trip.	Means.
Buffalo and Rochester	93	2.62	3.07	3.74	3.14
Rochester and Syracuse	93	2.51	3.07	3.39	2.99
Syracuse and Utica	55	2.89	3.12	3.32	3.11
Utica and Schenectady	80	3.15	3 24	3.15	3.18
Schenectady and Troy	23	2.90	3.07	3.07	3.01

Trips East and West.

BETWEEN	Distance, miles.	AVERAGE SPEED—MILES PER HOUR.		
		East.	West.	Means.
Buffalo and Rochester	93	3.50	3.14	3 32
Rochester and Syracuse	93	2.80	2.99	2.89
Syracuse and Utica	55	2.21	3.11	2.60
Utica and Schenectady	80	3.23	3.18	3.27
Schenectady and Troy	23	3.53	3.01	3.2

From the numbers in the final columns of the last three tables, by attaching to each speed a value corresponding to the distance to which it applies, the following results are obtained:

Average speed from Troy to Buffalo, miles	3.08
Average speed from Buffalo to Troy, miles	3.04
Average speed for the entire distance, steamed on the canal, miles	3.06

The final result is less than that in the "Summary of the 'Baxter's' performance," for the reason that, in making up the speeds over the special sections of the canal, those detentions claimed for running at part speed, on account of darkness, fog and eel-grass, and for all other causes which did not cause actual stoppage of the boat, were disallowed.

At 3.06 miles per hour, the time from Buffalo to Troy is 112¾ hours, or four days and sixteen and three-quarter hours. Adding the ten hours which have been allowed for lockage, the time is 122¾ hours, or five days two and three-quarter hours; and the average speed, including lockages, 2.81 miles per hour. Adding thirty hours for the trip from Troy to New York, the total time from Buffalo to New York is 152¾ hours, or six days eight and three-quarter hours;

and the average speed for the entire run from Buffalo to New York, 495 miles, is 3.24 miles per hour, including lockages on the canal.

In judging of the performance of the "Baxter" and of the capabilities of the system which she represents, some importance should, I think, be attached to the fact that neither the inventor nor the builder had any acquaintance with or experience in canal navigation, until this steamer entered the canal on the 29th of August last. It is, therefore, reasonable to assume that, with the experience gained and the opportunities for observation afforded, during the time occupied by the "Baxter" in making her trips, modifications and improvements have been suggested, which, when carried into effect, will insure still better results; even with the canal in the same condition that it was during the season of 1872.

It has been objected by some that the "Baxter" is too light and frail, and, hence, that her endurance will be far less than that of the ordinary boat. It is to be remembered, however, that the necessity which exists for great weight and strength in the ordinary horse-boats, grows out of the frequent and severe shocks to which they are subjected, from unavoidable collisions with other boats, and with the banks and structures of the canal. These collisions occur in most cases for the reason that the horse-boat possesses no means, within itself, of controlling its movements. With the steamer, the case is different; carrying her own power, she can go ahead, stop or back, as occasion may require, and thus, to a great extent, avoid collision and the resulting injuries. For this reason, the boat which is propelled by steam need not be so heavy or strong as the horse-boat is required to be. In case, however, experience shall demonstrate that the "Baxter" lacks strength, boats may be built upon the same model, six inches wider and two feet longer, and with a displacement, when drawing six feet of water, of at least 277 tons; or, if it be desirable, the bow may be made fuller and the displacement increased to 280 tons.

The economy of the compound engine for canal purposes seems to be demonstrated so far as it can be by a single experiment; and while these engines are necessarily more complex than the ordinary single engine, no extraordinary or uncommon skill is required in their management. The objectionable feature of complexity is far more than compensated by the advantages which they possess in the economy of fuel and in the condensing arrangement.

As an experiment, at least, I regard the "Baxter" as eminently successful.

IV. *Description and performance of the steamer "Chas. Hemje."*

The "Hemje" was built in Buffalo by Mr. Geo. H. Notter. In model and manner of building she differs but little from the ordinary lake boat, having the full bow of the latter, but being sharper at the stern to permit the water to reach the screw.

The weight of the "Hemje," including machinery, fuel and stores, is about seventy-eight and three-quarter tons; her motive power consists of a single upright non-condensing engine, with cylinder 14 inches in diameter and 12 inches stroke of piston; steam cut-off at half stroke.

The boiler is horizontal, is four feet nine inches in diameter and eight feet long, with return tubes, and has a grate surface of thirteen square feet. I have no further information as to the other general dimensions, or as to the details of the boiler; it is, however, of the usual form, and steams well when well fired. The exhaust steam may be turned into the smoke-pipe whenever it is found desirable or necessary to supplement the natural draught.

The "Hemje's" screw is an ordinary four-bladed true screw, four feet six inches in diameter, and having a pitch of six feet six inches.

The peculiar feature of this boat consists in a cylindrical casing of boiler iron, having its axis horizontal, and inclosing the screw which revolves within, but without connection with it. This cylinder or tube is from three to four feet in length, and in internal diameter exceeds the screw by about an inch, possibly two inches. It is mounted upon a vertical axis, occupying the position and performing the functions of the ordinary rudder post, and may be revolved by and about the latter through an angle of ninety degrees—forty-five degrees to starboard or port—thus serving the purpose of the rudder, which is dispensed with.

Mr. Hemje contends that the screw, being surrounded by this casing, will expend its entire force directly astern, and that any lateral disturbance of the water, which might cause it to act injuriously upon the banks of the canal, is entirely prevented.

Certified copies of the "Hemje's" clearances have been furnished, together with a statement of her detentions, with their causes, and of the coal burned during each trip. From these, the latter being verified by the oath of Mr. Hemje, the following log of the several trips made by the "Hemje" has been made up:

FIRST TRIP EAST.

Left Buffalo at 11 A. M. September 27th, 1872. Cargo, 7,200 bushels of corn; weight, 201.6 tons. Draft of water, six feet.

	DETENTIONS. Hours.	Min.
Detained leaving slip, aground	1	..
Detained at York-street bridge	1	40
Detained at Tonawanda, aground on sunken logs near railroad bridge	2	30
Detained near Rickardsville, aground on sunken boat	22	30
Detained at Pendleton, laid up; water 18 inches low	10	15
Detained at Lockport to repair damages received while aground, and to change part of crew	47	55
Detained by a boat across the canal	..	20
Detained near Hulberton, aground, water low	1	15
Detained east of Hulberton, aground, water low	..	15
Detained by nine boats, canal blockaded	..	30
Detained near Rochester by three boats aground	..	15
Arrived at *Rochester* at 7 A. M., October 2d.		
Detained at Rochester in passing out of weigh-lock, caught line in wheel	3	15
Detained, waiting for turn at lock—locking rafts	..	15
Detained passing a loaded boat, the captain of which refused to lay in to the tow-path	..	20
Detained one-half mile east of Macedon lower lock, aground	2	35
Detained passing a boat which would not lay in to the tow-path; had to "bank" him	..	20
Detained at Clyde, could not get to the lock on account of rafts	..	20
Detained at Port Byron in the night; lock-tenders would not open gates, and refused to give reason for their refusal	1	20
Detained at coal-yard, aground, and steersman sick	20	40
Detained, aground, in trying to pass a horse-boat, captain refusing to lay in	..	15
Detained, aground, in trying to pass two boats which were also aground	1	..
Detained 150 yards west of Geddes, fence post with iron wire and a grappling-hook in wheel	5	30
Arrived at *Syracuse* at 12 o'clock, noon, October 5th.		
Detained at Syracuse, waiting to get a steersman to relieve another who was sick	4	..
Detained, aground, in trying to pass twenty-five boats which were laid up	..	45
Detained by boats refusing to lay in	..	15
Detained by low water, aground	2	..
Detained at Rome, aground, low water	1	15
Arrived at *Utica* at 6.45 P. M., October 6th. (Time from Rome to Utica just five hours.)		

	Detentions. Hours.	Min.
Detained at Utica	..	15
Detained by a dozen boats aground	..	30
Detained at Little Falls for coal	6	15
Detained by boat across canal	..	20
Detained by low water, aground	..	20
Detained in clearing the canal of a jam of forty boats	3	25
Arrived at *Schenectady* at 8.30 A. M. October, 8th.		
Detained at Schenectady	1	..
Detained in a crowd at Upper Aqueduct	2	..
Detained for wood, water and provisions	..	45
Detained in passing a boat, the captain of which refused to lay in, entering aqueduct, and meeting boats bound west	..	30
Arrived at *West Troy* at 10.15 P. M., October 8th.		
Total detentions claimed	147	50

Deductions.

	Days.	Hours.	Min.
Total time from Buffalo	11	11	15
	Days.	Hours.	Min.
Detentions claimed	6	03	50
Add for lockage	..	10	..
	6	13	50
Running time	4	21	25

or $117\frac{5}{12}$ hours; distance 345 miles.

	Miles per hour.
Average speed	2.94
Average speed, including lockage	2.71
Average speed, including all detentions	1.25

Average speed over special sections of the canal, exclusive of all detentions claimed, and eight minutes for each lock passed.

	Distance. Miles.	Running time. Hours.	Min.	Average speed. Miles per hour.
Buffalo to Rochester	93	26	47	3.47
Rochester to Syracuse	93	39	02	2.38
Syracuse to Utica	56	21	58	2.55
Utica to Schenectady	80	23	36	3.39
Schenectady to Troy	23	6	50	3.37

The trip from Albany to New York was made in twenty-nine and one-half hours, running time. Average speed on the river, 4.9 miles per hour. Coal consumption from Buffalo to New York, fifteen and one-half tons, or at the rate of sixty-two pounds per mile. The consumption per mile, on the canal, was of course greater, and that on the river less, than sixty-two pounds; but owing to the serious delays

on the canal, it is impossible to assign proper values to the canal and river portions of the trip.

FIRST TRIP WEST.

Left *New York* at 9 P. M., October 17th, with a cargo of 140 tons of coal for Buffalo. Encountered thick fog and a freshet in the upper portion of the river; running time, from New York to Troy, thirty-six and a half hours; average speed on the river, 4.11 miles per hour.

Left *West Troy* at 5.30 P. M., October 20th.

	DETENTIONS. Hours.	Min.
Detained in passing the sixteen locks, waiting for locks,	..	15
Arrived at *Schenectady* at 4.30 A. M., Oct. 21st.		
Detained in trying to pass several boats, went aground,	1	25
Detained west of Fultonville, aground, trying to pass boats	1	20
Detained on a foggy night, aground	3	..
Detained at Little Falls, for coal	4	45
Detained in passing scow, captain refusing to lay in	..	15
Detained in getting past two light boats, which were kept swinging across the canal to prevent steamer passing	..	15
Detained in Utica, aground under bridge, ten feet from abutment	..	35
Arrived at *Utica* collector's office, at 5.55 P. M., October 22d.		
Detained at Utica for provisions	1	45
Detained aground	..	20
Detained by boat across the canal	..	15
Detained in passing a boat, the captain refusing to lay in,	..	12
Arrived at *Syracuse* at 1.15 P. M., October 23d.		
Made the run from Utica to Syracuse—56 miles, in 17 hours, 35 minutes, including all detentions; average speed, 3.18 miles per hour.		
Detained at Syracuse; captain left boat and refused to return	3	45
Detained west of Syracuse, aground, low water	..	25
Detained, laid up during a foggy night; had to run very slow before laying up	4	..
Detained to file and line brasses	4	15
Detained in jam and waiting for lock	1	45
Arrived at *Rochester* 11 A. M., October 25th.		
Detained at Rochester for provisions	1	..
Detained passing a boat; towed it a mile and was aground twice	..	15
Detained by boats which were tied up; had to wait for boats moving east	..	12
Detained at Albion; a very dark, stormy night	6	40
Detained for coal and repairs	2	..

	Detentions. Hours.	Min.
Detained by crowd of boats	..	15
Detained at Pendleton by crowd of fifty to sixty boats,	13	..
Detained trying to relieve a horse-boat, which was aground or on a rock	1	..
Detained at Black Rock, unable to pass boats in the narrow water	..	10
Detained near Buffalo by six boats aground	1	..
Arrived at *Buffalo* at 4.30 P. M., October 27th.		
Total detentions claimed	54	4

Coal consumption, between New York and Buffalo, fifteen tons.

Deductions.

	Days.	Hours.	Min.
Total time from West Troy	6	23	..
Detentions claimed	2	6	4
Add for lockage	..	10	..
	2	16	4
Running time	4	6	56

or 102.93 hours; distance 345 miles.

	Miles per hour.
Average speed	3.35
Average speed, including lockage	3.05
Average speed, including all detentions	2.07
Average speed on the river	4.11

Average coal consumption per mile, for the entire run from New York, 60½ pounds.

Average speeds over specical sections of the canal, exclusive of all detentions claimed and eight minutes for each lock passed:

	Distance. Miles.	Running time. Hours.	Min.	Average speeds. Miles per hour.
Troy to Schenectady	23	9	5	2.51
Schenectady to Utica	80	21	46	3.67
Utica to Syracuse	56	16	16	3.44
Syracuse to Rochester	93	29	27	3.16
Rochester to Buffalo	93	27	10	3.42

The effect of the horse disease in causing delay to the steamer will be observed in the number and character of the detentions claimed during the latter part of this trip. The slight delay properly chargeable to the machinery will also be noticed.

SECOND TRIP EAST.

Left Buffalo at 4.30 P. M., November 2d, 1872. Cargo, 6,700 bushels of wheat; weight, 201 tons.

	DETENTIONS. Hours.	Min.
Ran upon two rocks in Black Rock harbor and began to make water.		
Detained at Black Rock, to ascertain extent of the damage; found three inches of water in the bow	..	30
Detained at Tonawanda to procure additional pump, leak increasing	2	30
Detained at Pendleton, canal blockaded	2	..
Detained at Lockport, on dry-dock repairing damages,	39	..
Detained for repairs; upper gib and key of connecting-rod came out; engine disabled	6	..
Detained two miles west of Rochester, ran upon a rock twenty-five to thirty feet from berme; had to send to Rochester twice for assistance	19	30
Detained by crowd of boats at Rochester aqueduct	..	25
Arrived at *Rochester*, at 3.15 P. M., November 6th.		
Detained at Rochester weigh-lock	..	45
Detained at first lock east of Rochester; had just passed a horse-boat; lock-tender refused to lock the steamer; superintendent ordered steamer to fall back; did so, and allowed horse-boat to pass	..	40
Detained at third lock east of Rochester, waiting at lock; lock-tender refused to lock the steamer, saying that he had orders from the superintendent not to give steamer precedence	1	..
Detained at Pittsford by blockade	..	40
Detained near Lockville, aground	1	30
Detained at lock, canal blockaded	1	15
Detained at Clyde for coal and stores	1	30
Detained by getting aground twice	1	55
Arrived at *Syracuse* at 12.25 P. M., November 8th.		
Detained at Syracuse for coal and to clear the screw	4	..
Detained in passing a boat which was aground near tow-path; the "Hemje" grounded in five feet ten inches of water	2	35
Detained at Manlius; found eight or ten boats aground, and was compelled to lay up until morning	9	05
Detained at Chittenango, to key up	..	15
Detained at Canastota for water and provisions	..	25
Detained near Durhamville, aground in passing boats,	..	15
Detained near Dumbarton, aground	..	20
Detained near Higginsville, aground		10
Detained at Rome, to telegraph	..	40
Detained in passing many boats at night	..	15
Arrived at *Utica* at 3.40 A. M., November 10th.		
Detained at Utica to clear mass of iron fence-wire from screw	..	45

	Detentions. Hours.	Min.
Detained near Frankfort, aground	..	15
Detained by blockade of boats at lock	..	20
Detained, aground	1	20
Detained west of Schenectady, aground	..	40
Arrived at *Schenectady* at 9.30 A. M., November 11th.		
Detained at Upper Aqueduct by boats aground across the canal	2	..
Detained above lock 19, aground	..	15
Detained at head of sixteen locks; found canal blockaded,	1	..
Detained between locks 10 and 11, aground	..	45
Detained between locks 9 and 10, aground	..	30
Arrived at *West Troy* at 11.30 P. M., November 11th.		
Total detentions claimed	105	..

The "Hemje" left Albany at 1 P. M., November 12th; laid up at Coxsackie four and one-half hours on account of a thick fog, and arrived in New York at 7.30 P. M., November 13th. Coal consumption from Buffalo to New York, fifteen and one-half tons.

Deductions.

	Days.	Hours.	Min.
Total time from Buffalo to Troy	9	7	..
Detentions claimed	4	9	..
Add for lockage	..	10	..
	4	19	..
Running time	4	12	..

or 108 hours; distance 345 miles.

	Miles per hour.
Average speed	3.19
Average speed, including lockage	2.92
Average speed, including all detentions	1.59
Average speed on the river	5.54

Average coal burned per mile from Buffalo to New York, 62 pounds.

Average speed over special sections of the canal, exclusive of all detentions claimed, and eight minutes for each lock passed:

	Distance. Miles.	Running time. Hours.	Min.	Average speed. Miles per hour.
Buffalo to Rochester	93	24	2	3.87
Rochester to Syracuse	93	33	47	2.75
Syracuse to Utica	56	20	43	2.71
Utica to Schenectady	80	23	26	3.41
Schenectady to Troy	23	7	10	3.21

I joined the "Hemje" at Syracuse on the 8th of November, and accompanied her as far as Canastota. The detentions met with between those points, as well as the causes thereof, were observed by me, and are correctly stated by Captain Hemje.

SECOND TRIP WEST.

Left New York for Oswego at 7 A. M., November 17th, laden with 162$\frac{4}{10}$ tons of coal. Arrived at Newburgh at 5.45 P. M., same day; went alongside the dock to take a pilot; did not find one until 9 P. M. Left Newburgh at 9.45 P. M., and arrived in Albany at 4.30 P. M. on the 18th.

Left *West Troy* at 11 P. M., November 18th.

	Detentions. Hours.	Min.
Detained in passing the 16 locks; grounded five times; water very low	2	..
Detained at Upper Aqueduct; found canal blockaded by eastward bound boats	1	15
Arrived at *Schenectady* at 1 P. M., November 19th.		
Detained at Schenectady for coal	2	...
(Run from Schenectady to lock 23, two and three-quarter miles, in 38 minutes; speed, 4.34 miles per hour.)		
Detained near Port Jackson by blockade	..	40
Detained at Canajoharie, screw loose on shaft; went on dock to secure it; dock was full; had to wait for a berth	10	30
Detained at Fort Plain, aground	..	20
Detained near Little Falls, aground	..	45
Detained at Frankfort, lock-tender gave horse-boat the preference and allowed boat to remain in lock while changing horses	..	30
Arrived at *Utica* at 11 A. M., November 21st.		
Detained at Utica for provisions	..	15
Detained west of Rome, wedged in among a crowd of boats	4	10
Detained by finding four boats abreast in the canal; hauled them out	2	20
Arrived at *Syracuse* at 4 P. M., Nov. 22d.		
Detained at Syracuse to clear the screw	1	..
Detained by a line in the screw	..	45
Detained at Oswego lock; lock-tenders asleep	4	..
Arrived at *Oswego* at 9.30 A. M., November 23d.		
Total detentions claimed	30	30

Coal consumed from New York to Oswego, 10$\frac{1}{2}$ tons.

Deductions.

	Days.	Hours.	Min.
Total time from West Troy	4	10	30
Detentions claimed	1	6	30
Add for lockage	..	10	30
	1	17	..
Running time	2	17	30

or 65½ hours; distance 197 miles.

Average speed	3 miles per hour.
Average speed, including lockages	2.59 miles per hour.
Average speed, including all detentions	1.85 miles per hour.
Running time on the river	29.5 hours.
Average speed	4.88 miles per hour.
Average coal consumption per mile between New York and Oswego	60.5 pounds.

Average speeds between the several prominent points, exclusive of all detentions claimed and eight minutes for each lock passed.

	Distance. Miles.	Running time. Hours.	Min.	Average speeds. Miles per hour.
Troy to Schenectady	23	8	25	2.73
Schenectady to Utica	80	28	31	2.81
Utica to Syracuse	56	17	3	3.28
Syracuse to Oswego	38	9	21	4.07

THIRD TRIP EAST.

Left Oswego at 10.30 P. M., November 26th, 1872; cargo 597 barrels of flour; weight 64.47 tons. Could not get full cargo on account of lateness of the season.

	Detentions. Hours.	Min.
Detained at Fulton taking on 447 barrels of flour, making 112¾ tons	14	30
Detained at Phœnix, clearing and paying toll	..	30
Arrived at *Syracuse* at 2.30 A. M., November 28th.		
Detained at Syracuse, had to back out of weigh-lock	..	30
Detained at Rome, telegraphing and preparing for ice,	1	..
Arrived at *Utica* at 11.50 P. M., November 28th.		
Detained at night in consequence of running at full speed upon a sunken canal boat; received severe shock and sprung a leak	..	15
Arrived at *Fultonville* at 4.50 P. M., November 29th.		
Total detentions claimed	16	45

Coal consumed, 7,500 pounds.

The "Hemje" afterward proceeded as far as Port Jackson, where she is laid up for the winter. Her passage from Fultonville was so obstructed by ice, however, that it is not deemed just to include that part of the trip.

Deductions.

	Days.	Hours.	Min.
Total time from Oswego	2	18	20
	Hours.	Min.	
Detentions claimed	16	45	
Add for lockage	5	..	
	..	21	45
Running time	1	20	35

or $44\frac{7}{12}$ hours; distance 148 miles.

Average speed ..... 3.32 miles per hour.
Average speed, including lockage ..... 2.99 miles per hour.
Average speed, including all detentions ..... 2.23 miles per hour.
Average coal burned per mile ..... 50 pounds.

Average speeds between prominent points on the canal, exclusive of all detentions claimed, and eight minutes for each lock passed:

	Distance. Miles.	Running time. Hours	Min.	Aver. speeds. Miles per hour.
Oswego to Syracuse	38	9	36	3.96
Syracuse to Utica	56	19	18	2.90
Utica to Fultonville	54	14	45	3.66

SUMMARY OF RESULTS FOR THE SEVERAL ENTIRE TRIPS.

NUMBER OF TRIPS.	Cargoes, tons.	Times. Total. D.	H.	M.	Detentions. D.	H.	M.	Running. D.	H.	M.	Average speed, miles per hour.
On the canal.											
First trip east, Buffalo to Troy	201.6	11	11	15	6	13	50	4	21	25	2.94
First trip west, Troy to Buffalo	140.0	6	23	0	2	16	4	4	6	56	3.35
Second trip east, Buffalo to Troy	201.0	9	7	0	4	19	0	4	12	0	3.19
Second trip west, to Oswego	162.4	4	10	30	1	17	0	2	17	30	3.00
Third trip east, to Fultonville	112.75	2	18	20	..	21	45	1	20	35	3.32
On the river.											
First trip down	201.6	..	..	..	..	..	..	1	5	30	4.90
First trip up	140.0	..	..	..	..	..	..	1	12	30	4.11
Second trip down	201.0	1	6	30	0	4	30	1	2	0	5.54
Second trip up	162.4	1	9	30	0	4	0	1	5	30	4.88

The three round trips of the "Hemje" will not be completed until she shall have completed her last trip to Troy, and returned to Buffalo. Attention is called to the fact that her first trip was commenced on the 27th of September, only two months before the season of navigation closed.

Power Expended, and Slip.

My opportunities for observing data, from which to estimate the power expended by the "Hemje's" engines, have been limited to the run from Syracuse to Canastota. During the evening of the 8th of November, after the boat had been aground over two hours, and when she was running with full steam, I made the following notes: Steam, 70 pounds, revolutions, 110 per minute, cut-off, half stroke. These data indicate an effective power of about 57.5 horses, which is largely in excess of the average power. The latter I estimate at 40 horses.

At 110 revolutions of the screw, the advance due to its pitch was $110 \times 6\frac{1}{2} = 715$ feet per minute, or 8.1 miles per hour.

As the average speed between Syracuse and Utica, exclusive of all detentions and lockages, was only 2.71 miles per hour, it is doubtless safe to assume that the speed of the boat was not greater than three miles per hour over the ground. Adding half a mile for the current, against which the boat was at that time running, we have three and one-half miles per hour or 308 feet per minute, as the speed of the boat through the water.

If, then, our assumptions are correct, the slip of the screw was $\frac{715-308}{715} \times 100 = 57$ per cent. That the speed of the boat is not underrated, is evident from the fact that on the following morning, when the screw was making from 120 to 130 revolutions, the boat was observed to be making just three miles per hour over the ground. It is also evident from the further fact that the running time from Lodi lock to Manlius, a distance of seven miles, was two hours and twenty minutes, indicating an average rate of three miles per hour. The data which have been used in the foregoing estimates of power and slip, were observed between the two last named points.

It thus appears that the slip of the "Hemje's" screw is excessive. An explanation of this is found partly in the size of the screw, the propelling surface of which is only about two-thirds that of the "Baxter's" two screws; and partly, I think, to the obstruction which the casing of the screw must offer to the water in its passage to the screw; especially when, as in the "Hemje," the lines are quite full at the stern. The pitch may, and doubtless does, have some effect upon the slip. It is interesting to note, in this connection, that the "Dawson's" screw, which is of the same diameter and nearly the same pitch as that of the "Hemje," and which also acts in a confined space, has a slip of 60.7 per cent, while making even less speed.

COAL CONSUMPTION.

I was not able, during the time I spent on board the "Hemje," to observe the amount of coal burned. The reported consumption, however, is sixty and one-quarter tons or 120,500 pounds. The distance steamed was as follows:

	Miles.
On the Hudson river	600
On the canal	1,380
Total	1,980

The average coal consumption per mile was, therefore,

$$\frac{120,500}{1,980} = 60.86 \text{ pounds.}$$

The total running time was 565 hours, which includes five hours for four runs between Troy and Albany. The coal consumption per hour was, therefore, apparently about 213 pounds. But in this result no account is taken of the coal which was consumed while the engine was idle; in other words the entire coal consumption is treated as having taken place during the *running time* of the steamer.

As the machinery was idle much of the time, this hourly consumption and the consumption per mile, are both somewhat greater than they would have been had no detentions occurred. They are, however, the only results available for purposes of comparison, and for that reason they are taken simply as indices of the economy of the "Hemje's" engine, boiler and screw, as compared with the machinery of other steamers. Fair values for the power and hourly consumption of fuel of this steamer when running without detention, are believed to be forty to forty-five horses and 175 to 180 pounds, respectively.

GENERAL DEDUCTIONS.

Total boat miles	1980.
Boat miles on the canal	1380.
Boat miles on the river	600.
Total running time, hours	565
Running time on the canal, hours	438.43
Running time on the river, hours	126.57
Average speed on canal and river, miles	3.50
Average speed on the canal	3.15
Average speed on the river	4.73
Ton miles, including weight of boat	496,312.
Ton miles of cargo	341,638.
Total coal consumption, pounds	120,500

Coal consumption per boat mile, pounds	60.86
Coal consumption per ton mile, including boat	0.2428
Coal consumption per ton mile, cargo	0.3527
Cost of coal per boat mile (at $5.50 per ton) cents	16.74
Cost of coal per ton mile, including boat	0.0667
Cost of coal per ton mile, cargo	0.0960

It is to be distinctly understood that the above quantities and costs of coal apply to the entire run on canal and river, and that, under the circumstances, no estimates can be made which will be strictly correct for either, as distinct from the other. The results are, as before intimated, too large for the river, on account of the greater speed attained there, and too small for the canal.

AVERAGE SPEEDS FOR ALL THE TRIPS OVER SPECIAL SECTIONS OF THE CANAL.

Trips East.

BETWEEN	Distance, miles.	AVERAGE SPEED—MILES PER HOUR. First trip.	Second trip.	Third trip.	Means.
Buffalo and Rochester	93	3.47	3.87	.....	3.67
Rochester and Syracuse	93	2.38	2.75	.....	2.56
Syracuse and Utica	56	2.55	2.71	2.90	2.72
Utica and Schenectady	80	3.39	3.41	3.66*	3.49
Schenectady and Troy	23	3.37	3.21	.....	3.29
Oswego and Syracuse	38	.....	.....	3.96	3.96

*To Fultonville only.

Trips West.

BETWEEN	Distance, miles.	AVERAGE SPEED—MILES PER HOUR. First trip.	Second trip.	Third trip.	Means.
Buffalo and Rochester	93	3.42	.....	.....	3.42
Rochester and Syracuse	93	3.16	.....	.....	3.16
Syracuse and Utica	56	3.44	3.28	.....	3.36
Utica and Schenectady	80	3.67	2.81	.....	3.24
Schenectady and Troy	23	2.51	2.73	.....	2.62
Syracuse and Oswego	38	.....	4.07	.....	4.07

Trips East and West.

BETWEEN	Distance, miles.	AVERAGE SPEED — MILES PER HOUR. East.	West.	Means.
Buffalo and Rochester	93	3.67	3.42	3.54
Rochester and Syracuse	93	2.56	3.16	2.86
Syracuse and Utica	56	2.72	3.36	3.04
Utica and Schenectady	80	3.49	3.24	3.36
Schenectady and Troy	23	3.29	2.62	2.95
Syracuse and Oswego	38	3.96	4.07	4.01

The average speeds, deduced from the foregoing tables, are: East, 3.23 miles per hour; west, 3.32 miles per hour; both ways, 3.27 miles per hour. This last result exceeds that previously obtained by $3.27 - 3.15 = 0.12$ of a mile; the difference resulting from some trifling error in applying the detentions, or in estimating the number of locks between the several points limiting the special sections considered.

At 3.15 miles per hour, the time from Buffalo to Albany is 109.52 hours. Adding the ten hours allowed for lockage, the time is 119.52 hours, or four days 23.52 hours; and the average speed, including lockages, 2.88 miles per hour.

Adding, again, thirty hours for the run from Troy to New York, making 495 miles in all, the total time from Buffalo to New York is 149.52 hours, or six days 5.52 hours; and the average speed 3.31 miles per hour.

Thus it appears that the "Hemje," when free from the detentions caused by horse-boats and low water, may be relied upon to make the trip from Buffalo to New York in six days and six hours, at an average speed of 3.31 miles per hour, including lockages.

The machinery of the "Hemje" works admirably, and, at the close of the season, was in excellent condition, giving promise of the measure of endurance usually realized from such machinery.

V. *Description and Performance of the Steamer "Fountain City."*

The "Fountain City" is an old, full-modeled "lake boat;" is ninety-seven feet long, seventeen and a half feet wide, and weighs, with her boiler and machinery, 81.9 tons.

Her propellers, said to be the invention of her owner, Dr. Robert Hunter, of Cincinnati, consist of two feathering paddle wheels, placed under the quarters, aft, and revolving towards each other, on vertical axes. Each wheel is provided with four vertical paddles five feet

long, seven and a half inches wide at the top, and seventeen and a half inches wide at the bottom. The entire surface of all the blades is, therefore, forty-one and two-thirds square feet. The axes of the paddles revolve about the axes of the wheels, in circles, the diameters of which are two feet three inches. Upon the top of each wheel is placed a system of seven toothed wheels, which are disposed as follows: The first wheel is placed loose upon the main shaft of the wheel, permitting the latter to revolve while the former remains at rest. This wheel meshes into two other wheels at points diametrically opposite, each of which in turn meshes into two wheels of the same size, keyed to the axes of the paddles. The last six wheels revolve with the paddle wheel about the central wheel, and, at the same time, about their own axes.* Motion is communicated from the steering wheel, through the shafts and miter wheels, to the loose wheels upon the paddle shafts, by which the steersman is enabled to adjust and regulate the pitch of the paddles and to direct the resultant propelling action of the wheels at will. By this arrangement the rudder is dispensed with, and the steersman, by simply changing the pitch of the paddles, is enabled not only to steer the boat but to reverse the action of the paddle wheels at will, and without reversing the engines.

The engines of the "Fountain City" are two in number, non-condensing, having cylinders twelve inches in diameter by ten inches stroke of piston. The cylinders are placed back to back with their axes athwart-ship, and are located at the stern directly over the paddle wheels.

The boiler is horizontal, return-tubular, eight feet six inches long, four feet six inches in diameter, and has sixteen square feet of fire grate.

This steamer has not completed her three round trips, for reasons stated by the inventor in a communication addressed to the chairman of the Commission, in which he says: "This boat, known as the 'Fountain City,' I fitted out with a device which possessed great propelling power, but proved, on being subjected to actual work, not to be sufficiently manageable for canal purposes. This compelled me to make a radical change in my invention, and threw me too late into the past summer for me to complete three round trips before the canal closed. In my efforts to hasten the construction of my new device, a grave mistake was made in calculating the required strength of the shafts, which could not afterward be remedied for want of

* The diameters of the last six wheels are equal, and are double that of the first wheel.

time. This prevented me from using that pressure of steam generally used by competing boats, and which would have added correspondingly to our speed."

Certified copies of the several clearances of the "Fountain City," together with a complete log—the latter duly verified—have been furnished by Mr. R. J. O. Hunter, a son of the owner and inventor, who commanded the steamer. From these the following condensed statements have been made up:

FIRST TRIP EAST.

Left *Buffalo* at eight A. M., September 17th, 1872. Cargo, 180 tons of coal.

	Detentions. Hours.	Min.
Detained at Lower Black Rock waiting for one of the crew	1	..
Detained at Tonawanda by a sunken boat across the canal	4	45
Detained at Lockport packing pistons	1	15
Detained at Albion for stores	..	10
Detained at Brockville; boat leaking badly; shifted cargo to allow water to run to pumps	1	10
Detained at Hulberton by breaking "strap" and valve-stem	1	30
Detained at Brockport for repairs	7	10
Ran from Hulberton to Brockport, eight miles, with one wheel, in three hours fifty minutes.		
Detained at Brockway's, "strap" again broken	..	30
Arrived at *Rochester* at 6 A. M., September 19th.		
Ran from Brockway's to Rochester with one wheel.		
Detained at Rochester for repairs	16	30
Detained at Palmyra by pillar blocks heating; took them out and filed them	1	..
Detained at Newark by feed-pumps ceasing to work; fires were drawn, boiler blown off, and filled by hand,	6	20
Detained at Lyons; pumps out of order; mud in boiler,	5	..
Detained at Clyde; holding down bolts in port pillar; block broken	1	30
Detained at Montezuma, trying to get bolts	2	35
Arrived at *Syracuse* at 8.10 A. M., September 22d.		
Ran from Clyde to Syracuse with one wheel.		
Detained at Syracuse; bolts made and fitted; laid over Sunday	28	50
Detained at Lodi; bolts badly fitted; sent back to be refitted	6	25
Detained at Bolivar, aground	1	30
Detained at Durhamville, crank broken	3	30
Detained at Rome, trying to get repairs	3	30
Arrived at *Utica* at 5 A. M., September 25th.		

	Detentions. Hours.	Min.
Ran from Durhamville, thirty miles, in seventeen hours, with one wheel.		
Detained at Utica for new crank	14	15
Detained at Canajoharie by broken crank-pin	..	50
Ran from Canajoharie to Schenectady, thirty-eight miles, in twenty-four hours and fifty-six minutes, with one wheel.		
Arrived at *Schenectady* at 5 A. M., September 27th.		
Detained at Schenectady for new crank-pin	13	40
Arrived at *West Troy* at 4.30 A. M., September 28th.		
Total detentions claimed	122	55

Coal consumption, fourteen tons.

Deductions.

	Days.	Hours.	Min.
Total time from Buffalo	10	20	30
Detentions claimed	5	2	55
Add for lockage	..	10	..
	5	12	55
Running time	5	7	35

or $127\frac{7}{12}$ hours; distance 345 miles.

	Miles per hour.
Average speed	2.7
Average speed, including lockage	2.51
Average speed, including all detentions	1.32

The following shows the times and distances between points where detentions are noted. It serves as a check upon the accuracy of the above results for the whole trip (runs with one wheel not included):

	Distance. Miles.	Time. Hours.	Min.
Buffalo to Lower Black Rock	4	1	..
Lower Black Rock to Tonawanda	8	2	..
Tonawanda to Lockport	19	5	..
Lockport to Albion	28	8	..
Brockport to Brockway's	10	3	30
Rochester to Palmyra	27	11	5
Lodi to Bolivar	13	4	10
Bolivar to Durhamville	12	3	30
Utica to Little Falls	23	13	45
Little Falls to Canajoharie	19	6	15
Schenectady to Cohoes	19	5	50
Totals	182	64	5

Average speed, including lockage, 2.84 miles per hour.

The average speeds over special sections of the canal, exclusive of all detentions and eight minutes for each lock passed, were:

	Distance. Miles.	Running time. Hours.	Min.	Average speeds. Miles per hour.
Buffalo to Rochester	93	27	42	3.36
Rochester to Syracuse	93	39	07	2.38
Syracuse to Utica	56	24	33	2.36
Utica to Schenectady	80	29	51	2.68
Schenectady to Troy	23	7	10	3.21

FIRST TRIP WEST.

Left *West Troy* at 12.47 P. M., October 16th, 1872. Cargo, 132½ tons railroad iron.

	Detentions. Hours.	Min.
Detained at Crescent for stores	..	30
Detained at Upper Aqueduct, exhaust pipe broken	1	30
Arrived at *Schenectady* at 3.30 A. M., October 17th.		
Detained at Schenectady for repairs	13	10
Detained at Auriesville, lock too short	..	45
Detained near Fultonville, boats aground	2	30
Detained at Spraker's cleaning fires	1	10
Detained at Fort Plain for coal	2	40
Detained at East Canada creek, aground	..	30
Arrived at *Utica* at 12.20 P. M., October 19th.		
Detained at Utica cleaning fires	..	30
Detained at Oriskany, cleaning fires	..	45
Detained four miles below Rome, line in wheel	3	..
Ran with one wheel to Durhamville; detained at Durhamville removing line	3	22
Detained at Canastota, cleaning fires		40
Detained at Manlius, cleaning fires	..	30
Arrived at *Syracuse* at 9.20 P. M., October 20th.		
Detained at Syracuse, cleaning fires	..	40
Detained at Jordan by boats aground	..	28
Detained at Montezuma for coal	10	30
Detained at Clyde for coal	13	15

NOTE.—The boat, in charge of the engineer, exhausted her supply of coal at Montezuma, while the captain was awaiting her arrival at Clyde; waited at Montezuma until the captain arrived, when half a ton of coal was taken, and the boat proceeded to Clyde where four tons were taken.

Detained at Lyons, waiting for lock	1	30
Detained at Newark by boats aground	2	50
Detained at Waynesport by boats aground	3	..
Detained at Fairport, cleaning fires	..	30

	DETENTIONS. Hours.	Min.
Detained at lock sixty-five, aground	..	25
Arrived at *Rochester* at 3.20 P. M., October 23d.		
Detained at Rochester for stores and to clean fires	1	05
Detained at Adams' Basin by boats aground	3	30
Detained at Holly	2	..
Detained at Brockville, shifting cargo, boat leaking	3	..
Detained at Albion for wood and stores	1	50
Detained at Eagle Harbor, aground	1	45
Detained at Shelby's basin, cleaning fires	..	55
Detained at Gasport, cleaning fires	1	05
Detained at Lockport by boats aground	4	..
Detained at Pendleton by boats aground	1	20
Detained at Martinsville by boats aground	1	50
Detained at Tonawanda for oil and to clean fires	..	45
Detained at Lower Black Rock	1	50
Detained at Black Rock, boats aground	1	..
Arrived at *Buffalo* at 12.30 A. M., October 26th.		
Total detentions claimed	90	35

Coal consumption, sixteen tons.

Deductions.

	Days.	Hours.	Min.
Total time from West Troy	9	11	43
Detentions claimed	3	18	35
Add for lockages	..	10	..
	4	4	35
Running time	5	7	8

or $127\frac{2}{15}$ hours; distance 345 miles.

	Miles per hour.
Average speed	2.71
Average speed, including lockage	2.52
Average speed, including all detentions	1.51

Runs between points where detentions were noted.

	Distance. Miles.	Time. Hours.	Min.
Schenectady to Port Jackson	16	5	55
Fort Plain to East Canada creek	11	5	5
Little Falls to Utica	23	12	2
New Boston Landing to Manlius	9	3	28
Manlius to Syracuse	8	3	10
Syracuse to Jordan	19	7	54
Jordan to Montezuma	14	4	38
Fairport to lock 65	8	3	20
Rochester to Adams' Basin	15	4	50

	Distance. Miles.	Time. Hours.	Min.
Shelby's Basin to Gasport	9	2	15
Gasport to Lockport	6	1	55
Pendleton to Martinsville	8	2	10
Totals	146	56	42

Average speed, including lockage, 2.57 miles per hour.

The average speeds over special sections of the canal, exclusive of all detentions claimed and of eight minutes for each lock passed, were:

	Distance. Miles.	Running time. Hours.	Min.	Average speeds. Miles per hour.
Troy to Schenectady	23	10	3	2.29
Schenectady to Utica	80	33	1	2.42
Utica to Syracuse	56	23	41	2.37
Syracuse to Rochester	93	30	44	3.02
Rochester to Buffalo	93	31	27	2.98

Attention is called to the detentions claimed for stopping to "clean fires." Steamers do not ordinarily lay up or stop their machinery for the purpose of cleaning fires, although the steam pressure generally falls, temporarily, during that process. Of course the "Fountain City" made better speed than she would have done had the fires been cleaned while she was in motion.

I accompanied this steamer, while on this trip, from West Troy to a point just below lock 21, at which point I joined the "Baxter," as already stated. The run from West Troy to the head of the sixteen locks at Cohoes was made in three hours and fifty-three minutes, which is about ten minutes less than the time occupied by any other steamer, so far as I have observed, in making the same run. The boat was under perfect and easy control of the steersman, who was able to reverse the action of the paddle wheels and to back in less time than is ordinarily required to stop and reverse an engine. The boat could, I think, be turned in her length, in open water, without difficulty.

The engines were very poor, and, owing to imperfect design and construction, insufficient strength, and rigidity in their parts, together with the severe character of the work required of them, were the cause of much anxiety and trouble. The cylinders were entirely without protection, and hence were a source of great loss of heat and waste of fuel. The boiler, also, was without adequate protection.

Second Trip East.

Left *Buffalo* at 4.30 P. M., November 10th, 1872, with the boat "J. Holmes," laden with 1,200 barrels of oil, in tow. Cargo of the "Fountain City," 162 tons of coal, shooks and stone.

In going down the river to Tonawanda, ran on Strawberry island; put engines out of order, straining them badly; laid all night.

	Detentions. Hours.	Min.
Detained at Tonawanda to repair damage	44	20
Detained at Pendleton, aground	3	..
Detained at Lockport, waiting for locks	1	..
Detained at Gasport for water and stores	..	35
Detained at Middleport, packing pistons	3	40
Detained at Hindsburgh, connecting-rod of port-engine bent	1	30
Detained at Brockport, trying to get rod straightened	1	15
Arrived at *Rochester* at 10.45 P. M., November 14th.		
Ran from Hindsburgh to Rochester, 30 miles, with one wheel, in 12 hours and 20 minutes.		
Detained at Rochester, waiting to see parties about towing another boat, and for repairs	15	..
Detained at Brighton, aground	3	12
Detained at lock 65, aground	2	48
Detained at Bushnell's basin, aground	3	27
Detained at Fairport, aground	7	30
Detained at Macedon, waiting for lock	2	..
Detained at Palmyra, to see parties in regard to the "Holmes"	2	..
Detained at Newark, aground	2	03
Detained at E. Arcadia, waiting for lock	..	48
Detained at Lyons, by lock	1	25
Detained at Lock Berlin by boats aground	16	30
Detained at Clyde, engineer arrested	36	45
At Clyde the "Holmes" was abandoned, she having been found to draw 6 feet 4 inches.		
Arrived at *Clyde* at 9 A. M., November 8th.		
Left Clyde at 9.45 P. M., November 19th.		
Detained at Port Byron, aground	1	30
Detained at Weedsport for water, and to clean fires	..	45
Detained at Cold Spring to pack pistons	1	38
Detained at Canton, cleaning fires	..	45
Detained at Camillus, starboard engine disabled	2	..
Detained at Belle Isle, at lock	1	..
Arrived at *Syracuse* at 12.05 P. M., November 21st.		
Ran from Camillus to Syracuse with one wheel.		
Detained at Syracuse, coaling and repairing	25	..
Detained at Orville feeder, aground	1	03
Detained at Limestone feeder, port-shaft broken	1	05
Detained at Manlius, for repairs	74	25

	Detentions. Hours.	Min.
Detained at New Boston Landing, aground	3	10
Detained at Rome for stores and to clean fires	1	15
Detained at Whitesboro, boat across the canal	..	10
Arrived at *Utica* at 7.20 P. M., November 26th.		
Detained at Utica to clean fires	..	45
Detained at Canajoharie, repairing pillar block bolts, port-side	5	..
Detained below Sprakers', wating for lock	..	20
Detained at Hoffman's Ferry, aground	..	30
Arrived at *Schenectady* at 10.30 A. M., Nov. 28.		
Detained at Schenectady, for wood and to clean fires	1	40
Detained at Cohoes by boats aground	2	..
Arrived at *West Troy* at 12.15 A. M., Nov. 29th.		
Total detentions claimed	272	49

Coal consumption, 20 tons.

Deductions.

As a tow was brought as far as Clyde, only that part of the trip between that point and Troy will be considered.

	Days.	Hours.	Min.
Total time from Clyde to Troy	9	2	30

	Days	Hours.	Min.			
Detentions claimed	5	4	1			
Add for lockage	..	7	4			
				5	11	5
Running time				3	15	25

or $87\frac{5}{12}$ hours; distance 203 miles.

Average speed ..... 2.32 miles per hour.
Average speed, including lockage ..... 2.15 miles per hour.

As the running time from Clyde to Troy was very nearly equal to that from Buffalo to Clyde, the coal consumption of 20 tons, between Buffalo and Troy, is divided equally between the two runs, and that between Clyde and Troy put at 10 tons.

Runs between points where detentions are noted.

	Distance. Miles.	Time. Hours.	Min.
Clyde to Montezuma	11	5	15
Port Byron to Weedsport	4	1	15
Peru to Canton	5	2	15
Manlius to New Boston Landing	9	3	10
New Boston Landing to Rome	24	10	15
Rome to Whitesboro	11	2	50
Whitesboro to Utica	4	1	5

	Distance. Miles.	Time. Hours.	Min.
Utica to Little Falls	23	8	55
Little Falls to Fort Plain	16	5	45
Spraker's to Fultonville	9	2	35
Fultonville to Schenectady	26	11	..
Upper Aqueduct to Cohoes	19	6	20
	161	60	40

Average speed, including lockage ..... 2.65 miles per hour.
Deducting 4 hours and 24 minutes for lockage, the running time is 56 hours 16 minutes, and the average speed ..... 2.86 miles per hour.

The average speeds over special sections of the canal, exclusive of lockage, and of eight minutes for each lock passed, were:

	Distance. Miles.	Running time. Hours.	Min.	Aver. speeds. Miles per hour.
Clyde to Syracuse	44	30	10	1.46
Syracuse to Utica	56	20	35	2.68
Utica to Schenectady	80	29	30	2.71
Schenectady to Troy	23	7	25	3.03

SUMMARY OF "FOUNTAIN CITY'S" TRIPS.

NUMBER OF TRIPS.	Cargoes, tons.	TIMES. Total. D.	H.	M.	Detentions. D.	H.	M.	Running. D.	H.	M.	Average speed, miles per hour.
First trip east	180.0	10	20	30	5	12	55	5	7	35	2.70
First trip west	132.5	9	11	43	4	4	35	5	7	8	2.71
Second trip east *	162.0	18	7	45	11	18	49	6	12	56	2.19
Clyde to Troy	162.0	9	2	30	5	11	5	3	15	25	2.32

POWER EXPENDED.

On the 16th of October, I noted the performance of the engines of the "Fountain City," between Cohoes and Crescent. The run from the head of the sixteen locks to a point about a quarter of a mile beyond Crescent was made in one hour and twenty minutes. At the time of my observations the boat was making about two and three-quarter miles per hour, which may be taken as a fair average of the speed attained during the several trips. The steam pressure was sixty pounds, and the revolutions seventy-five per minute, indicating a power of about forty-five horses, in which a slight allowance is made for the uncertain effects of throttling.

In the absence of an accurate plan of the paddle-wheels, I have not

* Tow to Clyde.

been able to investigate their action far enough to enable me to say what their slip was. That it was large, however, is obvious from a consideration of the cargo, power and speed; unless it be admitted that a considerable portion of the power was expended laterally, and thus lost.

COAL CONSUMPTION.

During the first round trip and the run from Clyde to Troy, an aggregate of 893 miles, the coal consumption was about forty tons, or 80,000 pounds. The coal consumption per mile was, therefore, 89.6 pounds. That this excessive rate is due, in part, to the long delays experienced, and to the unavoidable consumption of fuel while the engines were idle, is quite true, but, as these delays were incidental to the peculiar machinery employed, we have no alternative but to adopt it in our comparisons.

GENERAL DEDUCTIONS.

Number of single trips made	3
Distance steamed on the canal, exclusive of towing, miles	893
Total tons carried	474.5
Total tons carried east	342
Total tons carried west	132.5
Average cargo east, tons	171
Average cargo west, tons	132.5
Total ton miles, of boat and cargo	213,835
Total ton miles of cargo	140,698
Total coal consumption, tons	40
Total coal consumption per boat mile, pounds	89.6
Total coal consumption per ton mile, including boat,	0.374
Total coal consumption per ton mile, cargo	0.569
Cost of coal per boat mile (coal $5.50 per ton), cents,	24.63
Cost of coal per ton mile, including boat, cents	0.1028
Cost of coal per ton mile, cargo	0.1564
Average horse-power employed	40 to 45

SUMMARY OF SPEEDS OVER SPECIAL SECTIONS OF THE CANAL.

Trips East.

BETWEEN.	Distance, miles.	AVERAGE SPEED—MILES PER HOUR.		
		First trip.	Sec'nd trip.	Means.
Buffalo and Rochester	93	3.36	Tow.	3.36
Rochester and Syracuse	93	2.38	Tow to Cl'e.	2.38
Syracuse and Utica	56	2.36	2.68	2.52
Utica and Schenectady	80	2.66	2.71	2.69
Schenectady and Troy	23	3.21	3.03	3.12

Only a single western trip was made.

Trips East and West.

BETWEEN.	Distance, miles.	AVERAGE SPEED—MILES PER HOUR.		
		East.	West.	Means.
Buffalo and Rochester	93	3.36	2.98	3.17
Rochester and Syracuse	93	2.80	3.02	2.70
Syracuse and Utica	56	2.52	2.37	2.44
Utica and Schenectady	80	2.69	2.42	2.55
Schenectady and Troy	23	3.12	2.29	2.70

The average speed for the entire distance steamed on the canal, exclusive of all detentions claimed, and of eight minutes for each lockage, appears from the above to have been 2.75 miles per hour. This result is, however, affected favorably by currents, as there were two trips in the direction of the prevailing current, and but one against the current.

VI. *Description and Performance of the Steamer "Port Byron."*

The "Port Byron" is a full sized boat, ninety-seven feet long, seventeen feet four inches wide, and weighing, with her machinery, eighty and one-tenth tons. She was built at Rochester, by F. M. Mahan, Esq., of Memphis, Tennessee, and Capt. Primus Emerson of St. Louis, Missouri, by whom she is now owned.

The only peculiarity in the model of the "Port Byron" consists in a *concave* bow below load-water line and a rectangular trunk extending from bow to stern, along the centre of the bottom of the boat. This trunk is twenty-four inches wide, twelve inches deep and terminates at the stern, in a recess cut for the reception of the paddle wheel. The recess is cut in the center of the stern and is ten feet six inches long in a fore and aft direction, by three feet eight inches wide.

The paddle wheel—said to be the invention of Captain Emerson—does not differ in any essential particular from the ordinary "feathering" paddle wheel. Its diameter to the axis of the paddles, is ten feet. The paddles are eight in number, are three feet six inches long by two feet four inches wide, and are made of boiler iron. The main shaft is so placed that, at six feet draft of water, its axis is eight inches above the water.

The motive power is furnished by two horizontal non-condensing engines, which are, of course, connected with the crank-shaft at right angles, to avoid difficulty from stopping "on the center." The cylinders are twelve inches in diameter, and the stroke of piston is twenty-four inches.

No note has been made of the general dimensions or details of the boiler, except that it has two furnaces, each four feet long by one foot eight inches wide, containing an aggregate of thirteen and one-third square feet of grate surface.

The "Port Byron" has completed her three round trips. The first was commenced on the 2d of July—after extensive repairs had been made at the works of Messrs. Skinner & Arnold of Albany—and the third was completed on the 19th of November. The total time occupied in making the three trips was, therefore, four and one-half months.

Certified copies of most of the clearances have been furnished, as well as a detailed statement of the detentions; the latter being duly verified by the oath of Captain Emerson. From these the usual condensed log is made, as follows:

FIRST TRIP WEST.

Left *West Troy* at 6.20 P. M., July 2d, 1872. Cargo 100 tons of stores.

	Detentions. Hours.	Min.
Detained at Lock 12, waiting to lock	..	30
Detained at Lock 13, waiting to lock	1	..
Detained west of Lock 16, altering smoke-stack	15	25
Arrived at *Schenectady* July 3d.		
Detained at Schenectady without an engineer	12	..
Detained west of Schenectady, aground	1	30
Detained at Fultonville, waiting for an engineer to arrive from Albany	17	30
Detained at Spraker's, repairing pump	5	..
Detained at Canajoharie for water	..	30
Detained at Little Falls, waiting to lock	..	45
Arrived at *Utica* July 6th.		
Detained at Utica, cleaning boiler	6	30
Detained at Rome by a crowd of boats	1	30
Arrived at *Syracuse* July 7th.		
Detained at Syracuse, Sunday	16	15
Detained at Montezuma, repairing crank pin key (?)	4	..
Detained at Clyde waiting for coal	4	30
Detained at Macedon by boats aground	20	..
Arrived at *Rochester* July 11th.		
Detained at Rochester, repairing steam-pipe	14	30
Detained at Brockport by leaky flues	1	..
Detained at Lockport, calking	3	..
Detained at Tonawanda by fog	7	..
Detained, waiting for coal	4	30
Arrived at *Buffalo* at 10.10 A. M., July 14th.		
Total detentions claimed	136	55

Deductions.

	Days.	Hours.	Min.
Total time from West Troy	11	15	20
Detentions claimed	5	16	55
Add for lockage	..	10	..
	6	02	55
Running time	5	12	55

or 132$\frac{11}{12}$ hours; distance 345 miles.

	Miles per hour.
Average speed	2.59
Average speed including lockage	2.42
Average speed, including all detentions	1.23

The hours of arrival at intermediate points not having been recorded, except in a very few instances, I am unable to indicate the speeds over special sections of the canal or between points where detentions occurred, as has been done in other cases.

FIRST TRIP EAST.

Left *Buffalo* at 4.40 P. M., July 24th, 1872. Cargo 7,150 bushels of corn; weight 200$\frac{1}{3}$ tons.

	DETENTIONS. Hours.	Min.
Detained at Fort Erie, unshipped rudder on a rock in middle of canal	10	20
Detained west of Lockport, repairing a paddle	5	30
Detained at Lockport	1	45
Detained at Middleport	5	30
Detained at Brockport, coaling	4	..
Detained above Spencerport	3	30
Arrived at *Rochester* July 27th.		
Detained at Rochester putting on new buckets	90	45
Detained at 4-mile grocery for water	..	30
Detained at lock 66 waiting to lock	..	30
Detained at Macedon, aground, 5 feet 9 inches of water in middle of canal	10	..
Detained at Palmyra, coaling	1	..
Detained at Arcadia, waiting to lock	1	05
Detained at Lyons, waiting to lock	1	10
Detained at Clyde, waiting to lock	1	30
Detained east of Clyde, aground, 5 feet 6 inches of water in middle of canal	8	..
Detained at Port Byron, on dock	44	..
Detained at Jordan, repairing crank	10	..
Arrived at *Syracuse* August 5th.		
Detained at Syracuse, putting on new cranks	131	55

	Detentions. Hours.	Min.
Detained at Rome, repairing smoke-stack	18	..
Arrived at *Utica* August 13th.		
Detained at Utica, repairing rudder	5	..
Detained at lock 25; broke wheel on a log in bottom of canal	13	..
Arrived at *Schenectady* August 15th.		
Detained at Schenectady, repairing wheel	46	15
Arrived at *West Troy* at 8 A. M., August 18th.		
Total detentions claimed	413	15

Deductions.

	Days.	Hours.	Min.
Total time from Buffalo	24	15	20
Detentions claimed	17	5	15
Add for lockage	..	10	..
	17	15	15
Running time	7		5

or $168\frac{1}{12}$ hours; distance 345 miles.

	Miles per hour.
Average speed	2.05
Average speed, including lockages	1.94
Average speed, including all detentions	.51

Second Trip West.

Left *West Troy* at 3.30 P. M., September 20th, 1872. Cargo, 126 tons of pig iron and cement.

	Detentions. Hours.	Min.
Detained to pack piston	3	30
Detained in sixteen locks, waiting to lock	3	20
Detained at Port Gibson, coaling	1	..
Detained west of Fultonville, on account of sunken boat and boats bound east	5	..
Detained at Canajoharie by crowd of boats	3	30
Detained at Little Falls, waiting for lock	2	30
Detained west of Little Falls by fog	4	30
Arrived at *Utica*, September 23d.		
Detained at Utica for coal	4	30
Detained at Rome for stores	..	20
Detained west of Higginsville, boats aground	6	..
Detained at Manlius for water	..	30
Detained at Canastota for wood	1	..
Arrived at *Syracuse*, September 25th.		
Detained at Syracuse, unshipped rudder	18	..
Detained at Geddes, cleaning flues	4	..

	Detentions. Hours.	Min.
Detained at Clyde, waiting for lock	2	..
Detained at Lyons, waiting for lock	2	30
Detained at Palmyra, boats aground	5	..
Detained at locks 63, 64 and 65, waiting to lock	1	35
Arrived at *Rochester*, September 27th.		
Detained at Rochester, waiting for coal	12	30
Detained at Brockport by crowd of boats	3	30
Detained at Middleport for wood and water	1	30
Detained at Orangeport by boats aground	2	..
Detained at Lockport, calking flues	18	..
Arrived at *Buffalo* at 4 A. M., October 1st.		
Total detentions claimed	106	15

Deductions.

	Days.	Hours.	Min.
Total time from Troy	10	12	30
Detentions claimed	4	10	15
Add for lockage	..	10	..
	4	20	15
Running time	5	16	15

or 136¼ hours; distance 345 miles.

	Miles per hour.
Average speed	2.53
Average speed, including lockage	2.29
Average speed, including all detentions	1.37

Second Trip East.

Left *Buffalo* at 3.20 P. M., October 10th, 1872. Cargo, 7,150 bushels of corn; weight, 200⅕ tons.

	Detentions. Hours.	Min.
Detained at Tonawanda, waiting to lock	..	25
Detained at Lockport, waiting to lock	..	40
Detained at Medina, aground	2	25
Detained at Brockport for coal	1	20
Arrived at *Rochester* October 12th.		
Detained at Rochester to transact business	2	20
Detained at locks 65, 64, 63 and 62, waiting	1	30
Detained at Pittsford by crowd of boats	2	..
Detained at Bushnell's, aground, 5 feet 7 inches water,	4	30
Detained east of Lyons, aground	4	..
Detained at Clyde	2	30
Detained at Jordan for coal	3	..
Arrived at *Syracuse* October 15th.		
Detained at Syracuse to repair wheel, broken by log in bottom of canal	19	50

	Detentions. Hours.	Min.
Detained at lock 35, waiting to lock	..	35
Detained at lock 34, waiting to lock	..	45
Detained at lock 33, waiting to lock	..	40
Detained between locks 34 and 33, aground, water only 5 feet 10 inches	1	..
Detained at Durhamville for coal	1	35
Detained at Rome, aground, 5 feet 9 inches water	3	..
Detained west of Utica, aground	3	30
Detained east of Frankfort, aground	2	10
Detained at Mindenville by boats aground	2	..
Detained at Fultonville for coal	3	45
Detained at Canajoharie by crowd of boats	4	40
Detained west of lock 22, aground, 5 ft. 8 in. water	4	..
Arrived at *Schenectady* October 19th.		
Detained at Schenectady, cleaning boiler	2	..
Detained in 16 locks, waiting to lock	2	5
Arrived at *West Troy* at 7 P. M., October 19th.		
Total detentions claimed	76	15

Deductions.

	Days.	Hours.	Min.
Total time from Buffalo	9	3	40
Detentions claimed	3	4	15
Add for lockage	..	10	..
	3	14	15
Running time	5	13	25

or $133\frac{5}{12}$ hours; distance 345 miles.

Average speed	2.58 miles per hour.
Average speed, including lockage	2.40 miles per hour.
Average speed, including all detentions	1.57 miles per hour.

THIRD TRIP WEST.

Left *West Troy* at 5.30 P. M., October 29, 1872. Cargo, 117 tons iron ore.

	Detentions. Hours.	Min.
Detained at lock 2, waiting to lock	..	30
Arrived at *Schenectady* at 3.45 A. M., October 30th.		
Detained at Spraker's for water	..	35
Arrived at *Utica* at 9.40 A. M., October 31st.		
Detained at Whitesboro for wood	..	45
Detained east of Rome for coal	1	..
Arrived at *Syracuse* at 4 A. M., November 1st.		
Detained at Syracuse, waiting at locks	1	30
Detained at Jordan for coal	3	..
Detained at Port Byron, waiting to lock	..	40

	Detentions. Hours.	Min.
Detained east of Pitt lock, by boats aground	..	40
Detained at Lockville, waiting to lock	..	30
Detained at Macedon, waiting to lock	..	35
Detained at lock 62, waiting to lock	..	40
Detained at lock 63, waiting to lock	..	25
Detained at lock 64, waiting to lock	..	20
Detained at locks 65 and 66, waiting to lock	..	40
Arrived at *Rochester* at 4.30 P. M., November 2d.		
Detained at Rochester for coal	2	..
Detained at Albion for swing-bridge	..	30
Detained at Holly for wood and water	1	..
Detained at Middleport for coal	4	40
Detained at Lockport, waiting to lock	..	30
Passed through Lockport locks in 25 minutes.		
Arrived at *Buffalo* at 4 A. M., November 4th.		
Total detentions claimed	20	30

Deductions.

	Days.	Hours.	Min.
Total time from West Troy	5	10	30
Detentions claimed	..	20	30
Add for lockage	..	10	..
	1	6	30
Running time	4	4	..

or 100 hours; distance, 345 miles.

Avarage speed ..... 3.45 miles per hour.
Average speed, including lockage ..... 3.14 miles per hour.
Average speed, including all detentions ..... 2.64 miles per hour.

THIRD TRIP EAST.

Left Buffalo at 11.30 A. M., November 10th, 1872. Cargo, 6,550 bushels of corn and 15 tons of coal; weight, 198$\frac{4}{10}$ tons.

	Detentions. Hours.	Min.
Detained at Tonawanda by crowd of boats	9	10
Detained at Tonawanda creek by wreck in middle of creek	12	..
Detained at Lockport locks, waiting to lock		40
Arrived at *Rochester* November 12th.		
Detained at Rochester for coal	5	15
Detained at lock 66 by boats aground	2	..
Detained at Macedon, waiting to lock	..	40
Detained at Palmyra	4	10
Detained at Port Gibson for wood and water	1	..
Detained at Newark locks, waiting to lock	1	30
Detained at Clyde, waiting to lock	3	40

	DETENTIONS. Hours.	Min.
Detained at Lock Berlin locks, waiting to lock	3	30
Detained at Port Byron, on dock	5	15
Arrived at *Syracuse* November 15th.		
Detained at Syracuse for coal	6	45
Detained at Lodi by crowd of boats	2	30
Detained at Manlius, aground; 5 ft. 9 in. water	2	40
Detained above Bolivar, aground; 5 ft. 8 in. water	2	20
Detained at Canastota, repairing pump	2	20
Arrived at *Utica* November 16th.		
Detained at Utica by crowd of boats	1	..
Detained at Ferguson's by a tug with 4 boats in tow	1	..
Detained at Little Falls, waiting for lock	1	45
Detained at Spraker's to repair steam pipe	8	30
Detained at Auriesville for wood and water	..	40
Arrived at *Schenectady* November 18th.		
Detained at Schenectady	2	35
Detained at locks 18 and 19, waiting to lock	1	30
Detained at 16 locks, waiting to lock	1	20
Arrived at *West Troy* at 9.45 A. M., November 19th.		
Total detentions claimed	83	45

Deductions.

	Days.	Hours.	Min.
Total time from Buffalo	8	22	15
Detentions claimed	3	13	45
Add for lockage	..	10	..
	3	23	45
Running time	4	22	30

or 118½ hours; distance, 345 miles.

Average speed ..... 2.91 miles per hour.
Average speed, including lockages ..... 2.69 miles per hour.
Average speed, including all detentions ..... 1.63 miles per hour.

SUMMARY OF THE "PORT BYRON'S" TRIPS.

NUMBER OF TRIPS.	Cargoes, tons.	TIMES. Total. D. H. M.	Detentions. D. H. M.	Running. D. H. M.	Average speed, miles per hour.
First trip west	100.	11 15 50	6 2 55	5 12 55	2.59
First trip east	200.2	24 15 30	17 15 15	7 .. 5	2.05
Second trip west	126.	10 12 30	4 20 15	5 16 15	2.58
Second trip east	200.2	9 3 40	3 14 15	5 13 25	2.59
Third trip west	117.	5 10 30	1 6 30	4 4 ..	3.45
Third trip east	198.4	8 22 15	3 23 45	4 22 30	2.91
Means	.....	11 17 20 5-6	6 5 49 1-6	5 11 31 3/4	2.685

SPECIAL PERFORMANCES.

The following are extracted from Captain Emerson's statement. On the second trip east, the "Port Byron" ran from Buffalo to Lockport, 31 miles, in 7 hours and 30 minutes, and from Port Byron to Montezuma, 5 miles, in one hour. On the same trip the run between Troy and Albany, on the river, was made in 1 hour and 10 minutes. On the final trip east, the "Port Byron" passed through the 16 locks at Cohoes, in 2 hours and 40 minutes; ran from Troy to Albany, on the river, in 50 minutes; and made the run from the weigh-lock in West Troy, to pier 9 East river, New York, in 30 hours and 30 minutes.

The indorsements upon the clearance for the third trip west (the only complete copy furnished) show that the average speeds for that trip, between the prominent points on the line of the canal, exclusive of all detentions claimed and of 8 minutes for each lock passed, were:

	Distance. Miles.	Running time. Hours.	Min.	Aver. speed. Miles per hour.
West Troy to Schenectady	23	7	5	3.25
Schenectady to Utica.....	80	26	6	3.07
Utica to Syracuse.....	56	16	3	3.49
Syracuse to Rochester.....	93	25	32	3.64
Rochester to Buffalo	93	26	2	3.57

The ability of the "Port Byron" to make an average speed of 3 miles per hour for the entire run from West Troy to Buffalo, carrying 117 tons of cargo, is thus demonstrated. It should be remarked, however, that her wheel, with the immersion due to a cargo of 117 tons, is much more efficient than it is with the excessive immersion due to a cargo of 200 tons, or with its axis only 8 inches above water. In the former case, the dip of the center of the bucket is only about 2 feet four inches; while in the latter it is 4 feet 4 inches.

POWER AND SLIP.

On the 18th of November I joined the "Port Byron" at lock 25, six and a half miles west of Schenectady, and accompanied her as far as the latter point. We left lock 25 at 2.45 P. M. and arrived at the collector's office in Schenectady at 5.15 P. M.; time 2½ hours; distance 6½ miles; lockages 2; running time 2 hours 14 minutes; average speed 2.9 miles per hour. The run from lock 23 to Schenectady, 2¾ miles, was made in 45 minutes, or at the rate of 3.67 miles per hour. Several boats were passed and considerable delay was experienced, of which no note was taken. Between locks 23 and 25 the

water was at least a foot low, so that the boat was almost constantly rubbing the bottom.

The average steam pressure and revolutions, during the time I was on board, were estimated at 80 pounds, and 25 per minute, respectively; indicating the expenditure of a power of 48 horses. At one time, when just below lock 23, 100 pounds and 30 revolutions were observed. Taking the whole run of 6½ miles, the slip of the wheel averaged about 67½ per cent. Taking the run from lock 23 to Schenectady, the slip was about 60 per cent.

COAL CONSUMPTION.

Captain Emerson's statement shows that, on the first trip east, the coal consumption was at the rate of 1½ tons of anthracite coal in 24 hours; but whether this was the consumption for each day of *running* time, or whether it was for each 24 hours of the entire time consumed in making the trip, is not stated.

On the second trip east, the coal consumption is put at 2 tons of bituminous coal in 24 hours.

On the third trip west, 8 tons of bituminous coal and 2 tons of anthracite coal were burned, making 10 tons for the entire trip.

On the final trip east, the quantity of coal burned was "the same as on preceding trips," or at the rate of 2 tons of bituminous or 1½ tons of anthracite, in 24 hours, "while running." If we take the loss of the several trips, and deduct from the total time of each an amount of time which may fairly represent the extent to which the coal consumption was interrupted by the several detentions which are noted, and allow 1½ tons per day for the remaining time—estimated as "running time"—the coal consumption, for the several trips, will stand thus:

	Estimated equivalent running time.	Coal.
First trip west	8 days.	12 tons.
First trip east	9⅜ days.	14⅛ tons.
Second trip west	7½ days.	11¼ tons.
Second trip east	7 days.	10½ tons.
Third trip west	5½ days.	8¼ tons.
Third trip east	6¾ days.	10⅛ tons.
Totals	44 5/12 days.	66⅝ tons.
Averages	7 days 9⅜ hours.	11 5/48 tons.

According to this estimate, which is believed to be very liberal, the coal consumption, per boat mile, on the canal, was 64.4 pounds of anthracite, or its equivalent of bituminous.

GENERAL DEDUCTIONS.

Distance steamed on the canal, miles	2,070
Tons moved over the canal, including boat	1,422.4
Tons moved over the canal, cargo	941.8
Coal consumed, tons (approximate)	66.62
Average power expended, horses (about)	45
Average duration of single trip, hours	281.35
Average running time of single trip, hours	131.52
Average speed, exclusive of all detentions, miles	2.68
Ton miles, including boat	352,555.5
Ton miles, cargo	324,921
Coal consumption per boat mile, pounds	64.4
Coal consumption per ton mile, including boat	0.378
Coal consumption per ton mile, cargo	0.410
Cost of coal per boat mile ($5.50 per ton), cents	17.71
Cost of coal per ton mile, including boat	0.104
Cost of coal per ton mile, cargo	0.113

These deductions, so far as relates to coal and its cost, are made upon an assumed exclusive use of anthracite. In fact, however, large quantities of bituminous coal were used at a larger rate of consumption and at a higher rate per ton. The actual cost as well as consumption of coal was, therefore, undoubtedly greater than is indicated by the above figures.

In so far as provision is made for the passage of a part of the displaced water through the trunk, already described, the "Port Byron" may be taken as representative of a large number of devices which have been brought to my attention during the last two years. The chief claim for this class of devices is, that the passage of a portion of the water astern, *through* the boat, will prevent the formation of the wave or swell which it is assumed is produced when the water is compelled to find its way astern along the sides and bottom of the boat.

The actual effects of any such modification of the hull are:

1st. A diminished midship section and displacement, and an increased weight of boat; and hence, a diminished carrying capacity.

2d. An increase in the surface of the boat, and hence an increased "skin-friction;" and the necessity of an increased power per ton of carrying capacity.

Now, so far as the water, in its movement to fill the void created

by the advancing boat, is influenced by gravity alone, the facility with which the interchange of position between the water and the boat is effected will depend entirely upon the ratio of the sections of the latter and of the prism of the canal; and there will be no difference, in the final result, whether the water passes through the boat, or whether the boat passes through the water, except that, in the former case, the water will move less freely than it will in the latter, on account of the greater wetted permieter and friction of the channel by which such movement is effected. In a word, the adoption of such a device would be equivalent to the adoption of a smaller and more expensive boat than those now in use, and requiring more power for its propulsion.

In the case of the "Port Byron," the effect of the trunk upon the carrying capacity amounts to about 6 tons, causing her to draw nearly two inches more water than she would without the trunk. Had her draft been two inches less, while making her trips east, much of her detention from grounding would have been avoided, and better running time would have been made. The increase in "skin-friction," due to this trunk, is about seventeen per cent.

If the flow of water through the trunk in question is to be accelerated to any considerable extent by the propelling instrument, at the expense of the power of the machinery, the merits of the device become still more questionable, as will appear from the following considerations: The area of a section of the trunk is 2 square feet, and the area of the midship section of the boat, when drawing 6 feet of water, 104 square feet. For our present purpose, we may consider the former as two per cent of the latter. While the loaded boat is advancing a distance equal to its own length, then, a volume of water equal to two per cent of the displacement may be considered as passing through the trunk (in fact the trunk passes through the water). If, now, the boat be moving at a speed of 3 miles per hour, and ten per cent of the water pass through the trunk, the velocity of the current will be 15 miles per hour, and the equivalent head due to this velocity, together with the resulting friction, will be about $9\frac{1}{2}$ feet. In one minute, then, $15 \times 88 \times 2 = 2{,}640$ cubic feet of water must pass through the trunk at the expense of sufficient power to raise it to a height of $9\frac{1}{2}$ feet. This power will be 47.5 horses, or more than is found necessary to propel the boat, under any circumstances, at the speed named. If 6 per cent of the water be passed through the trunk, or three times as much as would naturally pass, the velocity of the current will be

9 miles per hour, and the frictional head 3.3 feet; while the expenditure of power, on this account, will be 17.4 horses. My observations and estimates satisfy me that this amount of power could not, at any time, have been expended for the purpose indicated, and, hence, that the quantity of water drawn through the trunk could not have amounted to even 6 per cent of the displacement. It is therefore idle to undertake to obviate, by such means, an assumed difficulty which experience and careful observation have shown to have no existence as a matter of fact, or that, if it does exist, its effect is so trifling as not to attract or merit special notice or attention.

The precise effect produced upon the water at the sides of the canal, by the passage of boats, is a depression extending from bow to stern, on each side of the boat, while the normal elevation of the water, both ahead and astern, is not sensibly changed. This depression, which is segmental in profile, advances with the boat. Its greatest depth is at a point nearly opposite to the center of the boat, and varies, with the speed, from an inappreciably small amount, at very low speeds, to a maximum of about nine inches at the highest speeds thus far attained.

The feathering paddle-wheel of the "Port Byron" also requires special attention.

Let it be assumed that it is capable of giving the boat, with 200 tons of cargo, a maximum speed of 3.8 miles per hour through the water, and that the slip of the centers of the paddles, at such speed, is 33 per cent. The wheel will then make 16 revolutions per minute; and the velocity of each paddle, as it reaches its lowest point and greatest efficiency, will be 8.3 feet per second. At the same time the speed of the boat, in the opposite direction, will be 5.57 feet per second. The velocity of the paddle through the water will therefore be $8.3-5.57=2.73$ feet per second, which represents its slip. Now, at this instant, the two adjacent buckets, which are 45° distant from the former, will be moving astern at the rate of $8.3 \times \cos. 45° = 5.87$ feet per second. Deducting from this the velocity of the boat in the opposite direction, we find that the velocities of each of the two paddles through the water is $5.87-5.57=0.3$ of a foot per second. It appears, then, that the forward paddle has just begun to act usefully, and that the after one is just ceasing to act in that manner. The efficient action of each paddle is therefore limited to an arc of about 90°

From the instant that each paddle enters the water until it reaches a point about 45° below the horizontal, its motion, astern, is less than

the forward motion of the boat; and hence it is backing water, or retarding the progress of the boat. The same is true of each paddle from the instant it ceases to act efficiently until it leaves the water. Now, each paddle enters the water while its arm is still above the horizontal line passing through the axis of the shaft, and does not leave it until its arm has passed above this line on the after side. Tracing, then, the action of a paddle, from the instant when it enters until it leaves the water, it will be seen that while descending through an arc of about 45° it is backing water or impeding the progress of the boat; that when it passes the point where it ceases to act prejudicially, it begins to act effectively, which action is constantly increased until its lowest point is reached, where the effect is maximum; that beyond this last point the useful effect gradually diminishes, and finally ceases, at a distance of about 45° from the lowest point; and that beyond this point it again becomes an impediment, and continues to be such until it finally leaves the water.

It appears, therefore, that each paddle is effective only during one-half of its immersion; and that during the other half it is not only inefficient but becomes a serious impediment to the forward movement of the boat.

I have thus pointed out, in a general way, the character of the defects of this wheel when deeply immersed, as in the case of the "Port Byron." A careful analysis of its action when the boat is loaded to 6 feet draft, shows that, taking the effect of a paddle at its lowest point as unity, the aggregate useful effect of all the paddles is 1.123, or about 1⅛ paddles. Had the retarding effect, due to back water, been also estimated and deducted, the result would have shown a resultant useful effect for the entire wheel of less than one paddle.

We thus have an explanation of the fact that, on the 18th of November, the mean slip of this wheel was 67½ per cent. At 33 per cent slip the effective paddle surface is too small to accomplish the work required of it. In order, therefore, to develop a reaction equal to the resistance of the boat, the revolutions of the wheel and its slip must be increased to such an extent as to bring the paddles into earlier effective action, and at the same time to diminish the resistance due to back water.

With an immersion such that, with a reasonable amount of slip, the paddles would act effectively at the instant of entering the water, this wheel would doubtless give good results. During the three western trips, this condition was of course most nearly satisfied; and it is to this fact, in part at least, that the average speed in that direction,

against the current, exceeded by over a third of a mile an hour the average speed east.

VII. *The "Excelsior."*

This was an iron steamer, built at Green Point, N. Y., of full size, and was represented by W. H. Mallory, Esq., of Bridgeport, Conn. Her launching weight was said to have been less than 30 tons.

The peculiarity of the "Excelsior" consisted in her propelling instrument, which was the Fowler wheel. This wheel, like those of the "Fountain City," is a paddle-wheel, revolving about a vertical axis. It has four blades, each two feet long by one foot wide, giving an aggregate surface of 8 square feet. Its axis was supported at the bottom by a plate or shoe extending aft from the keel and supported at its other extremity by an iron rod suspended from the hull above. The pitch of the blades of this wheel is adjustable by means of an eccentric upon the shaft, from the strap of which rods lead to and connect with arms upon the upper extremities of their axes. The adjustment is effected by the steersman, who is thus enabled to direct the action of the wheel in such a manner as to cause it to drive the boat ahead, back it or turn it around within its own length without stopping or reversing the engine. This wheel, therefore, serves the double purpose of propeller and rudder, with the additional advantage that all the functions of these two instruments are performed simultaneously, while the direction of the motion of the wheel itself remains unchanged.

The engine of the "Excelsior" was a single cylinder, twelve inches in diameter by twenty inches stroke of piston, was provided with an independent adjustable cut-off valve upon the back of the main valve, and was non-condensing. The engine was connected directly with a crank upon the upper extremity of the wheel-shaft.

The boiler was horizontal, return-tubular, five feet in diameter and ten feet long; it had one flue twelve inches in diameter, two flues eight inches in diameter, and forty-four three-inch return tubes six feet in length. The grate surface was sixteen square feet, and the heating surface about 280 square feet. The exhaust could be turned into the smoke-stack, or outside, as desired. It was originally intended that the end of the boat containing the machinery should be the bow, but upon trial it was found not to work satisfactorily in that direction. In the other direction, however, she was found to perform to the entire satisfaction of her owners, except that the stern, which was built very full, did not serve the purpose of a bow quite as well as could have been desired.

This steamer entered the canal on the 4th of September last with a cargo of 100 tons of coal; but, in passing through the sixteen locks at Cohoes, a hole was stove in each bow, which, but for a water-tight bulk-head, would have caused her to sink. She, however, proceeded as far as Crescent, where she went upon the dock for repairs. I joined the steamer, at this point, on the 5th. It had already been decided, on account of the obvious frailty of the boat, and her evident inability to withstand the shocks which she would encounter in the canal, to return to New York and transfer the machinery to a wooden hull.

Major Mallory, however, for the purpose of exhibiting the capacity of his machinery, consented to make a run as far as lock 19, distant six miles from Crescent. Accordingly, on the morning of the 6th, the "Excelsior" left the dry-dock at 8 o'clock and ten minutes, and proceeded west. At 8.38 a line was caught in the wheel, which caused a detention of an hour and thirty-five minutes; at 10.50 proceeded and reached lock 19 at 12 o'clock noon. Running time, one hour and 46 minutes; average speed, against the current, 3.41 miles per hour. At 1.15 P. M. started on the return trip, and at 2.03 P. M., in endeavoring to pass a loaded boat at a point where the canal was obstructed by other boats, ran upon rocks upon the berme side and stove a hole in the port bilge. Upon backing off, a serious list to port indicated that the steamer was sinking. She was immediately backed into wide water and grounded on the berme side of the canal, where she soon filled with water. While running west the speed was at times as high as 3.8 miles per hour; running east with the current, four miles was exceeded. The coal expended during the six hours was 546 pounds; distance steamed, nine miles; average coal consumption per boat mile, 60.7 pounds. The engine was idle, however, over a third of the time.

The steam pressure ranged from 80 to 95 pounds, and the revolutions from 80 to 100 per minute. Average steam, 89 pounds; average revolutions, 94 per minute.

The steam having been throttled during the entire run, and the effect of the throttling being very uncertain, it is impossible to determine what power was expended. Judging from the coal consumption, I think it did not exceed 35 to 40 horses.

As to the efficiency of the wheel, as compared with other propelling instruments, the test was not sufficiently prolonged to warrant an expression of opinion.

VIII. *The "Eureka."*

This boat, which was built and is owned by Hiram Niles, Esq., of Buffalo, is of iron, full size, and weighs, with her machinery, 79¾ tons. She is unusually sharp, forward, below load water-line, and carries her machinery, consisting of a Perry and Lay compound engine and two screw propellers, forward.

Her cylinders are 8 and 16 inches in diameter, and the stroke of the pistons is 12 inches. Her boiler has 10½ square feet of grate, and consumes, as the captain informed me, two tons of coal in 24 hours.

The screws are 42 inches in diameter, and have a pitch of 4 feet 8 inches; these are so disposed that their axes are parallel with those lines of the bow which lie in the same horizontal plane, and are driven by a level wheel upon the outboard end of the engine shaft.

On the 17th of September I joined the "Eureka," at lock 5, while she was bound west with a cargo of 150 tons. She ran from this point to the head of the 16 locks, making the passage of 13 locks in three hours and five minutes. The time occupied in locking ranged from 6 minutes and 20 seconds to 9 minutes and 55 seconds. She did not enter the locks readily; this was partly on account of her extreme width, and partly, I think, on account of the location and arrangment of the screws.

The steamer left lock 18 at 2.12 P. M., and at 2.25 became disabled by the breakage of one of the bevel wheels. During the run of 13 minutes, while the engine was making 116 revolutions, the speed was observed to be at the rate of 2.7 miles per hour. The "slip" was, therefore," 56 per cent.

No clearances or statements of detentions have been furnished by Mr. Niles, who, it is understood, on account of the unsatisfactory character of the "Eureka's" machinery, withdrew her from competition.

IX. *The "George A. Feeter."*

This is an ordinary "bull-head" boat, transformed by Mr. Louis Stagg, of Springfield, Ohio, in accordance with a peculiar idea of his as to the best and most effective means by which the formation of the wave or swell may be prevented.

Mr. Stagg says: "The device or invention consists in taking the water in on either side of the boat and discharging it at the stern, through channelways placed in the bottom of the boat, starting from a point one-third the distance of the full length of the same from the stern." This plan, says Mr. S., "is based upon a hydrostatic law that

water drawn diagonally from the sides of the boat, revolving in opposite directions, will pass out in straight lines, without lifting or agitating the surface of the water, absolutely preventing the wash of the banks or injury to the canal or its structures."

The channel-ways are each 52 inches in diameter, and meet at a point 7 feet from the stern; from this point a single trunk, 7 feet wide and 52 inches high, extends directly to the stern. The combination, therefore, in plan resembles the letter Y.

The screws are 4 feet in diameter, are placed 2 feet within the hull, have a feed space extending 9 feet forward, and revolve in opposite directions. The machinery consists in a pair of Gothic inclined engines, with cylinders 10×12, and rated at 60 horse power.

The boiler is horizontal return tubular; has 16 square feet of grate surface, six 6-inch flues and seventy-two 2-inch return tubes.

The "Feeter" left Buffalo, on her first and only trip, on the 16th of November, with a cargo of 6,000 bushels of corn, weighing 168 tons, and drawing 6 feet of water.

No statement of detentions has been furnished, nor did the several collectors note the hours at which the boat passed their offices; but the *dates* are as follows: Buffalo, November 16th; Albion, 17th; Rochester, 17th; Palmyra, 19th; Montezuma, 20th; Syracuse, 21st; Utica, 24th; Schenectady, 25th; West Troy, 26th. The time consumed in making the trip, therefore, appears to have been about 10 days.

The coal consumption is put by Mr. Stagg at $1\frac{1}{2}$ tons in 24 hours. He accompanied the boat as far as Rochester, and states that the speed between Buffalo and Rochester averaged 3 miles per hour. The probable correctness of this statement, as to speed, is indicated by the indorsements on the clearance.

This boat cannot carry 200 tons, and, therefore, cannot meet all the requirements of the law. Mr. Stagg claims that she can carry 150 tons and tow four loaded boats. Her ability to do this, however, remains to be demonstrated.

X. *The "Central City."*

This is a new side-wheel boat, built expressly for steam propulsion by Mr. T. D. Davis of Syracuse. She is quite sharp forward, is 98 feet long and of the usual width.

The peculiar feature of the "Central City," so far as her machinery is concerned, consists in the provision which is made for adjusting the immersion of the paddle wheels to the draft of water, so as at all

times to insure the maximum efficiency of the paddles. The wheels, boiler and engine rest upon a frame which is supported by four vertical screws, by which the entire machinery and wheels may be raised or depressed at will. When the boat is loaded, all of the machinery will be even with or above the deck, leaving the entire space underneath available for the stowage of cargo. The wheels are placed in recesses built in the sides, at the stern of the boat, are 12 feet in outside diameter and have each 12 paddles 26½ inches long by 22 inches deep.

The boiler is 4 feet in diameter, has 14 square feet of grate and about 230 square feet of heating surface.

The engine is single, non-condensing, with a cylinder 10 inches in diameter, 17 inches stroke of piston and is geared to the paddle-shaft in the ratio of 6 to 1.

This boat was completed late in November last, and was able to make only a single trip from Syracuse to Albany, where she now lies. While making this trip she forced her way through the ice from Schenectady to Troy, after horse-boats had ceased running.

I was not able to join this boat on her trip, and, therefore, know nothing, personally, of her performance. Mr. Davis, however, expresses himself as quite satisfied that the boat will prove to be a success.

XI. *The "Montana."*

This is an ordinary "lake boat" remodeled to receive a feathering paddle-wheel in the center of the stern. For this purpose a recess was cut about 6½ feet wide, having its forward bulk-head vertical and distant about 10 feet from the stern. The paddle-wheel is 8 feet in diameter, to the axes of the paddles, and has eight curved paddles of boiler iron, each of which is 6 feet long and 21 inches wide.

The engines are two in number, direct-acting and non-condensing; the cylinders are 9 inches in diameter, and the stroke of the pistons is 18 inches.

The boiler is of the horizontal locomotive type, 4 feet in diameter and 10 feet long; it has 13 square feet of grate surface, and ninety 2½ inch fire tubes, 4 feet 3 inches long, the latter, together with the fire box, making about 288 square feet of heating surface.

The "Montana" has made one or two single trips, but, I believe, has not performed to the satisfaction of those interested in her. The plan resembles that involved in the "Port Byron," except that the trunk is wanting, and that the wheel is smaller and the buckets longer.

I saw this boat on the canal while coming east on board the "Baxter" on the morning of the 14th of November. It was quite dark at the time, and I was unable to judge as to her behavior. I was unable to join her at any time, as no information was furnished as to her movements.

Neither clearances nor statement of detentions have been furnished by the captain or owners of the "Montana."

The foregoing comprises all the boats to which my attention has been called during the last two seasons of navigation. Others have, I believe, been upon the canal, but whether or not they were considered as competing for the reward offered by the State, I am not informed. The list certainly embraces all that can by any possibility claim to have made the preliminary trips required by resolution of the Commission, or to have carried the cargoes and made the speed required by the law.

HORSE-BOAT "TIME."

In order to judge correctly as to the relative capacities and economy of steamers, as compared with horse-boats, it is of course necessary to know the average time of the latter between Buffalo and Troy. For the purpose of ascertaining this time, I caused an examination to be made of the clearances of 72 boats arriving, consecutively, at West Troy from Buffalo. The results of this examination are as follows: Average time between Buffalo and West Troy, 10 days 2 hours and 46 minutes; average cargo, 227 tons; average speed, 1.42 miles per hour. This examination was commenced on the 16th of October, and in only two or three instances was mention made of delay due to sickness of horses. It is assumed, therefore, that the results obtained fairly represent the average performance of the horse-boat between Buffalo and Troy.

STEAM TOWING.

The opinion is expressed by many persons interested in canal navigation that the true solution of the problem of "steam on the canals" is to be found in the employment of steamers which shall simply tow trains of boats, carrying no cargo themselves, or shall carry moderate cargoes themselves and shall tow one, two or three loaded boats besides. The arguments advanced in support of this opinion, and which seem plausible enough until critically examined, are that only one engine and crew may thus be made to do the work of several engines and crews, and that the space occupied by the single engine,

even though it be of greater power, will be much less than the aggregate space occupied by the machinery when applied to each boat, and, therefore, that the average paying cargo will be greater. The economy of steam towing on the canal will depend mainly upon the relative speeds of the tow and of the single steamer, and upon the costs at which these speeds are attained. If it be possible to tow a train of boats from Buffalo to Troy in the same time that the single steamer requires for the same trip, and with the same expenditure of power per ton, then there can be no further question as to the superior economy of that mode of transportation. But can this speed be attained?

The effective surface of the propelling instrument which may be employed upon the canal is limited by the depth of the canal and by the width of the locks. Hence no larger propelling surface can be employed in connection with the towing steamer than can be used in each steamer that does not tow. Now, the "slip" of any propelling instrument, and the loss of power due to it, increase rapidly with the work it has to do. It follows, then, since the work of the towing steamer must necessarily be much greater than that of the single steamer at the same speed, that a much larger per centage of the power of the former will be uselessly expended in "slip" than will be thus expended in the latter, and hence that the towing steamer cannot use its power as effectively as the steamer which does not tow. If the power cannot be used as effectively in the one case as in the other, then, with the same proportionate expenditure of power, the towing steamer cannot attain the same speed that can be maintained by the steamer without a tow.

This is a serious objection to towing, but it is not the only one. The canal steamer passes through the canal with a necessary average detention of say six minutes at each lock, or seven hours between Buffalo and Troy. The towing steamer passes a lock as quickly as the former; but after it has passed, it must wait for the first and succeeding boats of the tow to be locked through. Each additional single lockage will require nearly or quite double the time required for the first, on account of the greater difficulty in the management of the towed boats, and of the necessity of waiting for the locks to be "shifted," or for a boat to be locked in the opposite direction. The time of *three* single lockages is therefore required for the passage of the steamer with one boat in tow; but the boats already locked through must still await the slow process of locking the balance of the tow. If there be two boats towed, the detention will be increased *five* times;

if three, *seven* times; and if four, *nine* times. Thus the detention of a tow of four boats at each lock would be 54 minutes. This, between Buffalo and Troy would make an aggregate detention of 63 hours, or $2\frac{5}{8}$ days, against the detention of 7 hours experienced by the non-towing steamer. Thus it appears that the loss of time at the locks alone, by the tow, amounts to nearly or quite half the length of time required for the entire trip of the single steamer. If to this delay be added the effect of the reduced speed while running, and the delays from low water caused by waste in locking, the economy of towing becomes still more questionable.

That the foregoing is not mere speculation, we have abundant evidence in the performances of the "Newman," and of the several tugs which were put upon the canal, temporarily, during the prevalence of the horse disease in October and November last. The "Newman" made her three trips east in an average of six days, thirteen hours and fifty minutes, including all detentions, when running alone; but with two boats in tow her time was increased to twelve days and six hours, including all detentions; which may also be taken as a fair average for the time of a tug with four boats in tow.

Fortunately, the data in our possession, in regard to the "Newman's" performances, is so complete that we are able to make very reliable estimates of the costs of freight movement in the two cases.

In making these estimates, the cost of the steamer will be taken at $7,000, and the cost of the horse-boat at $4,000. Interest will be allowed at the rate of seven per cent upon the investment; also ten per cent per annum for depreciation or maintenance. The season of navigation will be taken at the average of 230 days; against which working time the interest and maintenance will be charged. The time of the steamer, between Buffalo and Albany, when running alone, with a cargo of 200 tons, will be taken at six days, to which three days will be added for detention in port. The time of the steamer with two boats in tow, carrying in the aggregate 660 tons, will be taken at twelve days, with three days added for detention in port. Finally, we shall use the recorded coal consumption in each case, and estimate the same at $5.50 per ton. The estimates will then stand as follows:

Estimated cost of transporting 200 *tons from Buffalo to Troy, by the steamer "William Newman."*

Interest, 9 days at $2.13	$19 17
Maintenance, 9 days at $3.04	27 36
Coal, $\frac{65.2 \times 345}{2000} \times \$5.50$	61 86
Engineers, 9 days at $3	27 00
Captain, 9 days at $2	18 00
Two men, 9 days at $1 each	18 00
Cook, 9 days at 40 cents	3 60
Board 9 days of 6 persons at 50 cents	27 00
Oil, tallow and waste, say	8 01
Total	$210 09

Cost per ton moved 345 miles $1.05
Cost per ton moved 1 mile ..... $3\frac{4}{100}$ mills.
Cost per bushel of wheat 345 miles ..... $3\frac{15}{100}$ cents.

Estimated cost of transporting 660 *tons from Buffalo to Troy by the steamer "William Newman," with two boats in tow.*

1. Cost of steamer's trip:

Interest, 15 days at $2.13	$31 95
Maintenance, 15 days at $3.04	45 60
Coal, $\frac{130.4 \times 345}{2000} \times \$5.50$	123 72
Engineers, 15 days at $3	45 00
Captain, 15 days at $2	30 00
Two men, 15 days at $1 each	30 00
Cook, 15 days at 40 cents	6 00
Board 15 days of 6 persons at 50 cents	45 00
Oil, tallow and waste, say	16 00
Total	$373 27

2. Cost of each horse-boat:

Interest, 15 days at $1.22	$18 30
Maintenance, 15 days at $1.74	26 10
Captain, 15 days at $2	30 00
Two men, 15 days at $1 each	30 00
Cook, 15 days at 40 cents	6 00
Board 15 days of 4 persons at 50 cents	30 00
Total for one boat	$140 40
Total for two boats	$280 80

The total cost of the trip is therefore as follows:

Cost of steamer's trip	$373 27
Cost of two horse-boats	280 80
Total	$654 07

Cost per ton moved 345 miles	$99\frac{1}{10}$ cents.
Cost per ton moved 1 mile	$2\frac{87}{100}$ mills.
Cost per bushel of wheat 345 miles	$2\frac{97}{100}$ cents.

Estimated cost of transporting 920 *tons from Buffalo to Troy in* 4 *boats, towed by a steam tug costing* $14,000.

Cost of tug and power:	
Interest, 15 days at $4.26	$63 90
Maintenance, 15 days at $6.09	91 35
Coal, 36 tons at $5.50	198 00
Captain, 15 days at $3	45 00
Engineers, 15 days at $4	60 00
Three men, 15 days at $1 each	45 00
Cook, 15 days at 75 cents	11 25
Board 15 days of 7 persons at 50 cents	52 50
Oil, tallow and waste, say	20 00
	$587 00
Add four boats at $140.40 each	561 60
Total cost of trip	$1,148 60

Cost per ton moved 345 miles	$1.25 nearly.
Cost per ton moved 1 mile	$3\frac{62}{100}$ mills.
Cost per bushel of wheat 345 miles	$3\frac{3}{4}$ cents.

Collecting these results per ton mile, we have:

1. For the "Newman"	3.04 mills.	100
2. For the "Newman" towing two boats	2.87 mills.	94
3. For the tug towing four boats	3.62 mills.	119

The cost of equipment per ton transported in each of three cases is as follows:

1. For the "Newman"	$35 00
2. For the "Newman" and two boats	22 73
3. For the tug and four boats	32 61

The cost of equipment per ton transported in each of the first two cases, reduced to what it would be for the same movement that was effected in the third case, in the same time, give the following results:

1. For the "Newman"	$21 00	100
2. For the "Newman," towing two boats	22 83	109
3. For the tug towing four boats	32 61	155

These results, based as they all are upon the same movement and time, show the relative costs of equipment for the same freight movement by the three modes considered. Taking the "Newman's" performance when running alone as the standard of comparison, it appears that in the case of the "Newman" towing two boats, the cost of movement is six per cent less; but that the outlay required for equipment is nine per cent greater. It further appears that, in the case of the tug towing four boats, the cost of movement and the cost of equipment are nineteen and fifty-five per cent greater respectively. Boats towed by steam on the canal are liable to greater injury from collisions and other causes than boats towed by horses, or boats propelled by their own machinery; the endurance of the steam-towed boat will, therefore, be less, while the cost of its maintenance will be correspondingly greater than that of the present boats.

In view of all the facts, then, it appears that, so far as the movement on the canal alone is concerned, the cost is very nearly the same, whether it be effected by placing steam in each boat, or by placing it in every third boat; and that either of these methods will be found far more economical than the use of tugs. When, however, the movement is continued down the river to New York, the results will be different. In that case, the single steamer, upon arriving at Troy, can enter the river and proceed directly to its destination, with the expenditure of thirty hours' additional time and not more than $2\frac{1}{2}$ tons of coal, amounting together to $39.10, and making the total expense of the trip from Buffalo to New York $249.10, or at the rate of $2\frac{52}{100}$ mills per ton per mile for 495 miles. Upon the arrival of the same steamer at Troy, with two boats in tow, the former would proceed to New York as before, and with the same expense, while the latter will require at least two days' extra time and an additional expense of $30 each to reach their destination. The total expense of the trip of the three boats, from Buffalo to New York, with an aggregate cargo of 660 tons, will therefore be:

For steamer, Buffalo to Troy	$373 27
For steamer, Troy to New York	39 10
For two boats, Buffalo to Troy	280 80
For two boats, Troy to New York	97 44
Total	$790 61

or at the rate of $2\frac{42}{100}$ mills per ton mile; showing a difference of only 3.9 per cent in favor of the latter mode of transportation. Upon the arrival of the tug, with its four boats, at Troy, the former would be at liberty to make up a tow for the return trip, and its expense would be the same as already estimated; the latter would proceed to New York with the same delay, and at the same cost, per boat, as estimated in the last preceding case. The total cost of the movement of 920 tons, from Buffalo to New York, will therefore stand thus:

Expense of tug, from Buffalo to Troy.....	$587 00
Expense of 4 boats from Buffalo to Troy.....	561 60
Expense of 4 boats from Troy to New York.....	194 88
Total	$1,343 48

or at the rate of $2\frac{75}{100}$ mills per ton mile; which is 17.3 per cent greater than the cost by the first mode.

SUMMARY OF RESULTS AND DEDUCTIONS.

MODE OF TRANSPORTATION.	Tons per trip.	Cost equipment, per ct.	BUFFALO TO TROY, 345 MILES. Cost of movement. Per ton.	Per ton per mile.	Per bush. wheat.	Per cent.	BUFFALO TO NEW YORK, 495 MILES. Cost of movement. Per ton.	Per ton per mile.	Per bush. wheat.	Per cent.
				mills.	cents.			mills.	cents.	
By steamer alone	200	100	$1 05	3.04	3.15	100	$1 24½	2.52	3.736	100
By steamer, towing two boats on canal	660	109	99.1	2.87	2.97	94	1 19.8-10	2.42	3.594	96
By tug, towing four boats on canal.	920	155	1 25	3.62	3¾	119	1 46	2.95	4.383	117

The foregoing estimates and comparisons are based upon authentic information as to the actual performances of the "Newman;" but, in the case of the tug, the time occupied in making the trip is not so certainly known. General report, however, together with my own observations of their movements on the canal, as compared with those of other boats, seem to justify the assumption that the time adopted in the estimate is nearly correct. But if it shall appear that a fair average of the time consumed between Buffalo and Troy was actually less than twelve days, the results which have been obtained may be very readily corrected. Let it be assumed, for example, that this time was in fact ten days, making, with the three days allowed for detention at destination, thirteen days for the trip from Buffalo to Troy.

We have then each item of expense reduced two-fifteenths, except the coal consumption, which will be reduced one-sixth. The total expense of the trip, thus modified, will therefore be:

Cost of tug 13 days	$502 13	
Cost of 4 boats 13 days	486 72	
Total	$988 85	
Cost per ton 345 miles		$1.07½
Cost per ton 1 mile		$3\frac{116}{1000}$ mills.
Cost per bushel of wheat, Buffalo to Troy		$3\frac{225}{1000}$ cents.
If we add the cost of towing the four boats to New York, as in the former estimate, the total cost of the movement of 920 tons from Buffalo to New York is	$1,183 73	
Cost per ton, 495 miles	1	$28\frac{7}{10}$
Cost per ton 1 mile		2½ mills.
Cost per bushel of wheat 495 miles		$3\frac{861}{1000}$ cents.

A comparison of these with the results first obtained for this mode of transportation shows that the reduction in cost, due to the reduction of two days in the duration of the trip, amounts to 14 per cent between Buffalo and Troy, and to 11.16 per cent between Buffalo and New York. If the time of the tug between Buffalo and Troy, with its tow of four boats, be twelve days, the conclusion is, that the first two modes of transportation are much the cheapest, and that, as between those two modes, it is not easy to decide. If, however, the time of the tug be ten days, the costs of movement are so nearly equal that the preference must depend upon certain contingencies which may, and no doubt will, affect the three modes differently, but which cannot be estimated.

Considering the independent character of the boat carrying its own power, its higher rate of speed, and the ability which this speed will give it to command paying return cargoes, it would seem that transportation can be effected by such boats with decidedly greater economy than by either of the other two modes.

RELATIVE ECONOMY OF STEAM AND ANIMAL POWER.

The experience of the past two seasons of navigation has furnished reliable data upon which to base estimates of the cost of effecting the movement of the tonnage, of the Erie canal, both by steam and animal power, and to ascertain to what extent a saving may be effected by the substitution of the former for the latter. These estimates, in order that they may be at all satisfactory or reliable, must be made upon the basis of an entire season's work, and, so far as steam is con-

cerned, upon what steam *might* do with full seven feet of water, and with horse-boats out of the way, rather than upon what it *has* done, in spite of all the obstacles which it has encountered during the recent trials. A season's movement will therefore be taken at 3,000,000 tons from Buffalo to New York, and 750,000 tons from New York to Buffalo. It will be assumed that this tonnage is to be transported annually, and that the question to be answered is, what will be the cost of equipping the canal with the necessary boats, and of transporting this tonnage by each of these two modes?

The duration of a round trip, or the number of round trips that may be made by the steamer and the horse-boat, during the average season of navigation, with the same condition of canal, must first be determined. In the case of the horse-boat we have already seen that, under present conditions, the average time occupied in making the trip from Buffalo to Troy is, practically, ten days. Allowing two days each way on the Hudson river, and ten days for the return trip from Troy to Buffalo, partly loaded, against the current, and allowing six days for detentions at Buffalo, Troy and New York, the time consumed in making a round trip will be thirty days, and $7\frac{2}{3}$ trips may be made in a season of 230 days. At present it is believed that boats towed by horses in efficient condition do not exceed 7 trips, while the average for all the boats is not more than 6. The estimate will, therefore, be upon the basis of 7 round trips for the horse-boat, allowing one additional trip for the improved condition of the canal. Towing will be estimated at 35 cents per mile on the canal, and at $40 per single trip on the river, in Troy, and in the harbors of Buffalo and New York.

In the case of the steamboat, the time from Buffalo to Troy will be taken at 5 days, allowing 10 hours for improved condition of the canal and the absence of horse-boats, and at 30 hours on the river; making the time from Buffalo to New York, $6\frac{1}{4}$ days and the running time per round trip, $12\frac{1}{2}$ days. Adding 5 days for detention at both ends of the route, the total time consumed in making a round trip will be $17\frac{1}{2}$ days; while the number of round trips per season will be 13.1-7, say 13. The coal consumption will be taken at 45 pounds per mile, or a little less than the mean of the rates of the "Baxter" and the "Newman," and the cost of the coal per ton will be estimated at $5.50. The cargoes east or in the direction of the maximum tonnage, for the horse-boat and steamer, will be taken at 230 and 200 tons, respectively.

The foregoing embrace all the items of expense about which there

can be any serious question; the other items will appear in their proper places and need not be particularly referred to here. The estimates will then stand as follows:

Estimate of the cost of transporting 3,750,000 *tons between Buffalo and New York in* 7½ *months by animal power, in boats carrying* 230 *tons each.*

Number of boats required, 1,863.		
Cost of boats at $4,000 each		$7,452,000
Cost of horses, 7,452, at $150		1,117,800
Cost of harness, etc., at say $20 per horse		149,040
Total cost of equipment		$8,718,840
Interest on cost of boats at 7 per cent		$521,640 00
Maintenance 10 per cent		745,200 00
Cost of towing on canal, 8,998,290 miles at 35 cents		3,149,401 50
Cost of towing on river and in harbors		1,043,280 00
Cost of crew for wages and subsistence, per boat:		
1 captain 7½ months at $60	$450	
2 men 7½ months at $30	450	
1 cook 7½ months at $12	90	
Board, 4 persons, 230 days at 50c.	460	
Board, 2 drivers,* 140 days at 50c.	70	
	$1,520	
Cost of crews for 1,863 boats 7½ months		2,831,760 00
Total cost of a season's work		$8,291,281 50

Deductions.

Cost per boat per season	$4,450 50
Cost per ton moved 495 miles	2 $21\frac{1}{10}$
Cost per ton moved 1 mile	$4\frac{404}{1000}$ mills.
Cost per bushel of wheat from Buffalo to New York	$6\frac{633}{1000}$ cents.

If the boats run light from New York to Buffalo, the foregoing will be modified thus:

Cost per ton moved 495 miles	$2 $78\frac{9}{10}$
Cost per ton moved 1 mile	$5\frac{656}{1000}$ mills.
Cost per bushel of wheat 495 miles	$8\frac{367}{1000}$ cents.

* One driver on duty at a time.

An analysis of this estimate shows that the per centages of the several items of cost are as follows:

Interest	6.3 per cent.
Maintenance	8.9 per cent.
Towage on the canal	38.0 per cent.
Towage on river and in harbors	12.6 per cent.
Crew and subsistence	34.2 per cent.
	100.0 per cent.

Or, if we take only the three elements of boat, towage and crew, we have:

Boat (interest and maintenance)	15.2 per cent.
Towage	50.6 per cent.
Crew	34.2 per cent.

In the foregoing estimate it has been assumed that the canal towage is to be done by towing companies, and the result of course includes their profits. In order to eliminate these, it will be necessary to estimate the actual cost of towing when the horses are owned and subsisted by the boatmen.

Estimate of the cost per mile of horse-towage.

Cost of four horses at $150	$600 00
Cost of harness	80 00
Total	$680 00
Interest on cost of horses at 7 per cent	$42 00
Maintenance, 33⅓ per cent	200 00
Keeping, 230 days, at 60 cents each	552 00
Keeping, 135 days, at 25 cents each	135 00
Shoeing, at $25 each	100 00
Harness, interest and maintenance	25 00
Two drivers, 7½ months, at $18 each	270 00
Total	$1,324 00

Distance towed, miles, $7 \times 2 \times 345 = 4{,}830$. Cost per mile, 27.4 cents.

If the board of the drivers be added, the cost will be about 30 cents per mile; but as that item has been included in the subsistence of the crew, it is not introduced in the above. Employing this sum—27.4 cents—as the cost per mile of canal towage, the cost of a season's work for the assumed tonnage will be reduced to $7,607,411.46

From which we deduce the following:

Cost per boat per annum	$4,083 42
Cost per ton moved 495 miles	2 $02\frac{8}{10}$

Cost per ton moved one mile	$4\frac{1}{10}$ mills.
Cost per bushel of wheat, 495 miles	$6\frac{87}{1000}$ cts.

If the boat run light from New York to Buffalo, these results, except the first, will be increased 25 per cent, and will therefore stand as follows:

Cost per ton moved 495 miles	$\$2\ 53\frac{6}{10}$
Cost per ton moved one mile	$5\frac{1}{5}$ mills.
Cost per bushel of wheat, 495 miles	$7\frac{608}{1000}$ cts.

The per centages of the several items of cost will be:

Interest	6.8 per cent.
Maintenance	9.8 per cent.
Towage on the canal	32.3 per cent.
Towage on the river and in harbors	13.9 per cent.
Crew and subsistence	37.2 per cent.
Total	100 per cent.

Or, taking only the three elements of boat, towage and crew, we have:

Boat (interest and maintenance)	16.6 per cent.
Towage	46.2 per cent.
Crew	37.2 per cent.
Total	100 per cent.

Estimate of the cost of transporting 3,750,000 *tons between Buffalo and New York, in* $7\frac{1}{2}$ *months, by steam power, in boats carrying* 200 *tons.*

Number of boats required, 1,154.

Cost of boats at $7,000 each		$8,078,000
Interest on cost of boats at 7 per cent		$565,460 00
Maintenance of boats at 10 per cent		807,800 00
Coal, 334,169.55 tons at $5.50		1,837,932 52
Oil, tallow and waste		160,000 00
Cost of crew, wages and subsistence per boat:		
1 captain, $7\frac{1}{2}$ months, at $60	$450 00	
2 men, $7\frac{1}{2}$ months, at $30	450 00	
2 engineers, $7\frac{1}{2}$ months, $90 for both,	675 00	
1 cook, $7\frac{1}{2}$ months, at $12	90 00	
Board, 6 persons 230 days, at 50c.	690 00	
	$2,355 00	
Cost of crews for 1,154 boats, at $2,355 each		2,717,670 00
Total cost of a season's work		$6,088,862 52

Deductions.

Cost per boat per season	$5,276 31
Cost per ton moved 495 miles	1 62 3/10
Cost per ton moved 1 mile	3 28/100 mills.
Cost of bushel of wheat moved 495 miles	4 87/100 cts.

If the boats run light, west, these costs, except the first, will be increased 25 per cent, and will therefore be:

Cost per ton moved 495 miles	$2 02 9/10
Cost per ton moved 1 mile	4 1/10 mills.
Cost per bushel of wheat moved 495 miles	6 87/1000 cts.

If the steamer carry 100 tons west, the annual tonnage would be 4,500,000 tons, and cost as follows:

Cost per ton moved 495 miles	$1 69 1/10
Cost per ton moved 1 mile	2 73/100 mills.
Cost per bushel of wheat moved 495 miles	5 7/100 cents.

An analysis of the estimate shows the cost to be distributed as follows:

Interest on cost of boats alone	5.3	per cent.
Maintenance	7.6	per cent.
Steam power, including engines, fuel, engineers, etc.,	59.6	per cent.
Crew, including subsistence (exclusive of engineers),	27.5	per cent.
Total	100	per cent.

Or, taking the three elements of boat, steam power and crew, the distribution of cost will be:

Cost of boat, exclusive of engines	12.9	per cent.
Cost of steam power	59.6	per cent.
Cost of crews	27.5	per cent.
Total	100	per cent.

Comparing the two modes of transportation, under the same conditions as to tonnage, we have the cost per ton mile by animal power hired by the boatmen 4 464/1000 mills.
Cost per ton mile by animal power owned by the boatmen 4 1/10 mills.
Cost per ton mile by steam power 3 28/100 mills.

It appears, therefore, that the transportation by steam power is 26½ per cent cheaper than by hired animal power, and 20 per cent cheaper than animal power owned by the boatmen.

The following table shows the distribution of cost in the three cases:

COST OF TRANSPORTATION.	MODE OF TRANSPORTATION.		
	By animal power, hired, per cent.	By animal power, owned, per cent.	By steam power, per cent.
Cost of boat	15.2	16.6	12.9
Cost of power	50.6	46.2	59.6
Cost of crew	34.2	37.2	27.5
Totals	100	100	100

It is to be observed here, that the estimates from which the foregoing deductions have been drawn have been made upon the basis of an assumed improved condition of the canals, by which an additional round trip has been allowed to the horse-boat, and that in the case of the steamer the coal consumption used was nearly 50 per cent greater than that of the "Baxter" during the season of 1872. As results of this treatment, we have the cost in the former case smaller than it now is; and in the latter, larger than we should have been justified in making it. For this reason, the economy of steam power appears less than may, and doubtless will, be realized.

The following modifications of the foregoing estimates are presented as indicating the *ultimate* measure of the economy which may be expected to result from the use of steam as compared with the present performances of horse-boats, making an average of 6 round trips between Buffalo and New York, and carrying 230 tons. The steamer is assumed to make 14 round trips, with a coal consumption of 35 pounds per mile, which is believed to be all that can be accomplished by steam on the canal.

Estimated cost of transporting 3,750,000 *tons annually between Buffalo and New York, in boats carrying* 230 *tons and making* 6 *round trips per season (including profits of towing companies).*

Interest on cost of boats	$608,580 00
Maintenance	896,400 00
Towing	4,192,681 50
Crews, including subsistence	3,303,720 00
	$9,001,381 50

Deductions.

Cost of boat per season	$4,140 47
Cost of boat per round trip	690 08
Cost per ton moved 495 miles	2 66 7/10
Cost per ton moved one mile	5 39/100 ms.
Cost per bushel of wheat from Buffalo to Troy,	8 cents.

These results include, of course, interest upon investment, cost of maintenance and cost of operating the boats, and are based upon movements of 3,000,000 tons toward tide water and 750,000 tons from tide water. If 1.55 cents per bushel be added for tolls, the total cost of transporting a bushel of wheat from Buffalo to New York, by the present mode, appears to be $9\frac{55}{100}$ cents.

Estimated cost of transporting 3,750,000 *tons annually between Buffalo and New York, in steamers carrying* 200 *tons and making* 14 *round trips per season:*

Interest on cost of boats	$525,070 00
Maintenance	750,100 00
Coal, oil, tallow and waste	1,181,073 62
Crews and subsistence	2,523,550 71
Total	$4,979,794 33

Deductions.

Cost of boat per season	$4,645 33
Cost of boat per round trip	331 81
Cost per ton moved 495 miles	1 32 8/10
Cost per ton moved 1 mile	2 68/100 mills.
Cost per bushel of wheat from Buffalo to Troy,	3 984/1000 cents.
Cost per bushel of wheat from Buffalo to Troy, including tolls	5 534/1000 cents.

Comparing results in the two cases, we find that by the use of steam a reduction in the present cost of transportation of $50\frac{2}{10}$ per cent may be effected. Including tolls in both cases, the reduction in cost is 42 per cent.

To accomplish the assumed number of round trips, it will be necessary—

1. To maintain an average speed of three miles per hour on the canal, including lockages.

2. To maintain an average speed of five miles on the river.

3. To reduce the detentions, at Buffalo and New York, to 4 days $8\frac{1}{2}$ hours per round trip.

With the canal in good condition, the experience of the past season has demonstrated that the first two conditions can be satisfied. With regard to the third requirement, it does not seem unreasonable to suppose that, with proper supervision and direction, it may also be satisfied. A slightly increased rate of speed would admit of longer delay in port, but it would be attended with an increase in the coal consumption, which would be more than an equivalent to the extra exertion necessary to reduce the delay to the time stated.

Steam on Foreign Canals.

Through the courtesy of Hon. W. King, U. S. Consul at Dublin, I have been put in possession of a pamphlet containing "Excerpt Minutes of the Proceedings of the British Institution of Civil Engineers," and comprising papers presented at a meeting held in November, 1866, together with discussions of the same at subsequent meetings. From this pamphlet the following information has been compiled:

Steam towing on the Gloucester and Berkeley canal.

This is a ship canal, 16½ miles in length, extending from Gloucester, on the Severn, to Sharpness Point, in the parish of Berkeley. It is level from end to end, and has a depth of from 18 to 18½ feet. Its width varies from 80 to 200 feet at the surface, and from 13 to 20 feet at the bottom. The banks were originally unprotected, and were built upon slopes as follows: From the water line to a depth of about 3 feet, the slope was 2 to 1; at this depth occurred a level bench about 3 feet wide, from the inner edge of which a slope of 1¼ to 1 extended to the bottom.

This canal is navigated by vessels up to 600 and 700 tons register, drawing 15 to 16 feet of water.

Prior to 1860, all sea-going vessels having occasion to pass through this canal were towed by horses at a speed of from one to three miles per hour, and a cost of one farthing (4½ mills) per register ton mile.

In 1860, three steam tugs were placed on this canal. Two were 65 feet long, 12 feet beam, and drew 6 feet 3 inches of water; they were fitted with high-pressure engines, with cylinders 20 inches in diameter by 18 inches stroke. The screws were three-bladed, five feet in diameter and 6½ feet pitch. The third tug was 55 feet long, 9½ feet beam, and drew 5 feet of water. The cylinder was 16 inches diameter, and had a stroke of piston of 18 inches. Screw, 3-bladed, 4 feet diameter and 5½ feet pitch. Coal consumption 1½ to 2 gross tons per 24 working hours.

In 1866, these tugs did nearly all the towing required on the canal.

In four years ending March 25, 1865, 1,119,334 tons of goods were towed 16 miles, at a cost of 6,400 pounds, including 15 per cent per annum on the cost of the tugs to cover interest, repairs and renewals, or at the rate of $1\frac{56}{100}$ mills per ton mile, showing a saving of over 65 per cent on the cost of horse towage. With an increase in tonnage during 1865, the cost per ton mile was reduced to less than half the above, or about $\frac{7}{10}$ of a mill.

Vessels are towed singly or in trains, and the speed varies from 2 to 4 miles per hour. The speed, as a rule, is limited to the latter figure.

The employment of steam is said to have been found, in nearly every way, advantageous. The work is found to be economized and the banks are less injured by the rubbing of the vessels.

The only disadvantage of this system, on a canal, the sides of which at the water edge are unprotected, is the constant wear at this part by the disturbed water. This injury is confined to a depth of 18 inches only, one-half of which is above and one-half below the water line. It was remedied by a wall, 2 feet high, half above and half below the water line, along which the water runs harmlessly. A portion of this wall, which had been in use three years, was found to answer the purpose completely.

In concluding this paper, Mr. Clegram, who presented it, says: "An extent of traffic has been carried on the canal during the last year that could scarcely have been accomplished by horse-power; and so manifest is the economy and efficiency of the system, that it far more than compensates for the increased cost of protecting and maintaining the sides of the canal."

Grand Canal, Ireland.

This canal is 160 miles in length. Its locks are 60 feet long, 13 feet 6 inches wide, with a depth of 5 feet 2 inches of water upon the miter-sills; but the draft of water by the boats is limited to 4 feet 3 inches. The width of the canal varies from 60 to 80 feet, and the side slopes are so flat that there is but about 30 feet in width at the center of navigable depth.

The annual tonnage of the Grand canal is about 300,000 tons.

The first effort to introduce steam upon this canal was made in the year 1851, when Mr. J. Scott Russell built a boat which was designed to carry its own power and cargo. This boat, which was propelled by a single screw, was not a success on account of the extent to which

its carrying capacity was reduced by the weight of the machinery. Two other boats were built about the same time, which were provided with double, or twin screws, but they were also unsuccessful, and for the reason already stated.

In 1860, a system of chain haulage was experimented with and proved a perfect failure.

The most successful effort was made about eight years ago. It consisted in the introduction of small steam-tugs, which were placed upon a level 25½ miles long, for towing boats in trains. These tugs were 60 feet long and 7 feet beam; were fitted with powerful machinery, and were able to tow five boats, carrying 40 tons each, or an aggregate of 200 tons. They were able to tow a train of three boats, carrying an aggregate of 120 tons, at a speed of 2½ miles per hour, with a slip of about 50 per cent. The boats of this canal are 60 feet long, 13 feet wide and draw four feet when carrying 40 tons.

In 1866, horses had been withdrawn from the level referred to, and the towing was done exclusively by two of these steamers.

Upon the Shannon, steamers 72 feet long, 13 feet 3 inches beam, drawing 4 feet 8 inches of water, and carrying 50 tons of cargo, have been successfully introduced.

The small size of this canal, and the limited carrying capacity of its boats, would seem to preclude the successful general introduction of steam upon it, in cargo-carrying boats, or for towing purposes, where locks occur at short intervals.

Forth and Clyde Navigation.

The Forth and Clyde canal extends from Grangemouth on the Forth, to Bowling on the Clyde, a distance of 35 miles. From a point about 26 miles from Grangemouth, a branch 4 miles in length leads to Glasgow, where it connects with the Monkland canal, leading from Glasgow, 12 miles, to Woodhall. On the Forth and Clyde, in 35 miles, there are 40 locks, at intervals varying from 50 yards to 17 miles, while on the Monkland there are 10 locks in a distance of 12 miles.

The capacity of the horse-boats used on the Monkland canal is about 60 tons, and the movement is nearly all in one direction, the boats returning light. The cost of transporting 60 tons ten miles, for towing and for the crew, including the return of the empty boat, was, in 1859, about 9½ pence per boat mile for the round trip, which is at the rate of about 2¾ mills per ton mile.

For a round trip of 80 miles, made up of 10 miles on the Monk-

land canal and 30 miles on the Forth and Clyde and return, the cost per boat mile was about 11⅝ pence, or at the rate of 3½ mills per ton mile.

Efforts to introduce steam upon this line date back as far as 1789, when Symington designed and built steamers for that purpose. Again, in 1801, the "Charlotte Dundas" was built and tried; and at intervals since that time experiments have been made, all of which, however, resulted unsatisfactorily.

In the year 1856, a steamer designed by Mr. James Milne, of the Forth and Clyde navigation, was built and put in operation. This steamer, which had been a horse-boat, carrying 80 tons, had two 6½ inch cylinders, with ten inches stroke of piston. The boiler was upright, tubular, 3 feet in diameter, and weighed, together with the engines and water, 2½ tons. With 35 pounds of steam, the boat was propelled, loaded, at a speed of 4½ to 5 miles per hour. From the date of their completion, in 1856, to 1866, a period of ten years, the engines had been constantly at work, and were still (1866) working most satisfactorily, but little repair and no renewals having been needed either for boiler or engines. The boiler was intended to carry 100 pounds pressure, and the surplus power was designed to be employed in towing, but the traffic not requiring it, the boat had not been so used. Mr. Milne objected to towing, on account of the delay which must occur at the numerous locks.

Mr. Milne said, "The application of steam power to this boat having proved successful, engines were designed and fitted to the luggage boat 'Marjory,' carrying 35 tons; to one of the canal ice-breakers; to masted lighters for canal and coasting trade, carrying 120 tons; and designs for a scow or mineral barge, carrying 60 tons, on the Monkland canal, and 75 tons, on the Forth and Clyde canal, all of which proved successful, and had been the precursors of about 70 canal steamers now (1866) at work on the canal, and from the canal to the contiguous sea-coasts."

The rate of increase in the number of steamers on these canals is indicated in the following table:

1856.....	1 steamer.	1862.....	36 steamers.
1857.....	2 steamers.	1863.....	44 steamers.
1858.....	7 steamers.	1864.....	50 steamers.
1859.....	18 steamers.	1865.....	58 steamers.
1860.....	25 steamers.	1866.....	70 steamers.
1861.....	30 steamers.		

The costs of transportation by horse and steam power appear to have been as follows:

By horse power ..... 60 tons, 10 miles, 2¾ mills per ton mile;
By horse power ..... 60 tons, 40 miles, 3½ mills per ton mile;
By steam power ..... 60 tons, 40 miles, 2 mills per ton mile;

showing a saving of about 43 per cent. In each case the boat made the return trip light.

As to the saving in time, it is said that on trips of average distance, as 30 or 40 miles and return, the steamers make three trips while the horse-boat makes two; on longer trips, the saving would obviously be greater.

Regent's Canal.

On this canal the sectional area of the waterway, as compared with that of the boats navigating it, is about as 4 to 1. The average weight of the boats or barges is taken at 15 tons, and the average cargo at about 55 tons.

In the year 1854 the canal company issued an advertisement offering a premium of £100 for the best, and of £50 for the second best tug-boat which should be put in competition by a certain day. The premium was awarded in August, 1855, to Mr. Inshaw, of Birmingham, for the screw tug-boat "Birmingham," which was purchased by the company, and which was, until 1865, constantly employed in towing barges upon the summit level of the canal. This tug-boat was 70 feet 8 inches long, 6 feet 8 inches beam, and drew 3½ feet of water. It was fitted with a multitubular boiler and an engine having a pair of 7-inch cylinders, which was operated with steam of 60 to 70 pounds pressure. Two screws, having a pitch of 4 feet, were placed near the stern, and revolved in opposite directions by means of bevel wheels geared two to one. The capacity of this tug may be understood from the following performance, made June 15th, 1862. Between the hours of 6.15 A. M., and 7.45 P. M., a train of 20 barges, 17 of which were laden with an aggregate of 931 tons, was towed a distance of 11¼ miles. The cost of working this tug for the 8 months ending May 31st, 1865, was £344 2*s*. The distance steamed was 3,519 miles; number of barges hauled 2,023; the gross amount of cargo conveyed was 59,738 tons. The cost, per train mile, for labor, repairs and fuel was 1.96 of a shilling (33½ cents). The cost per ton mile for the same items was 1.383 of a penny (2½ cents). In each case the cost of fuel was ⅔, and that of labor and repairs ⅓ of the entire cost. The coal consumption is said to have been rather large, on account of insufficient boiler capacity.

The opinion was expressed that steam could not be economically employed on the Regent's canal by the canal traders, unless some plan were adopted for combining the tug with the cargo vessel, so that they might pass through the locks together, and be readily separated at the end of the journey. In accordance with this view, Mr. Thomas, in 1859, in a report to the canal company, recommended that the boats be constructed in two parts; the total length not to exceed the length of the boats then in use. It was proposed that the part containing the machinery and rudder should be as short as it might be practicable to have it, and should form the after part of the combination. This should be made to connect with the fore, or cargo-carrying part of the boat, in such a manner that the two would form a perfectly continuous and complete steamer. The principal advantage which it was claimed would be derived from this plan would result from the possibility of keeping the steam power constantly at work, and from the fact that the necessity of fitting steam power permanently to each boat would be obviated.

The River Severn.

This river, which is in some places narrow and tortuous, has been rendered navigable by the construction of dams and locks. The boats trading upon it carry 30 to 40 tons and draw about 3½ feet of water Steam tugs were introduced about the year 1856. Those first used had engines of 30 to 40 horse-power, and were propelled by reefing paddle-wheels. These boats answered very well; they towed trains of as many as twelve boats, carrying cargoes of 30 tons each, at speeds of from 2½ to 3 miles per hour, against a current of 2 miles per hour. In order to avoid the detentions at the locks, the plan has been adopted of constructing large basins in connection with them. These basins are each provided with a pair of gates, and thus permit the passage of an entire tow at a single lockage. Tows are thus locked through very expeditiously.

Since the introduction of these tugs, boats of a different description have been employed and have been found to work still more satisfactorily. These are barges 70 feet long, 12 feet beam, and drawing 3½ feet of water; they are each fitted with a pair of direct-acting engines, with cylinders 7½ inches in diameter and 9 inches stroke of piston. Twin screws 2 feet 6 inches in diameter are used. The boats thus fitted are able to carry 40 tons of cargo, and at the same time to tow two boats carrying 30 tons each. The steamer with a single boat in tow, together carrying 70 tons, can make 2½ miles per hour against

a current 3½ to 4 miles per hour. This is considered the most economical mode of steam towing on the Severn. One hundred tons has been moved, with a consumption of from 67 to 85 pounds of coal per mile.

Ashby-de-la-Zouch Canal.

Upon this canal there is a large coal traffic, and as there is a 30-mile level over which this traffic passes, the coal owners proposed, some years since, to employ steam power for towing purposes, and with that view ordered a tug from Mr. Inshaw, the successful competitor upon the Regent's canal. The Midland Railway Company, however, who were the proprietors of the canal, refused to allow the boats to be used, on the ground that it would cause injury to the banks.

Proceedings were instituted in chancery, and for the purpose of obtaining information as to the effect which would be produced, Mr. Pole was directed, as engineer, to conduct experiments with the boat which had been provided. These experiments were made in the month of May, 1859, with the tug, which was of the size ordinarily used on the canal, to wit: 70 feet long, 7 feet wide, 4 feet deep. It was fitted with engines of 6 horse-power (nominal?), working twin screws at the stern. The experiments comprised a variety of conditions, as to the load of the steamer and as to the number of boats towed, and the speeds attained varied from 1¼ to 5 miles per hour.

The results of the experiments are thus stated by Mr. Pole: "Up to a speed of 3 miles per hour no wave of injurious character appeared. Between 3 and 3½ miles per hour, a breaking wave appeared occasionally, in curves and shallows. Above 3½ miles per hour, the breaking wave became continuous and took a more marked character. At 4 miles per hour the injurious character of the wave became very decided. At 5 miles per hour, even in a much enlarged section, the wave was still more increased, breaking sometimes over the tow-path, and being followed by other waves in succession." "It was a very decided result of these experiments that the twin screw did not, of itself, at any speed attained, give rise to any wave or surge at all injurious to the banks of the canal."

Mr. Pole, as the result of his experiments, was led to recommend the admission of steamboats upon the canal, with such a limitation of their speed as would avoid the production of an injurious wave. Steamers were admitted upon the canal in accordance with this recommendation.

Towing on the River Thames.

Steam was substituted for horse-power for towing on that portion of this river extending from London to Oxford, some years ago. Two tugs were furnished with engines of 30 and 40 horse-power, and feathering floats immersed three feet below the surface. These tugs frequently towed as many as ten barges from London to Richmond, where three or four were left, and the remainder taken as far as Oxford. The towing had to be done against a current in some places reaching 3 miles per hour. These steamers worked profitably for four years, until the traffic left the Thames and went to the Great Western railway.

The cost of towing was $1\frac{8}{10}$ mills per ton mile.

These tugs were sold to the commissioners of the river Severn. One was lost on the passage, the other, in 1866, was still at work.

Mr. Allen, who built these tugs, says: "Probably one of the greatest obstacles to the development of steam-power on the canals is the smallness of the locks, which generally admit of only two barges being locked at the same time."

The River Weaver.

Improvements in the navigation of this river were undertaken with the view of enabling it to compete with railways in the transportation of about a million tons of salt, together with the coal used in its manufacture. In a distance of 24 miles, 8 pools were formed, which were from 3 to 6 miles in length, and connected by locks. The locks were 100 feet long, 23 feet wide, and admitted vessels drawing 8 feet of water and carrying 150 tons.

It was found, however, that even with double locks, the delay with steam tugs towing several barges was so serious and so interfered with the traffic that the plan had to be abandoned.

In 1864, steam barges carrying their own cargoes were tried, and were so successful that others were afterward introduced. These barges were 85 feet long, 19 feet 6 inches beam, drew about 7 feet 6 inches of water, and carried from 180 to 200 tons each. With engines of 20-horse power, no difficulty was found in towing two or three barges carrying 100 tons each; but the locks were still a cause of serious delay. To remedy this difficulty, a third lock was built for each pool. These locks were 200 feet long and 40 feet wide, and enable each tug to take three barges through at a single lockage.

In 1866, horse towage was being abandoned on the Weaver, the last described steamers being considered to be most profitable.

The improved navigation has the following minimum dimensions of cross section: width at surface, 90 feet; width at bottom, 54 feet; depth, 12 feet.

Grand Junction Canal.

The steamer "Dart," upon this canal, was 70 feet long, 7 feet beam, and drew, loaded, 4 feet of water. She was fitted with a vertical, high-pressure engine, the cylinder of which was 9 inches in diameter, and had 8 inches stroke of piston. The boiler was of the vertical flue type, 7 feet high and 4 feet 3 inches diameter, and its grate and heating surfaces were 5 and 120 square feet respectively. The screw was of the Griffith's patent, 3-bladed and 3 feet in diameter; and, with a boiler pressure of 75 pounds, the steam being cut off at half-stroke, made 180 revolutions per minute.

The "Dart" was designed to tow a single barge, and, between October 1st, 1864, and October 1st, 1865, steamed 11,280 miles, carrying and towing 3,182 tons. The working expense, including the engine and accompanying boat, was £366 13*s.*, or at the rate of 7.8 pence (14⅔ cents) per train mile, or 0.184 of a penny (3⅔ mills) per ton mile of cargo.

Aire and Calder Navigation.

The main line of this navigation extends between Leeds, Wakefield and Goole, a distance of 36 miles. The depth of water is 8 feet 6 inches in the canals, and 9 to 10 feet in the rivers. The width at top and bottom is 60 to 66 feet and 30 feet respectively; while on the rivers the surface width is 100 to 150 feet. The average sectional area is 380 (?) square feet. In the 36 miles there are 17 locks, having a total fall of 116 feet. In some portions of the canal, the banks were protected by dwarf slope-walls, having a depth of 1½ feet of water against them.

Steam towage was introduced here as far back as 1836, and was at first conducted by means of paddle-wheel tugs, with high-pressure engines, having two cylinders 11 inches in diameter and a stroke of 20 inches. The paddle-wheels were 9½ feet in diameter and 3 feet 6 inches wide. The speed attained with three boats carrying 100 tons of cargo was 3 miles per hour in the canals and 4 miles in the rivers. The cost per boat per mile was 8.516 pence (15$\frac{4}{10}$ cents), and per ton mile 0.473 of a penny (8.56 mills).

In 1853, improved means of steam towage were introduced, which, in 1866, were still in use. These consisted of two systems, the one

that of the tug, carrying cargo and towing at the same time, and the other that of tugs having greater power, towing exclusively.

The dimensions of the first class, which was employed exclusively in merchandise traffic, were: Length, 63 feet 6 inches; beam, 12 feet 6 inches; depth, 7 feet 6 inches; capacity for cargo, 30 tons. The machinery occupied 20 feet of the after part of the boat, and consisted of high-pressure direct-acting engines, with cylinders $8\frac{1}{2}$ inches diameter and 12 inches stroke of piston. The boilers had 12 square feet of grate and 243 square feet of heating surface, and the working pressure was 100 pounds. The screw propeller was 5 feet 3 inches in diameter, 7 feet pitch, and made about 180 revolutions per minute. The traffic was conducted during the night at an average speed of $4\frac{1}{2}$ miles per hour, at which speed the banks sustained no injury. For the seven years preceding 1866, the average cost of towing was 2.125 pence ($3\frac{9}{10}$ cents) per boat mile, and 0.085 of a penny (1.54 mills) per ton mile.

The second class of boats were similar in size to the first, and were employed solely in the general traffic of the canal. The whole space was devoted to the machinery, except so much as was set apart for the crew. The engines were direct-acting, had cylinders varying from 15 to 18 inches in diameter, and with strokes varying from 12 to 16 inches, and the working steam pressure was from 60 to 80 pounds. The boilers were return-tubular, and for the 16-inch cylinders had $16\frac{1}{2}$ square feet of grate and 920 square feet of heating surface. These tugs would tow 10 boats, carrying 700 tons of cargo, at 3 miles per hour on the canal and at 4 miles in the rivers. The charges for towing were $\frac{1}{10}$ of a penny ($1\frac{8}{10}$ mills) per ton mile against the current, and $\frac{1}{12}$ of a penny ($1\frac{1}{2}$ mills) down stream.

Still later, two boats, carrying 160 tons, were fitted with steam power and put to work on this navigation, but with what results we are uninformed.

In 1866 a new plan was devised by Mr. Bartholomew for the transportation of minerals on this canal. This plan was thus described: "It consisted of a train composed of 7 rectangular boats, having their ends constructed with an outward curvature of 6 inches. The dimensions of the boats were: Length 20 feet, beam 15 to 16 feet, depth 7 feet 3 inches. Each compartment or boat was capable of carrying from 25 to 35 tons. When formed into a train, they retained their lateral position by means of a projecting stem which fitted into a corresponding hollow stern post. They were held together and steered by wire ropes which passed through suitable guides on each

side, and which extended from the steam compartment at the after end to the leading or stem portion at the other. They were tightened by hydraulic power, and, when together, formed a train or vessel 190 feet in length. They were steered by two steam cylinders having their pistons in direct connection with the wire ropes, and were found to answer well in all respects. Each compartment was fitted with spring buffers at its corners." * * * "The compartments were discharged by hydraulic power, which raised the compartment and its cargo, weighing about 42 tons, to the elevation required to suit the height of the ship. At this stage of the operation the compartment was gradually turned on its side and the contents discharged into a *chute*, and thence into the ship. In this way 100 to 200 tons per hour were shipped."

An examination was made of this canal after screw propellers had been in use upon it about 10 years, and it was found that no mischief had been done to the banks.

Steam has also been introduced upon the river Lee, the Shropshire Union canal, the Kennet and Avon, Leeds and Liverpool, and many other canals; but so far as steam trains are concerned, the results have been almost invariably unsatisfactory whenever there were numerous locks. The chief causes of failure have been the difficulties encountered in passing the locks, and in passing the shoal water sections where the resistance, on account of the restricted water-way, was necessarily greater than in water of fair width and depth.

The canals referred to, as well as foreign canals generally, are, as a rule, very small. The surface widths are, in many cases, not over 45 feet; while the depths, which in some cases are 5 feet and over, are generally not more than 4 feet. The sections of the water-ways are in some instances as small as 120 square feet, while even in many of the larger canals they do not exceed 150 feet. In introducing steam upon such canals, we can readily understand that serious, and sometimes insurmountable difficulties may be presented. Yet it appears that, notwithstanding these difficulties, steam navigation has, in some of its forms, been successfully introduced on many of these canals. It appears further, that the machinery used may be run 5, 7 and even 10 years with very trifling repairs, and hence that its endurance may be regarded as nearly, if not quite, equal to that of other steam machinery.

The following table gives the lengths and dimensions of some of the English canals:

NAME OF CANAL.	When completed.	Length in miles.	Breadth.		Depth.
			Top.	Bottom.	
			Feet.	Feet.	Ft. In.
Sanky	1755	12	48	.....	5 7
Leeds and Liverpool	1770	108¾	42	27	5
Basingstroke	1778	37	38	.....	5 6
Thames and Severn	1783	30	42	30	5
Gloucester and Berkeley	1793	16½	70	13 to 20	18
Grand Junction	1793	90	43	.....	5
Kennet and Avon	1794	57	44	24	5
Aberdeenshire	1796	18½	23	.....	3 9
Thames and Medway	1800	8½	50	28	7
Caledonian	1803	23	40	.....	20
Rye, or Royal Military	1807	30	72	36	9

Prior to the general introduction of railways, the number of miles of canal—exclusive of improved rivers—in England alone, amounted to over 2,200.

In Holland and Sweden, too, steam has been successfully introduced, and is rapidly superseding horse-towage. At first, steam was used for towing simply, but the advantages of larger boats, carrying their own steam power, were soon discovered, and such boats adopted. The chief objection to these was, that the engineers were not constantly employed. This has been met by arranging steam-winches combined with the engines, by which the engineers are not only constantly employed while loading and discharging cargo, but these operations are accelerated to such an extent that the earnings of the boat are largely increased.

On nearly all the lines of Holland these steamers are understood to be paying well. They have increased in size from 35 feet in length to dimensions giving a capacity of 160 to 200 tons, which, however, are regarded as too large, and the tendency has recently been to return to boats carrying from 130 to 160 tons. These are 130 feet long, 16 feet beam, and draw 6 feet of water, having an ultimate capacity of 160 tons. The engines of these boats are of 25 horse-power, nominal, and their screws are 3 feet in diameter, having a pitch of 7 feet, and making 120 revolutions per minute.

In a great number of voyages, extending over a year and a half, between Rotterdam and Nymwegen, a distance of about 70 miles, these boats, towing a 70-ton barge, made a speed of 3½ miles per hour against the current. The trip was usually performed in about 14 hours, giving an average speed of 5 miles per hour. The total cost

of this performance, for wages of crew, coal, oil, waste, etc., was about $1\frac{3}{10}$ mills per ton mile.

In France, the canals are of medium size, and the carrying capacity of the boats is not greater than 150 to 160 tons.

Towing, for the most part, is done by men, though in some instances animal power is used. Within a few years, and in a few cases only, regular towing companies have been formed, and continuous service provided for. Boats towed by men make from 12 to 15 kilometres ($7\frac{1}{2}$ to $9\frac{3}{8}$ miles) in 12 hours; while boats towed by horses or mules make from 20 to 24 kilometres ($12\frac{1}{2}$ to 15 miles) in the same time. When the service is continuous, day and night, with regular relays of horses, 50 kilometres ($31\frac{1}{4}$ miles) are made in 24 hours.

In October, 1871, experiments were made upon the canal of Bourgogne, under the direction of the engineers, with a system of steam-towage patented by M. Larmanjat, of Paris, and designated "*Le system de petites locomotives et d'unrail unique.*" This system consists of a single iron rail, weighing about 12 pounds per yard, laid along the towing-path and supported at intervals of about three feet by small transverse timbers. This rail serves to guide the locomotive and to regulate the weight upon the two driving or traction-wheels which run upon the ground. The traction-wheels, which mainly support the weight of the locomotive, are placed nearly under its center of gravity; are about 3 feet in diameter, and are surrounded by a tire of caoutchouc about 3 inches in thickness, and with a face of say 12 inches. Under the forward and after ends of the locomotive are placed smaller wheels, about 15 inches in diameter, which run upon the rail. The connection between the locomotive and these wheels is such that by simply turning a screw by means of a small hand-wheel, any desired part of the weight may be taken from the traction-wheels and transferred to the smaller wheels upon the rail. The object of this provision is, to adjust the weight upon the drivers to the tractive force required. The total length of the locomotive is $12\frac{1}{2}$ feet; its width, 5 feet; its height, to top of smoke-pipe, 10 feet, and its weight about 4 tons.

In adapting this system to any canal it is proposed to divide the latter into sections of greater or less length, depending upon the extent of traffic and the number of boats in use. A locomotive is to be put upon each section, upon which it is to operate exclusively. A boat is to be towed in one direction until a locomotive is met moving in the opposite direction, when the boats in tow are exchanged, and the locomotives return to the opposite ends of their

respective sections where boats are exchanged with the locomotives of adjacent sections. When the experiments were made, although the rail had not yet been laid, the results were regarded as most satisfactory. The first boat, drawing 16 inches of water and carrying 29 tons, was easily towed at a speed of 6 kilometres (3¾ miles) per hour. A second experiment was made upon a boat drawing 4.6 feet and carrying 129 tons, which may be taken as fairly representing the conditions of ordinary service on this canal. In this case, upon the straight levels, and where no obstacles occurred, the speed attained was 5 kilometres (3⅛ miles) per hour; but upon the shorter and more sinuous levels, the speed was reduced to 4 kilometres (2½ miles), and in some cases to even 3½ kilometres (2⅛ miles) per hour. The mean time expended in passing locks was 6 minutes, being much less than the time required by other boats. No difficulty was experienced in stopping and starting, or while under way, and the engineers declared that "when the men shall have become accustomed to the machinery, boats towed by this system will be managed with as great facility as they now are."

The final conclusion of the engineers was that a speed of 4 kilometres an hour could be maintained; that 7½ minutes was a proper allowance for the time of lockage, and that a single trip of 242 kilometres (151¼ miles), including 191 lockages, could be made in 86 hours, at an average speed, including lockages, of 1¾ miles per hour. The report concludes as follows: "The little machine of M. Larmanjat is well adapted to the towage service; it is managed with the greatest facility, and may be stopped almost instantly upon signal from the captain of the towed boat. Its driving-wheels have wide rims, leaving no trace of their passage upon the towing-path in a dry time; they should be provided with a thick band or tire of caoutchouc (they were not thus provided during the experiments) in order to reduce the pressure upon, and consequently the abrasion of, the towing-path during wet weather. The requisite tractive power for towing a boat may be obtained with a reduction of one-fourth in the weight, or to 3 tons. The motor, therefore, fills all the desirable conditions." The report of the engineers was approved, and its recommendations concurred in by the engineer-in-chief of the canal, and by the Inspector-General of Public Works.

A concession has been asked by M. Larmanjat for the exclusive use of this device upon the canal of Bourgogne for 50 years.

The proposed charges for towing vary with the distance and with the class of merchandise carried by the boats which may be towed.

From 0 to 100 kilometres, from 100 to 150 kilometres, from 150 to 200 kilometres, and from 200 to 242 kilometres, the proposed charges vary from 0.012 to 0.008 of a franc, per ton kilometre ($3\frac{61}{100}$ to $2\frac{41}{100}$ mills per ton mile), for merchandise of the first class, and from 0.006 to 0.004 of a franc, per ton kilometre ($1\frac{81}{100}$ to $1\frac{2}{10}$ mills per ton mile), for merchandise of the second class. "These rates," says the Inspector-General, "are equal to the present cost of towing, by animal power for the two classes of merchandise upon the canal of Bourgogne."

The lower rates for merchandise of the second class, it will be observed, are almost precisely equal to the charge upon the Erie canal; the latter being, at 35 cents per mile for 230 tons, $1\frac{52}{100}$ mills per ton mile, and the mean of the former $1\frac{505}{1000}$ mills. If, however, we take the actual *cost* of towing 230 tons, at 27.4 cents per mile, the rate per ton mile is $1\frac{19}{100}$ mills, or about 21 per cent less than the mean cost upon the Bourgogne canal.

From a recent report upon the internal navigation of France, prepared by M. Kranz, chief-engineer in the service of the Seine navigation, it appears that upon the 3,270 miles of French canals the average annual ton mileage is 841,847,830, and that the net cost of transport, exclusive of tolls, is $4\frac{2}{10}$ mills per ton mile. M. Larmanjat estimates that by the adoption of his device the capacity of the canal will be doubled, and that the cost of transport will be materially diminished.

COST OF RAILROAD TRANSPORTATION.

In order to show how far railroads may be able to compete with the Erie canal, in the transportation of such freights as would naturally seek the latter, and to ascertain to what extent the canal may be expected to retain or to increase its present large tonnage by reason of improved and more economical modes of transport, the following investigations have been undertaken:

The cost of freight movement by rail depends principally upon three elements:

1. Upon the number of net tons that may be hauled by a single locomotive at the ordinary speed of freight trains.

2. Upon the number of trains which may be run in a given time.

3. Upon the cost per train mile, including interest, maintenance, operating expenses, etc.

The number of tons hauled per train will depend upon the weight of the locomotive and upon the ruling grade in the direction of the maximum movement. The experience upon our principal railroads

shows that with locomotives weighing 70,000 pounds—50,000 pounds being on the drivers—the tractive force, which may be depended upon in all conditions of the rail, is about 10,500 pounds. The number of tons, including engine and tender, which such a locomotive can be depended upon to haul upon any grade, is given by the following formula:

$$\text{Load} = \frac{0.21\ W}{9.2 + 0.38\ i}\ \text{Gross tons};$$

in which W = Weight in pounds upon the drivers.
i = Grade in feet per mile.

The following table has been constructed by the use of this formula. In it the weight of the locomotive and tender, with fuel and water, is taken at 58 tons; and the effective load of a single car at about 10 tons.

GRADE—FEET PER MILE.	LOADS HAULED PER TRAIN.		
	Gross tons.	Net tons.	No. cars.
Level	1,141	540	54
10	808	375	37
20	625	282	28
30	510	226	23
40	430	186	19
50	372	157	16
60	328	135	14
70	293	117.5	12
80	265	103.5	10
90	242	92	9
100	223	82.5	8

The weight of a car has been taken at ten tons; in fact, however, it is probably somewhat less; but the effect of curvature has been neglected, it being assumed that this, if not excessive, would practically offset the slight error resulting from the assumption that the average weight of a freight car is ten tons.

The number of trains which may be run per day, or as to the practicable limit of time between trains, will depend largely upon the facilities for loading, dispatching and unloading at termini. Taking the New York Central and Hudson River as a representative road, having first-class facilities for handling and transporting freight, we deduce from its annual report for 1871 the following:

Tons moved one mile	888,327,865
Train miles (freight)	6,986,107
Average number of tons per train	127

Taking the eastward movement at double the westward, we have—

Average tons per train, east	169.$\frac{1}{8}$
Average tons per train, west	84.$\frac{2}{8}$
Ton miles per day (313 days)	2,838,108
Tons over the road per day (500 miles)	5,676
Trains over the road per day (each way)	22
Average interval between trains, minutes	65+

The train mileage of passenger trains is reported to have been, for the same year, $\frac{4}{7}$ of that for freight trains. Taking both, then, the average daily number of trains each way was, say 36, and the average interval between trains moving in the same direction, 40 minutes. Much delay is, of course, caused to freight trains by the necessity of keeping out of the way of passenger trains, and in waiting for them to pass; this delay would, however, be avoided on a road used exclusively for freight purposes, and, on such roads, it may perhaps be safely assumed that trains may be run at intervals of 20 minutes. This, taking the western movement at one-half the eastern, would give a ton mileage about $5\frac{1}{4}$ times as great as that of the Central road for the year 1871—provided so much could be secured to the road. The cost, per train mile, is made up of four principal elements, as follows:

1. Interest on cost of road and equipment.
2. Maintenance of road and equipment.
3. Repairs of cars and machinery.
4. Operating expenses.

How, and to what extent, will the cost of movement be affected by an increase in ton mileage?

The interest upon the cost of road, simply, being practically constant, the rate per train mile will vary inversely as the number of train miles; but, since the cost of equipment will necessarily be increased with the tonnage, the total rate of the first element of cost, while it will be diminished, will not be diminished to the same extent that the tonnage is increased. It will not be safe to estimate a reduction of more than $\frac{2}{3}$ in this element, for an increase to five times the present tonnage. The expense of maintenance may be assumed to vary, within the limits considered, with the amount of business done, and hence the rate per train mile may be regarded as constant. The expense of repairs to cars and machinery, and the operating expenses, may also be regarded as varying with the business done, and the rate per train mile may be considered as constant.

The following table, showing the several elements of cost and the

total cost per train mile on several prominent roads, is made up from the annual reports of the operations of the several roads for the years 1869 and 1871.

NAME OF ROAD.	Year.	Cost per Train Mile.				
		Fuel, cents.	Maintenance.	Repairs of machinery.	Operating.	Total.
New York Central	1869	21⅛	$0 69	$0 35	$0 72	$1 76
Erie	1869	10	34	23	70	1 27
Northern Central	1871	12	21	34	55	1 10
Pennsylvania Central	1871	6.6	30	18	47	95
Philadelphia, Wilmington and Baltimore	1871	9	31	42	71	1 44
Philadelphia and Reading	1871	6	39	47	90	1 76
Albany and Susquehanna	1869	21	45	16	86	1 47
Buffalo and Erie	1869	10⅛	23	14	54	91
Hudson River	1869	17	90	23	1 01	2 14
Rensselaer and Saratoga	1869	31	83	36	87	2 06
Troy and Boston	1869	36	83	33	1 14	2 30
Rome, Watertown and Ogdensburgh	1869	22	77	12	1-10	1 99
New York Central and Hudson River	1871	16	44	23	62	1 29
Total	....	...	$6 69	$3 56	$10 19	$20 44
Means	....	16.8	$0 51.5	$0 27.4	$0 78.4	$1 57.3

The cost of fuel is included in the operating expenses. If these lines be separated into two classes, the one embracing those which may be regarded as east and west trunk lines, or parts of such lines, having moderate grades and doing a large through freight business, and the other embracing those lines which have steeper grades, and upon which the business is smaller and more of a local character, we get the following:

1. *Trunk Lines having Moderate Grades.*

NAME OF ROAD.	Year.	Cost per Train Mile.				
		Fuel, cents.	Maintenance.	Repairs of machinery.	Operating.	Total.
New York Central	1869	21⅛	$0 69	$0 35	$0 72	$1 76
Hudson River	1869	17	90	23	1 01	2 14
New York Central and Hudson River	1871	16	44	23	62	1 29
Erie	1869	10	34	23	70	1 27
Pennsylvania Central	1871	6.6	30	18	47	95
Buffalo and Erie	1869	10⅛	23	14	54	91
Totals	....	81.6	$2 90	$1 86	$4 06	$8 32
Means	....	13.6	$0 48⅓	$0 22¾	$0 67⅝	$1 38⅝

2. *Local Lines having steeper grades or doing less business.*

NAME OF ROAD.	Year.	COST PER TRAIN MILE.				
		Fuel, cents.	Maintenance.	Repairs of machinery.	Operating.	Total.
Northern Central	1871	12	$0 21	$0 34	$0 55	$1 10
Philadelphia and Reading	1871	6	39	47	90	1 76
Rensselaer and Saratoga	1869	31	83	36	87	2 06
Troy and Boston	1869	36	83	33	1 14	2 30
Rome, Watertown and Ogdensburgh	1869	23	77	12	1 10	1 99
Philadelphia, Wilmington and Baltimore	1871	9	31	42	71	1 44
Totals	....	116	$3 34	$2 04	$5 27	$10 65
Means	....	19⅓	$0 55⅔	$0 34	$0 87 5-6	$1 77½

Taking one of the lines of the first class, having, like the New York Central, ruling grades of about 20 feet in the direction of the maximum movement and assuming the number of loaded cars at twenty-eight per train, we have, for the maximum load hauled per train, 280 tons. But the fluctuation in the quantity of freight seeking movement, will not warrant the assumption that all trains will run with full loads; 240 tons may, perhaps, be taken safely as the average load east, and one-half that sum, or 120 tons, for the average load west, making the average for both directions 180 tons, or 53 tons more than the average of the New York Central and Hudson River for 1871. The cost of moving this average load, for maintenance, repairs of machinery and for operating expenses, will then be $\$1.38\frac{2}{3}$ per mile, or at the rate of $\frac{138667}{150}=7\frac{704}{1000}$ mills per ton mile.

The total cost of the roads embraced in the first class, together with their equipments up to and including the year 1869, is reported to have been $164,270,747; the annual interest upon which at 7 per cent is $11,498,952.29. The aggregate ton mileage of the same roads for 1869 was not far from 2,500 millions. The cost per ton mile to cover interest for that year was, therefore, $4\frac{592}{1000}$ mills. Adding this last result to the sum of the costs of the other three items, we have finally for the total cost per ton mile, upon the basis of the business of 1869, $12\frac{296}{1000}$ mills.

If, however, a ton mileage of five times as great be provided for, and only one-third the cost for interest just found, or $\frac{4.592}{3}=1.531$ mills be added to the sum of the costs for maintenance, repairs and operating, we have as the total minimum probable cost of transportation by rail, $7.704+1.531=9\frac{235}{1000}$ mills per ton mile.

Upon the Pennsylvania Central the cost of transportation, exclu-

sive of interest for the year 1871, was $8\frac{74}{1000}$ mills per ton mile, while the charge was $13\frac{57}{100}$ mills. If we add our estimated rate for interest ($4\frac{592}{1000}$ mills) to the actual cost for maintenance, repairs and operating, we get for the total cost of movement, $8.74+4.592=13\frac{332}{1000}$ mills or $1\frac{78}{100}$ per cent less than the charge.* This road, which is $344\frac{9}{10}$ miles in length, had in 1871 a ton mileage of something over one thousand millions, while the New York Central and Hudson River, between Buffalo and New York, say 500 miles, had only eight hundred and ninety millions. It appears, therefore, that the ton mileage per mile of the former was $1\frac{6}{10}$ times as great as that of the latter. Again, the cost of fuel, which was $21\frac{1}{2}$ cents per train mile on the New York Central in 1869, was only $6\frac{6}{10}$ cents on the Pennsylvania Central in 1871, showing a difference of over 69 per cent in favor of the latter. Comparing the cost of fuel on the Pennsylvania Central with the average used in our estimate, the difference is nearly 54 per cent in favor of the Pennsylvania Central. Finally, much of the freight business of the Pennsylvania Central consisted in the transportation of coal, in which the per centage of net load is much larger than in the transportation of freight other than coal. This road, then, with its unusual advantages for cheap transportation, such as cheap fuel and a tolerably uniform and very heavy traffic, may be taken as an example indicating:

1. To what extent the cost of transportation by rail may be reduced below the present average cost.

2. To what extent our estimate, for a maximum ton mileage on roads employed exclusively in freight movement, may be relied upon, and,

3. How far railroads, under the most favorable circumstances, may be expected to compete with the Erie canal in the transportation of such freights as naturally seek the latter, or may be attracted to it by an increase in speed and by diminished cost.

At $9\frac{236}{1000}$ mills per ton mile, the cost of transporting a bushel of wheat from Buffalo to New York—say 500 miles—will be $13\frac{86}{100}$ cents; while from Chicago to New York, calling the distance 1,000 miles, the cost will be $27\frac{7}{10}$ cents.

I am aware that, during the past year, an estimate has been made, upon the authority of which it has been asserted that grain may be transported by rail 1,000 miles at a total cost of about 6 cents per bushel. In regard to this statement, it is sufficient to remark that the

* The average charge per ton mile on all freight carried upon the Lake Shore and Michigan Southern Railway was: 1870, 1.5 cents; 1871, 1.39 cents.

sum stated would, perhaps, barely cover the cost of fuel and pay the interest upon the cost of the road and its equipment.

The following summary of the results of our estimates shows the costs of freight movement by the several modes examined, exclusive of tolls on the canal:

SUMMARY OF RESULTS.

MODE OF TRANSPORTATION.	TOTAL COST.		Per cent.
	Per ton mile.	Per bushel wheat, Buffalo to N. Y.	
	mills.	cents.	
By railroad	9.235	13.85	100
By Erie canal and Hudson river, with animal power on canal	5.039	8	57.76
By Erie canal and Hudson river, with steam power on both	2.68	3.984	28.04

If we add tolls on the canals at the present rates the costs will stand as follows:

MODE OF TRANSPORTATION.	TOTAL COST.		Per cent.
	Per ton mile.	Per bushel wheat, Buffalo to N. Y.	
	mills.	cents.	
By railroad	9.235	13.85	100
By Erie canal and Hudson river, with animal power on canal	6.89	9.23	66.64
By Erie canal and Hudson river, with steam power on both	4.018	6.207	44.82

CONCLUSION.

The foregoing deductions from the results of the trials made during the past year, and the careful estimates which have been made of the present cost of transportation on the canal and upon railroads, together with the results attained upon foreign canals, seem to justify the following conclusions:

1. That the practicability of substituting steam for animal power on the canal is substantially demonstrated.

2. That an average speed of three miles an hour, including lockages, may be attained.

3. That by the substitution of steam the tonnage of the canal may be very largely increased.

4. That an ultimate saving of 50 per cent, under the conditions previously stated, may be effected in the cost of transportation, exclusive of tolls.

5. That, all things considered, the cheapest and most convenient mode of employing steam is in boats, carrying their own machinery and 200 tons of cargo.

6. That as to the power required, and its cost in fuel, the estimate given in the report of 1871 is reasonably correct.

In order, however, that the fullest measure of success may attend the introduction of steam, it is imperatively necessary that the full depth of seven feet of water be at all times maintained during the season of navigation.

The accumulations in the bottom of the canals, together with the bench walls, should be removed.

The locks should be more efficiently manned, in order to reduce the detention at locks to the lowest practicable limit.

The locks themselves are, it is believed, large enough to pass boats as large as should be permitted to pass through the prism of the canal.

With the improvements suggested, and the introduction of steam, the canal will be rendered fully capable of transporting not only the present tonnage, but all the freight that may reasonably be expected to seek it or be attracted to it for many years.

Respectfully submitted.

D. M. GREENE,
Engineer.

TROY, *February* 18*th*, 1873.

APPENDIX.

In order to make a complete record of what has been done since the passage of the law, and for the purpose of supplying information upon questions relating thereto, it has been deemed advisable to append a copy of the law, together with the substance of the reports of the Commission and of the engineer, made last year.

CHAPTER 868, LAWS OF 1871.

AN ACT to foster and develop the internal commerce of the State by inviting and rewarding the practical and profitable introduction upon the canals of steam, caloric, electricity, or any motor other than animal power for the propulsion of boats.

PASSED April 28, 1871; three-fifths being present.

The People of the State of New York, represented in Senate and Assembly, do enact as follows:

SECTION 1. GEORGE B. MCCLELLAN, HORATIO SEYMOUR, ERASTUS S. PROSSER, DAVID DOWS, GEORGE GEDDES, VAN R. RICHMOND, WILLIS S. NELSON, GEORGE W. CHAPMAN, WILLIAM W. WRIGHT and JOHN D. FAY are hereby appointed a commission to practically test and examine inventions, or any and all devices which may be submitted to them for that purpose, by which steam, caloric, electricity, or any other motor than animal power may be practically and profitably used and applied in the propulsion of boats upon the canals; said examination and tests shall be had by the said commissioners at such time or times during the season of canal navigation, for the years 1871 and 1872, as they may order and direct; said commissioners shall have the right,

and they are hereby expressly required to reject all such inventions or devices, if in their opinion none of the said inventions or devices shall fully and satisfactorily meet the requirements of this act; but said commissioners shall demand and require: *First.* The inventions or devices to be tested and tried at their own proper costs and charges of the parties offering the same for trial. *Second.* That the boat shall, in addition to the weight of the machinery and fuel reasonably necessary for the propulsion of said boat, be enabled to transport, and shall actually transport on the Erie canal, on a test or trial exhibition, under the rules and regulations now governing the boats navigating the canals, at least 200 tons of cargo. *Third.* That the rate of speed made by said boat shall not be less than an average of three miles per hour, without injury to the canals or their structures. *Fourth.* That the boat can be readily and easily stopped or backed by the use and power of its own machinery. *Fifth.* That the simplicity, economy and durability of the invention or device must be elements of its worth and usefulness. *Sixth.* That the invention, device or improvement can be readily adapted to the present canal boats; and, lastly, that the commissioners shall be fully satisfied that the invention or device will lessen the cost of canal transportation, and increase the capacity of the canals. Any means of propulsion or towage other than by a direct application of power upon the boat, which does not interfere in any manner with the present method of towage on the canals, and complying in all respects with the provisions of this act, may be entitled to the benefits thereof; but this shall not be construed to apply to the system known as the Belgian system, or to any mode of propulsion by steam engines or otherwise upon either bank of the canals.

§ 2. No such test shall be made if the same shall in any manner retard, hinder or delay the passage of boats navigating the canals under the present system.

§ 3. If the commissioners herein appointed shall, upon such examination and test as is provided for in the first section of this act, conclude and determine at any time that one or more inventions or devices as aforesaid, but not to exceed three in number, shall be in all respects a full and satisfactory, practicable and profitable adaptation to the wants of the canals by reason of a new, useful and economical means of propulsion for boats within the meaning of this act, it shall then, and not otherwise, be their duty to grant unto the owner or owners of such inventions or devices, his or their attorney, their certificate or certificates, under their hands as such commissioners, that they have so determined and adjudged to the owner or owners of the invention or device which, in the judgment of the said commissioners, possesses in the greatest degree of perfection the requisites mentioned in the first section, they shall grant a certificate which shall be known as certificate number one, and to the owner or owners of the next best invention or device, they shall grant a certificate as aforesaid, which shall be known as certificate number two; and to the owner or owners of the third best invention or device, they shall grant a certificate as aforesaid, which shall be known as certificate number three.

§ 4. Before entering upon the duties of his office each of the commissioners herein named shall take and subscribe an official oath, which shall be filed at once in the office of the Secretary of State. Any vacancy arising from any cause in said commission, may be filled on the application of the remaining commissioners, by the Governor.

§ 5. The reasonable expenses of the said commission, not exceeding in all the sum of $5,000 to be determined by the said board, shall be paid out of any sum which may be awarded to the person or persons receiving the certificate mentioned in the third section of this act, in proportion to the amount awarded to the holders of said certificates, providing such certificates shall be granted; and if no such certificate shall be granted, then the same shall be paid by the Treasurer, on the warrant of the Comptroller out of any moneys in the treasury not otherwise appropriated.

§ 6. Upon the production by the owner or owners, or his or their attorney, of such certificate or certificates as may be granted under the provisions of this act, to the Comptroller, he shall draw his warrant upon the Treasurer of the State of New York for the sum of $50,000, payable to the said owner or owners of said invention, device, his or their attorney, out of any money in the treasury not otherwise appropriated, in case but one certificate, shall have been granted by said commissioners. If two certificates shall have been granted and no more, then the said Comptroller shall draw his said warrant upon the said Treasurer for the sum of $35,000, payable to the owner or owners of certificate number one; and said Comptroller shall also draw his said warrant upon the said Treasurer for the sum of $15,000, payable to the owner or owners of certificate number two. If three certificates shall be granted by said commissioners, then and in that case the said Comptroller shall draw his said warrant upon the said Treasurer for the sum of $30,000, payable to the owner or owners of certificate number one; and one of $15,000, payable to the owner or owners of certificate number two; and one of $5,000, payable to the owner or owners of certificate number three.

§ 7. If on or before the 1st day of November, 1873, the commissioners hereinbefore named shall, upon due examination, find and determine that the said invention or device, has been successfully operated upon the canals, and has been or will be largely adopted as a motor on said canals by reason of its superiority over any other known method of propulsion, then and in such case they shall grant a further certificate of that fact, and the Comptroller upon its presentation to him, shall draw his warrant upon the Treasurer of the State for the further sum of $50,000, payable to the said owner or owners of the said device, his or their attorney, out of any money in the treasury not otherwise appropriated; but in case of the granting by said commissioners of more than one certificate, as stated in section six of this act, then and in that case the sum of $50,000, mentioned in this section, shall be divided among and paid to the owners of the said certificates in the proportion, and in the manner as stated in section six of this act.

FROM THE REPORT OF THE COMMISSION MADE FEBRUARY 14, 1872.

The Commissioners appointed by chapter 868 of the Laws of 1871, met at the office of the State Engineer and Surveyor, at Albany, on the 10th day of July, 1871, and were duly sworn into office, and entered upon the duties assigned to them by the Legislature, and of their action since that time, beg leave to make the following

REPORT:

The Commission was organized by the election of Van R. Richmond, chairman. Henry A. Petrie, of Albany, was appointed secretary, and David M. Greene, of Troy, civil and mechanical engineer, was appointed engineer to aid the Commission in making the examination and tests provided for in the act.

The Hon. Horatio Seymour having declined to serve, the remaining Commissioners, as provided by the third section of the law, applied to the Governor to fill up the commission, and the Governor, thereupon, appointed Daniel Crouse, of Utica, to fill the vacancy.

The following resolutions were adopted:

Resolved, That for the purpose of carrying out the intent of the law, this Commission will require, among the tests to be made, that the several competitors shall make not less than three round trips, from New York and Buffalo or Oswego; each boat to be loaded with not less than 200 tons of cargo each way; the trips to be commenced as soon as any party is ready, and all completed in the least practicable time. For the purpose of determining the time consumed by each and all the trips, the clearance must show the day of the month and time of day that the boat passes each collector's office; certified copies thereof to be furnished to the Commission. In order to obtain information in regard to the practical working of the several devices in competition, as soon as practicable, the engineer of the commission, Mr. David M. Greene, of Troy, will inspect the same from time to time, as in his judgment may be necessary, and report the facts obtained to this Commission.

Resolved, That competitors are hereby notified that for the purpose of carrying out the intent of the law, that though it is desirable that the three consecutive round trips from Buffalo or Oswego to New York be made at the earliest time practicable, that the whole of the year 1872 will be allowed to such persons as may desire so much time, and that the awards will not be made until the close of navigation in that year.

Resolved, That a copy of the foregoing resolutions and of the law be furnished by the secretary to all persons who may desire to compete under it, and that on Monday, the 14th day of August, 1871, at three o'clock, P. M., the Commission will meet at the office of the Canal Commissioner, in Syracuse, for the purpose of transacting any business that may properly come before them.

On the 14th day of August, 1871, pursuant to adjournment, the Commission met at the office of the Canal Commissioner, in the city of Syracuse.

A large number of inventors, with drawings and models, appeared before the Commission and made full statements and explanations of their various plans. Several questions regarding the intent and meaning of the law were raised, which were submitted to the Attorney-General for his opinion.

An impression seemed to be almost universal among the inventors that the great difficulty to be overcome in navigating the canals by loaded boats with steam power, at the rate of three miles an hour, was the injury done to the banks by the swell created by the boat and machinery. Having this impression, most of the attempts of inventors were directed to some new wheel or model of a boat. The Commissioners being unanimously of the opinion that this impression of the inventors was based on mistaken views of the difficulties really to be overcome, adopted a resolution, which appears in the proceedings hereinafter given, hoping thereby to prevent further waste of time and money to obviate an imaginary difficulty.

The following are the resolutions adopted at the meeting heretofore referred to:

"*Resolved*, That the Attorney-General be requested to favor this commission with his opinion on the following points, viz.:

"1st. Would it be within the intent of the law (chapter 868, Laws of 1871) to allow competition by boats that do not carry, 'in addition to the weight of the machinery and fuel necessary for the propulsion of said boats,' 200 tons of cargo, that is in part or wholly carried on boats towed by the one on which is placed the machinery? Or, in other words, can tug-boats drawing one or more freight-boats, or boats in sections, compete under the law? The *second* requirement of the first section, in plain words, cuts off such tug-boats drawing freight-boats, but the point has been raised that another clause of the same section alters this *second* provision. The clause referred to is: 'Any means of propulsion or towage other than by a direct application of power upon the boat, which does not interfere in any manner with the present method of towage on the canals, and complying in all other respects with the provisions of this act, may be entitled to the benefits thereof.'

"2d. Does the word 'new,' in the third section of the law, occurring in the connection hereinafter given, require that the device should be something not before known or tried, or may it be sufficient to make some old or known device successful?

"§ 3. If the Commissioners herein appointed shall, upon such examination and test as is provided for in the first section of this act, conclude and determine at any time that one or more inventions or

devices as aforesaid, but not to exceed three in number, shall be, in all respects, a full and satisfactory, practical and profitable adaptation to the wants of the canals, by reason of a *new*, useful and economical means of propulsion for boats, within the meaning of this act." * *

To which the Attorney-General replied as follows:

"STATE OF NEW YORK:

"OFFICE OF THE ATTORNEY-GENERAL,
ALBANY, *September* 6, 1871.

"HON. VAN R. RICHMOND, *Chairman, etc.:*

"DEAR SIR.—In answer to a resolution adopted by your honorable board of the date of August 14th, ult., which has been submitted to me,

"I respectfully report that, after a careful examination of the act and a comparison of its several provisions, I am of opinion that the motive power, contemplated by it to be applied to the propulsion of boats, may be applied upon a boat other than the one which carries the cargo, and that tug-boats propelled by steam or other motive power specified in the act, may be made competitors for the prize under the act.

"The universal and fundamental rule for the construction of all statutes is, that the several provisions must be harmonized and given their full effect, so as effectually to carry out the scheme or purpose intended.

"The concluding paragraph of section one is as follows: 'Any means of propulsion or towage other than by a direct application of power upon the boat, which does not interfere in any manner with the present method of towage on the canals, and complying in all other respects with the provisions of this act, may be entitled to the benefits thereof; but this shall not be construed to apply to the system known as the Belgian system, or to any mode of propulsion by steam engines or otherwise upon either bank of the canals.'

"This provision expressly authorizes your Commission to accept any means of propulsion or towage other than by a direct application of power upon the boat, provided such means of propulsion does not interfere with the present method of towage upon the canals, and must be held to modify the other provisions of the act by which such means of propulsion or towage are excluded. This construction is very much strengthened by the concluding paragraph of the portion of the section quoted, which excludes the system known as the Belgian system and any mode of propulsion by steam engines or otherwise upon either bank of the canals.

"The exclusion, by the express terms of the section in its last paragraph, of these two modes of propulsion from your consideration, furnishes strong evidence that it was the intention of the Legislature to include all other modes of propulsion by steam, caloric, electricity or any other motor than animal power.

"The word 'new' in the third section, in my opinion, is satisfied

by the application of the power intended by the act as a useful and economical means of propulsion of boats upon the canals, although such power was before applied to other uses. In its application to this purpose, within the provisions of the act, if successful and useful, it would be *new* in the sense intended by the scope and spirit of the act.

"Respectfully yours,

"MARSHALL B. CHAMPLAIN,

"*Attorney-General.*"

The following resolution was also adopted:

"*Resolved*, That the experiments heretofore made in navigating the canals by freight-boats propelled by steam have not been failures by reason of injury done the banks of the canals by the swell caused either by the motion of the boat or the wheels through the water; and that, in the judgment of this Commission, there is no practical difficulty in navigating the canals by boats carrying 200 tons of cargo, at the rate of three miles per hour, that arises from 'injury to the canals or their structures.' The main difficulty to be overcome is to establish the economy of steam or other motor as compared with animal power."

The Commission then went on board the steamer "Andrew H. H. Dawson," of New York, which was on its way to Buffalo with a cargo of coal, and examined the wheel, machinery, etc.; after which the Commission adjourned to meet on the call of the chairman.

* * * * * * * * * *

The anxiety of the inventors to secure the money offered by the State is such that a large number of devices, we are informed, are now in the course of construction; and there is every reason to expect that during the coming season many more boats will attempt the trial trips required by this Commission. Some of the inventors express great confidence in success, while others insist that the law should be amended in such a way as to be more favorable to their particular schemes.

This Commission does not advise any change in the law of the kind desired by such persons as think its objects cannot be secured as it now stands, and is construed by the Attorney-General. On the contrary, we think all the things now required by the law should be insisted upon being complied with before the money should be awarded.

All the time allowed by the law will be given to the competitors, but the Commission will adhere to the determination expressed at its first meeting, that boats in actual service, and not drawings or models, will be considered as competing for the money offered by the State.

Appended hereto will be found the report of David M. Greene, engineer of the commission, giving his views on the whole subject. As an officer of naval engineers in the United States service, Mr. Greene has enjoyed unusual facilities for becoming acquainted with the design and construction of steam machinery, and with its manipulations both ashore and afloat. He expresses the opinion, based on the knowledge he has acquired from actual examinations of the workings of various plans and devices, that the objects of the law may be attained in a canal of the depth and width that our canals are, by law, supposed to be. We invite attention of all parties interested to Mr. Greene's report.

REPORT OF DAVID M. GREENE, ENGINEER OF THE COMMISSION.

HON. VAN R. RICHMOND, *Chairman, etc.:*

SIR.—Having been directed by the Commission appointed under act chapter 868, Laws of 1871, "To foster and develop the internal commerce of the State," etc., to report the results of my investigations and observations, together with my present views in relation to the introduction of steam as a motive power upon the canals of this State, I have the honor to submit the following

REPORT:

In the performance of this duty, I cannot, perhaps, do better than to present to the Commission a brief history of my connection with this important problem; the board will then be better able to understand and appreciate the views which I may express in relation to the present status of the problem, with the attempts at the solution of which it has to deal.

In the summer of 1867, while on duty as an officer of naval engineers, in the bureau of engineering of the Navy Department at Washington, Mr. S. H. Sweet, late deputy State Engineer, called my attention to the importance of the economical introduction of steam, as a motive power, on the canals; informing me of the fact that several unsuccessful attempts had then been made, and requesting me to undertake an investigation of the question, with the view, if possible, of discovering the cause or causes of the failures.

Accordingly, I proceeded, with such information as I was able to procure at the time, to make such investigations as the question seemed to require. As the result of those investigations I reached the following conclusions:

First. That the washing of the banks was an *imaginary* difficulty, which had been anticipated, from the fact that the old packets, when towed at high speeds, produced injurious swells; or that if these swells and the resulting injury to the banks, existed as a matter of fact, being produced by the steam propelled freight boats, drawing six feet of water, they must have been produced by an attempt to attain a rate of speed by far too great for economy. The obvious remedy was to reduce the speed.

Second. That an average rate of speed of about three miles per hour could, probably, be economically maintained; and,

Third. That it was quite probable that the machinery which had been used, was not properly adapted to the duty required of it; that it was not properly designed and proportioned to develop power economically; and that, to insure success, it was absolutely necessary that the machinery should be specially designed for the particular duty in question; the special requisites being simplicity, compactness, strength, durability and a proper relation between its several elements.

A simple, though not rigorously exact, computation will show how groundless are the fears that injurious waves, or washing of the banks, will result from the attainment of the desired speed.

The distance from Buffalo to West Troy is 345 miles; and in that distance there are seventy-two locks. Allowing ten minutes for the time of lockage and detention from other causes, the time expended at the locks must be 720 minutes or twelve hours. An average speed of three miles per hour would accomplish the trip from Buffalo to West Troy in 115 hours. Deducting the time lost at the locks, there remains $115 - 12 = 103$ hours as running time; which would necessitate a speed, between locks, of 3.35, say 3.5 miles per hour; or 5.11 feet per second.

The boat, in moving over a space equal to its own length, displaces a definite volume of water, which finds its way astern on either side of and underneath the boat, in virtue of a current induced by an elevation of the water at the bow, and a corresponding depression toward the stern.

To show what inclination of the surface, resulting from the elevation and depression mentioned, will suffice to cause the water to move astern as fast as the boat moves ahead, I assume the case to be similar to that of water flowing in an open canal; and, so far as our present purpose is concerned, subject to the same treatment.

Assuming the depth of the water to be seven feet (and it is to be observed here that the competitors, under the act, have the right to expect that this depth will be maintained throughout the canal), the width of the boat 17.5 feet, the draught of water six feet, and the width of the canal, at top and bottom, seventy feet and fifty-six feet, respectively, the wetted perimeter of the canal, including that of the boat, will be 105.3 feet, and the transverse section, exclusive of the boat section, 336 square feet.

Then, using a modification of Eytelwein's formula, for the motion of water in canals, we find that the requisite current will be induced by a surface inclination of considerably less than one inch in the length of a boat.

The process by which we arrive at this result, while not assuming to indicate or measure the precise effect of the moving boat, upon the water ahead of it, nevertheless shows, that there is no difficulty in disposing of the displaced water.

The waves generated by the old packets are readily accounted for, when we consider that the speed attained was nearly, if not quite, double that now contemplated; that there is a great disparity between the sections of the new and old canals; and that, in the case of the packets, the disturbance was limited, almost exclusively, to the *surface* of the canal, instead of extending to within a foot of the bottom, as in the case of a loaded boat of the present day.

In regard to the power required to propel a boat laden with 200 tons of cargo, we have, as a datum, the fact that two horses, with extra exertion, such as is required to develop *two standard horse-power*, maintain a speed between locks, of about two miles per hour.

In case the same speed were obtained by steam-power, an excess of, say fifty per cent, in effective power, must be provided to cover the loss due to the "slip" of the propelling instrument. The "slip" should of course be much less than this, but it will not be prudent to provide for a loss less than the amount stated. This provides for a loss, due to "slip," of $33\frac{1}{3}$ per cent of the effective power of the engine. Again, a further excess must be provided to cover the loss from friction, etc., of the machinery itself. So that it will be entirely safe to say, that a steam power of nearly or quite 3.5 horses, must be provided, in order to accomplish the speed attained by two *horses*. Then, to cover contingencies, let us provide for a maximum speed of four miles per hour.

The gross power to be provided will then be $3.5 \times \frac{4^3}{2^3} = 28$ horses, which is, in my opinion, a very liberal estimate.

Putting the consumption of coal at five pounds per horse-power per hour—properly designed and constructed machinery ought not to require more—the daily consumption of fuel will be $5 \times 28 \times 24 =$ 3.360 pounds, say $1\frac{1}{2}$ tons.

If now an average speed of three miles be attained, the distance made in twenty-four hours will be seventy-two miles, at a cost for coal, of say $10, or at the rate of 13.9 cents per mile.

To accomplish the same distance, the horse boat, at an average speed of 1.5 miles per hour, would require forty-eight hours, at a cost for towing of $72 \times 35 = \$25.20$. The average speed of the horse-boat 1.5 miles, and the cost of towing thirty-five cents per mile, are both believed to be fair estimates.

Assuming now that the crew of the steamer is twice as expensive as that of the horse-boat, the cost of crew per mile, or per trip (neglecting the time for loading and unloading at termini), will be the same, in each case, and the difference in expense per trip will be that due to the cost of power alone. For 345 miles at thirty-five cents per mile, the expense of towing would be $120.75 by horse-power, while for steam-power, at 13.9 cents per mile, the cost would be $47.96, showing a difference of $72.79 in favor of steam-power, aside from the ability of the steamer to make nearly twice as many trips in a season as the horse-boat can make.

In other words, if our assumption be correct, twice the amount of freight could be transported, at an aggregate cost less than that now incurred with animal power as a motor.

There are, of course, numerous other elements which should enter into the comparison, and, which would, to some extent, modify the result.

Enough, however, has been said, to indicate the grounds for the conclusion that a speed of three miles per hour can be attained, economically, on our canals, by the introduction of properly designed and constructed steam machinery. It may be stated, too, in this connection, that the time required for loading and discharging many kinds of freight, would be considerably shortened by the use of suitable steam-power for that purpose. It is to be remembered too, that we have assumed that the water in the canals will be maintained at a depth of seven feet, as a minimum. The fulfillment of this condition, I consider essential to the success of the scheme.

In regard to the third conclusion, it may be said, that the proper proportions of boilers do not appear to have received that attention which their importance demands. The secret of success, in steam machinery, lies in the boiler, where the power is *generated*, rather than in the engine, which is simply the medium through which such power is transmitted and applied. In order to insure success, therefore, it is of the utmost importance that the relations between the various elements of the boiler shall be such, that it will generate the largest practicable amount of steam with a given consumption of fuel; a condition of things only to be realized by those acquainted with the actual performances of boilers of the various types and proportions now and heretofore in use.

The engine must be large enough, and yet not so large as, with its boiler, to occupy too much space, and thus unnecessarily reduce the space available for the storage of cargo.

If the engine and boiler be too large, and be worked up to their full capacity, a rate of speed may be attained, at which the cost of power would reach, and possibly exceed the cost of horse towage; while the increase in speed would be trifling, when compared with the increase in power, and in its cost. At the same time the carrying capacity of the boat would be reduced. In other words, any increase in speed, beyond that which may be most economical, operates prejudically in the two directions of increased expense, and diminished capacity.

I have thus endeavored to point out some of the reasons which led to the conclusions heretofore stated, and which still lead me to believe that the object sought may be accomplished, provided that the canals are kept in proper condition, as to depth of water, during the trials to be conducted by the Commission during the coming season.

Should any difficulty be experienced in maintaining the full depth of seven feet, and should the coming trials prove successful with that depth, then surely the State would be justified in adopting such measures as would, at all times, insure the requisite supply of water. My observation, during my connection with your board, leads me to the conclusion, that the first and gravest difficulty in the way of success, on the part of those who have heretofore sought to solve the problem under consideration, as well as in the case of a large majority of those who are now proposing to undertake its solution, consists in the want of sufficient knowledge of the principles of steam navigation. Most of these parties, instead of directing their attention to a judicious application of well known and successful modes of propulsion, have endeavored, and are endeavoring, to invent some new propelling instrument; producing, in their efforts, the same device, or devices similar to those which were proposed, and, in many instances, tried, by the early laborers in this field, during the experiments which finally resulted in the adoption of the paddle-wheel and screw, to the exclusion of all other devices.

I feel no hesitation in expressing the opinion that success will, ultimately, be attained, if attained at all, by the adoption of one or the other of these instruments; or with some modification of them, which may be necessary to adapt them to the peculiar conditions under which they are to be employed. Assuming that the best propelling instrument is adopted, then a serious difficulty may be, and indeed has already been, encountered, in the shape of shoal water on those portions of the canal where, during dry seasons, the water supply is likely to be deficient.

In order to comply with the provisions of the law, in regard to carrying capacity, the boats must draw so much water as to require the full depth of seven feet, in order that the requisite speed may be attained without the employment of excessive power. This condition is rarely, if ever, satisfied. During the past season, several points were found where the depth did not exceed six feet to six feet six inches; and where a boat, carring 200 tons of cargo, must touch bottom, or so nearly touch bottom, that the resistance to its movement will be very largely increased, or its speed diminished. This difficulty, if not remedied, I believe may be fatal; unless the boats themselves be made lighter, by the use of iron in their construction; or unless some other plan be contrived, whereby the draught of water may be reduced without impairing the carrying capacity of the boat.

Another difficulty suggests itself; and that is, the fact that, when light, the propelling instrument—particularly the screw—will be, to a large extent, out of water. While this is true of all vessels propelled by steam, it is to be observed that, in the case of the canal boat, the difference between the draughts, when light, and loaded, is much larger, relatively, than in the case of other water craft propelled by steam.

The diameter of the screw for a boat drawing six feet of water when loaded, would be from four feet six inches to five feet. Suppose it to be five feet; and that, at top and bottom, it is six inches below the surface, and above bottom of the boat, respectively.

Now, when the boat is light, and drawing from sixteen to eighteen inches of water, the immersion of the propeller blades will be only ten to twelve inches. This difficulty would be remedied, to some extent, by the location of the machinery well astern, so as to increase the draught there considerably above the average, or by admitting a sufficient quantity of water to increase the draught to such an extent as would insure the requisite immersion of the propelling instrument. The former might alone produce the desired result. The latter, alone, or in conjunction with the former would certainly do so.

THE "DAWSON."

This is the only steamer that has been brought to the official notice of the board. She has made two round trips from New York to Buffalo and return, and one to Syracuse, during the season. An abstract of the "log" of this steamer, for one trip from Albany to

Buffalo, and return to West Troy, has been furnished me by Mr. Thomas Main, the inventor of the system employed therein.

The boat left the weigh-lock at Albany, at 9.45 A. M., on August 4th, laden with 180 tons coal, and reached Syracuse on the 14th of the same month at 2 P. M., where thirty tons of coal were discharged on account of low water. On the 16th she left Syracuse at 1 P. M., and reached Buffalo at 9.30 A. M. on the 22d; having been fifteen minutes less than eighteen days on the way.

The detentions were noted as follows:

	Hours.
At lock No. 5, on account of the breaking of a lock-gate...	3.00
Schenectady, Saturday P. M. and Sunday	42.50
Schoharie lock, bar.....	12.50
Fultonville, for water.....	0.75
Spraker's	0.75
Little Falls.....	25.50
Mohawk	8.83
Six miles east of Utica, aground, level twelve inches low,	6.25
Utica, repairing steam pipe.....	19.00
West of Utica, shoal water	5.50
Rome, for water	0.75
Durhamville	1.25
Canastota, Sunday	30.50
Syracuse.....	23.00
Geddes, for coal	1.00
Clyde, at locks	1.67
Beyond Palmyra, locks	3.00
Rochester.....	0.75
Albion.....	0.75
Knowlsville, Sunday.....	33.00
Middleport, for water.....	0.50
Lockport, locks.....	0.55
Locked through five locks in twenty-five minutes.	
Tonawanda	3.25
Total detentions.....	224.88

Or about nine days and nine hours; which, deducted from the total time, seventeen days twenty-three hours forty-five minutes, leaves eight days and fifteen hours, nearly, as the running time, and indicates an average speed of 1.69 miles per hour.

Three miles, west from Schenectady, is said to have been made in one hour, "against a strong current."

On the return trip, this boat left Buffalo on the 28th August, at 4.30 P. M., and reached the West Troy weigh-lock at 12.30 A. M., September 7th; making the run in nine days and eight hours, with the following detentions:

	Hours.
At Black Rock	1.00
Lockport, locked through five locks in thirty minutes.	
Middleport	0.50
Brighton	1.00
Clyde	0.50
Montezuma	0.75
East of Montezuma, aground	1.00
Jordan	1.45
Geddes	1.00
Lodi	2.00
Utica, Sunday	26.25
Little Falls	13.50
Fort Plain	6.50
Total detentions	54.45

Or two days six and a half hours, nearly.

The running time was, therefore, seven days and two and a half hours; indicating an average speed of 2.02 miles per hour. On this trip the load is said to have been 200 tons of corn.

In a printed pamphlet, Mr. Main gives the result of a subsequent trip from Buffalo to Cohoes, which is, in substance, as follows:

Left Buffalo 18th October, at 3.45 P. M., loaded with 200 tons of wheat. From Buffalo to Rochester, ninety-three miles, running time thirty hours; speed 3.04 miles per hour.

Brighton to Geddes, eighty-eight miles, including time through thirteen locks, time fifty hours, or 1.76 miles per hour.

From Lodi to Rome, forty miles; time, twenty-two hours; or 1.82 miles per hour. From Utica to Cohoes, ninety-nine miles; time, including passage of twenty-six locks, forty-seven and one-half hours; or 2.1 miles per hour.

During the season, I endeavored to spend some time on board this boat, going to Utica and Fultonville for that purpose; but, owing to unexpected detentions, I failed to meet it. On one occasion, however, I visited the boat at West Troy, and went part of the way to Cohoes on board; my object at that time being to observe her behavior in passing locks. This I found to be very satisfactory, indeed. In one instance the steamer and a horse boat reached a double lock at the same moment. When the steamer had cleared the lock, and was well under way, the horse boat had just entered the lock and the lower gates were being closed.

In addition to the difficulty experienced by this boat, on account of shoal water, I think her power somewhat too small. Judging from the reported coal consumption, and my observations while on board, I am of the opinion that the power was uniformly about twenty-two horses.

That this power is not employed to the best advantage, is indicated by the enormous slip of the screw. The pitch of the screw is six feet, and the revolutions are put at eighty to ninety per minute. Taking the revolutions at eighty, the advance per minute due to the pitch would be $6 \times 80 = 480$ feet. Take now the speed of the boat at its maximum of three miles, its movement per minute would be $60 \times 3 \times 1.46 = 263$ feet. The difference, $480 - 263 = 217$ feet, represents the slip; which, therefore, appears to be $217 \times 100 \div 480 = 45.2$ per cent. At ninety revolutions, or at a less speed, the slip would be correspondingly increased.

This excessive slip of the screw is due, in my judgment, to the fact that the water thrown astern by it has to effect its passage through a contracted channel at great speed, developing a resistance which has the effect to seriously impede the progress of the boat.

The principal claim of Mr. Main, as I understand it, consists in this: that the screw, forcing the displaced water under the boat, precludes the necessity of its passing along the sides, and thus prevents the formation of an injurious wave or swell in advance of the boat.

Now, the most the screw can do, in the direction indicated, is to throw astern a cylinder of water, whose diameter is equal to that of the screw, or four feet six inches. While the boat is moving ahead, a distance equal to its own length—taking the slip at fifty per cent—the length of this cylinder will be $1\frac{1}{2} \times 98 = 147$ feet, and its weight 73 tons. Taking the displacement of the loaded boat at 275 tons, and it will not differ much from that, it appears that $275 - 73 = 202$ tons, or about seventy-three per cent, of the water has to find its way astern along the sides of the boat, as in the case of ordinary boats.

FORMER ATTEMPTS TO INTRODUCE STEAM UPON THE CANALS.

Diligent inquiry, in various quarters, has been made, with a view to obtain information in regard to the earlier efforts to introduce steam as a motive power on the canal.

No precise information in regard to the details of these efforts could, however, be obtained. Beyond the simple fact that the attempts proved unsuccessful, no satisfactory or useful record appears to have been preserved. For this reason, the design, originally entertained, of presenting a detailed history of the earlier experiments and failures has been abandoned.

Respectfully submitted.

D. M. GREENE,
Engineer, etc.

TROY, *February* 13, 1872.

DIMENSIONS OF THE ERIE AND OSWEGO CANALS AND THEIR STRUCTURES.

CANALS.

Length of Erie canal	351.78 miles.
Length of Oswego canal	38 miles.
Width at surface of water	70 feet.
Width at bottom:	
With slope wall, 1 to 1	56 feet.
With slope wall, 1¼ to 1	52½ feet.
With bench wall	42 feet.
Depth of water	7 feet.

BRIDGES.

Height in clear, above water line	12 feet.

LOCKS.

No. of locks on the Erie canal: Double, 57; single, 15,	72
No. of locks on the Oswego canal	18
Length of locks, 110 feet between hollow quoins, admitting the passage of boats ninety-six feet in length.	
Width at surface of water of lower level	18 feet.
Width on bottom	17 ft. 4½ in.

AQUEDUCTS.

Width, about	50 feet.

BOATS.

The following are the outside dimensions of two kinds of the largest sized boats in general use on the canals:

LAKE-BOATS.

Length	95 feet.
Midship section:	
Width at one foot from bottom	17 ft. 3 in.
Width, seven feet up from bottom	17 ft. 7 in.
Depth	9 ft. 7 in.
Carrying capacity, about	225 tons.
Light weight, about	60 tons.

The above is the usual form adopted in the construction of boats of this class; they vary, however, somewhat in depth of hull.

BULLHEAD-BOATS.

Length	96 feet.
Width on bottom	17 ft. 2½ in.

Width, six feet up from bottom	17 ft. 8 in.
Depth of hull	9 feet.
Depth over all	12 ft. 1 in.

From the point six feet from bottom to the top of hull the sides fall in two and a half inches.

Carrying capacity, about	240 tons.
Light weight, about	55 "

FORM OF BOWS.

The following from the canal regulations and from instructions issued by the auditor of the canal department, show the shape of bow required and generally used on boats navigating the canals:

"40. In order to protect other boats and the canal banks and structures from injury, no scow or other boat, hereafter to be built and registered, shall be permitted to navigate any canal unless the whole bow of said scow or boat be constructed of an elliptical or semicircular form, the versed sine of which shall not be less than one-fourth of the chord."

"The bow of a ship, vessel or boat is defined to be the rounding of '*her sides* forward, beginning where the planks arch inward, and terminating where they close at the stem or prow.' In this sense the word or term is used by the canal board in the regulation when requiring the *whole bow*, not the top of it or deck only, to be constructed in the elliptical form designated.

"A boat constructed with a bow having the *versed sine* longer than one-fourth of the chord, does not conflict with the regulation."

"The radius, where the *versed sine* is one-fourth of the chord, can always be found by multiplying the chord by ten and dividing by sixteen. The result is the length of the radius."

FROM THE REGULATIONS OF THE CANAL BOARD.

No boat drawing more than six feet of water shall be cleared after the first day of June, 1864, by any collector on the Erie, Oswego, and Cayuga and Seneca canals; and that it shall be the duty of every collector, superintendent, inspector and weighmaster to cause every boat found violating the regulation on this subject to be so far unloaded as to bring her within the prescribed limits; and in every case where a boat is so unloaded, the fact shall be entered on her clearance, with a statement of the portion of her cargo taken off; and in every case where a boat shall be found drawing more water than six feet, as provided in this regulation, her master or owner shall be sub-

ject to a penalty of twenty-five dollars, to be imposed and collected by any and every collector, superintendent, inspector and weighmaster who may, at different times and places, detect such overdraft; and every collector shall enter upon the clearance the draft of water of every boat at the time of such clearance.

No boat or other craft, whose height or distance from the water line of such boat or craft to the top thereof, shall exceed eleven feet and three inches; and no loaded boat or other craft whose cargo, or any part thereof, is so arranged or placed on such boat or craft so that the top, or extreme height of the same shall exceed eleven feet and three inches from the water line of such ladened boat or craft; and no steamboat, tug or other craft propelled by steam, whose height, when the top of the deck, machinery, fixtures or other apparatus shall exceed eleven feet and three inches, shall be allowed or permitted to navigate the Erie, Oswego, and Cayuga and Seneca canals.

All boats propelled or drawn by steam, together with the boats in tow thereof, shall have preference at the locks over other boats and floats, except as otherwise provided by statute.