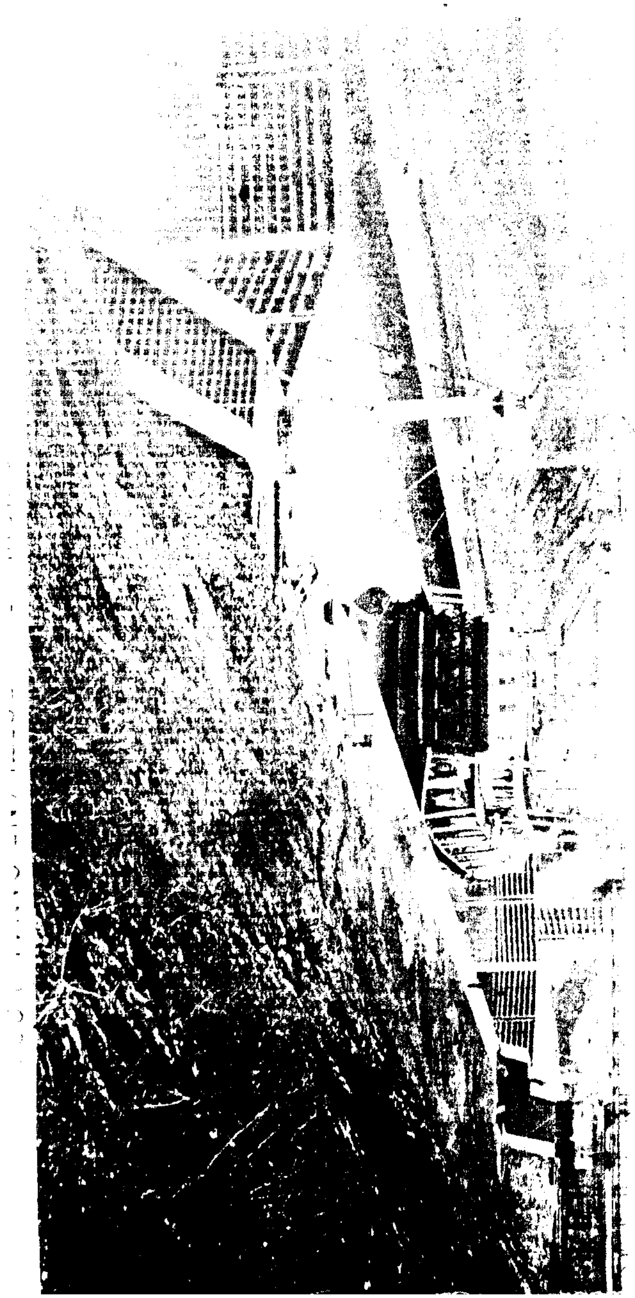


NOTES

ON

SOME OF THE CHIEF

NAVIGABLE RIVERS AND CANALS

IN THE

UNITED STATES AND CANADA,

MADE FOR THE

GOVERNMENT OF MADRAS,

DURING A TOUR IN 1876,

BY

GEORGE T. WALCH, M. INST., C.E.—EXVE. ENGR., MADRAS P. W. DEPT.

MADRAS:
Printed at the Lawrence Asylum Press, Mount Road,
BY W. H. MOORE.

1877.

PREFACE.

The following extracts from official documents will show how these notes originated, and why they are now printed.

No. 11,445.

Dated, India Office, 3rd November, 1875.

To G. T. WALCH, Esq.

I am directed by the Secretary of State for India to acknowledge the receipt of your letter of the 15th ultimo, and in reply to state that you have his Lordship's authority to visit at the public expense the works in the United States and Canada, specified in your letter to the Officiating Secretary to the Government of Madras of the 8th July last.

2. The terms and conditions upon which this privilege is granted are the same as those accorded to officers visiting Engineering works in the United Kingdom, copies of which are enclosed herewith.

3. In regard to the disbursements authorized by this letter, complete and detailed vouchers must be furnished for all items excepting those for which vouchers cannot be procured, and in regard to these latter, statements in detail must be submitted.

(Signed) G. HAMILTON.

Madras, *4th June*, 1877.

To

Lt.-Col. J. MULLINS, R. E.,
Chief Engineer for Irrigation, and
Joint Secy. to Govt., P. W. D., Irrigation Branch.

Sir,

(1). I have the honor to forward herewith my notes of a visit to American and Canadian Canal and River Navigation

Works, undertaken in accordance with the authority granted in the accompanying letter* from the Secretary of State for India.

* No. 11,445, dated 3rd November, 1875.

According to the rules printed with G. O., No. 2,267, 15th September, 1873, an officer having visited Engineering works at the public expense must send his "Report or Paper of Notes" to the Secretary of State for India for "transmission to the Local Government under which he is serving." It seems to me therefore that being in Madras my proper course is to forward my notes to the Local Government through you.

(2). * * * * *

* Most of the plans which accompany the notes were given to me by the Engineers connected with the various works I visited, gentlemen whom I found uniformly courteous and in most cases even more obliging and attentive than mere official or professional courtesy demanded.

(3). I trust that the information contained in the "Notes" will prove of some interest and value.

I have the honor,

&c., &c.,

(Signed) GEORGE T. WALCH, *M. Inst., C. E.*,
Acting Deputy Chief Engineer for Irrigation.

No. 3 E. W.

No. 291-A. *Note by the Chief Engineer for Irrigation.*

In transferring to the Chief Engineer, Public Works Department, Mr. Walch's letter of the 4th instant and its accompaniments, the undersigned desires to say that he has read Mr. Walch's Notes on works inspected by him in the United States and Canada with the greatest interest, and he feels sure that they will prove of great interest and value to all officers of the department employed on hydraulic works.

2. In reading of the great water highways of the Western Continent, and more especially of the works by which the American rivers have been made navigable whether by canalization or by the construction of canals round barriers, it is impossible not to regret greatly that the opening of the Godavery and its tributaries to navigation by means of similar works has been abandoned, and to hope that some day the advantages which the great extent of country, which this river would serve, would reap from its improvement will be deemed to warrant the no doubt considerable outlay which would be required, an outlay however not, it is believed, out of proportion to the mileage of cheap communication which would be opened or to the extent of country which would be benefited.

3. The undersigned hopes Mr. Walch's application to be allowed in addition to the bill he has submitted for expenses and cost of drawings, the amount which he would have been entitled to claim had he returned from Keokuk on the Mississippi to England, instead of going thence to San Francisco and Australia, will be considered fair and reasonable. With this addition the cost of the tour will be under a hundred guineas, and the information obtained will certainly be of far greater value to the department to which Mr. Walch belongs.

4. Mr. Walch has, it is considered, fully justified the special recommendation* made by Government on which the Secretary of State was pleased to authorize the tour to be undertaken.

* G. O., No. 2,284, dated 7th August, 1875.

(Signed) JOHN MULLINS, *Colonel, R. E.*,
Chief Engineer for Irrigation.

FORT ST. GEORGE, 22*nd June*, 1877.

No. 292. ORDER THEREON, 31*st August*, 1877, 665 W.

The Government have read Mr. Walch's Notes with much interest, and consider that it will be useful to place them in the hands of those officers of the department who have been or are likely to be, engaged on hydraulic works. Copies of the notes will be printed at the Lawrence Asylum Press, and the plans will be lithographed in the Lithographic Department.

2. The Governor in Council resolves to authorize, as a special case, and subject to the confirmation of the Secretary of State, the disbursement to Mr. Walch of the amount of his several claims, namely, his travelling expenses while engaged on his tour of inspection, the cost of the drawings, and the passage fare which would have been incurred by Mr. Walch had he returned from Keokuk to England in the usual course.

3. The Secretary of State and the Government of India will be addressed.

(Here enter No. 665-A W, dated 31st August, 1877.)

(True Extract.)

(Signed) E. A. FOORD, *Colonel, R. E.*, *Secretary to Government*, *P. W. D.*

THE MORRIS CANAL.

(Visited 29th April to 7th May, 1876.)

Introductory.

THIS canal was not included in the list* of works that I proposed to visit in America, but it was commended to my notice after my arrival in New York on account of the peculiar and successful way in which the steepness of the country over which it runs has been dealt with, a difference of level of 1,674 feet being overcome in its course of 102 miles, chiefly by "inclined planes" worked by hydraulic power. It is also of interest from its having been one of the earliest canals of any size in the United States, and its vicissitudes of fortune appearing to me to point some useful lessons in canal construction and management, I have taken some trouble in ascertaining and condensing the main facts of its history from various scattered documents, and have devoted more attention to it generally, than its present importance might seem to warrant.

General History of the Canal.

The date of the charter of the "Morris Canal Company" is December, 1824. Work was commenced in July, 1825, and the canal, as then designed, was finished in 1831 from the Delaware river to the Passaic river at Newark. In 1836, the canal was continued to the Hudson river at Jersey City, which is really a suburb of New York. The canal, as then constructed, had a bottom breadth of only 20 feet, and a depth of 4 feet; its locks were 75 feet × 9 feet, and the largest boats which could navigate it did not exceed 18 tons. It was soon found that, with such small dimensions, it could not pay, and in 1841 the locks and planes were enlarged, (locks to 95′ × 11′) the prism of the canal being, in 1845, increased to 25 feet bottom width and 5 feet depth, which enabled boats carrying 44 tons of cargo to be used. The traffic and income immediately sprang up from, in 1845,

* Accompanying my letter 8-7-75, to Secy. to Govt. of Madras, P. W. D.

58,259 tons and 18,997 dollars to, in 1846, 109,595 tons and 51,212 dollars, and gradually increased till they were, in 1860, 707,631 tons and 350,710 dollars. In that and the following year the locks were lengthened to 100 feet clear in the chamber and improved boats were constructed, carrying from 70 to 80 tons of coal, and the traffic and income further increased till they reached their culmination in 1866, when they were respectively 889,220 tons and 616,350 dollars. After this date the severe competition of railways, which had been constructed near the line of canal and which tapped the Pennsylvanian coal fields, reduced the traffic and income of the canal to 707,572 tons and 391,549 dollars in 1870. In that year the canal was leased to the Lehigh Valley Railroad Company, with whose line it was competing, and in their hands it now is. In order to comply with the requirements of the charter, the accounts of the canal are kept separate from those of the railway, and an organization for its working is kept up, but it is evidently treated with no great favour and, excepting the "planes" and their machinery, the works bear an appearance of disrepair. The interests of the lessees (or really lessee as the railway is virtually controlled by one large capitalist) are in the railway, and the canal is probably to them only a troublesome charge which they undertook in order to get entire command of the traffic of the country through which their lines pass, and to secure the valuable river frontage belonging to the canal at Jersey City.

Financial History.

The financial history of the Company is not a happy one. The original capital was 4,100,000 dollars in 41,000 shares of 100 dollars each, and nearly all this sum was expended in the original construction and expenses of the canal. When it became evident that the canal was too small, money could not be raised for enlarging it except by mortgaging the works, and this was done to some capitalists in Holland. The payment of interest on the debt having fallen into arrears, the mortgage was foreclosed and the property was, in 1844, sold by order of the law courts. The purchasers were a company of the original shareholders who raised the funds necessary for the purchase and improvement of the canal by an issue of 11,750 "preferred shares" of 100 dollars each, and at the same time the

original 41,000 shares were "consolidated" into 10,250 shares of the same nominal value as before, the arrangement being that all profit was to go to the "preferred" shares till 10 per cent. per annum was paid on them, after which only were the "consolidated" shares to participate in the profits. It was some years before anything thus became payable to the "consolidated" shares. They did, however, eventually receive dividends which rose to $2\frac{1}{2}$ per cent. in 1866, but from that fell off to nothing in 1869. The canal was then leased, as above stated, the terms being payment of 10 per cent. per annum on the "preferred" shares, and of 4 per cent. on the "consolidated" shares and on some other bonds for small sums; the total annual payment being 175,000 dollars.

The following statement gives the income of the canal from all sources for each year, from 1845 to 1870 and 1874 and 1875:—

	Dollars.
1845	18,997
1846	51,212
1847	67,687
1848	65,531
1849	99,220
1850	98,224
1851	110,730
1852	140,202
1853	187,449
1854	245,431
1855	272,125
1856	313,026
1857	286,668
1858	275,019
1859	305,537
1860	350,710
1861	291,846
1862	303,154
1863	374,601
1864	590,393
1865	600,584
1866	616,350
1867	419,652
1868	423,767
1869	431,245
1870	391,549
1874	271,436
1875	270,216

General description of line of canal.

The Morris Canal connects the river Delaware at Phillipsburg with the Hudson river at New York, and in doing so crosses the Muscanetcong hill, a spur of the Alleghenies, where it is 760 feet above low water of the Delaware and 914 feet above half-tide water in the Hudson. The western end of the canal enters the Delaware at the town of Phillipsburg, nearly opposite the mouth of the Lehigh river, and the town of Easton. For about a mile and-a-half the canal is forced by a steep rocky hill to keep close to the left bank of the Delaware, it then turns eastward and ascends (rising 760 feet in 38 miles) the Muscanetcong valley, crossing the water-parting between the streams that run westwards to the Delaware and those that run eastwards to the Hudson, near the south end of lake Hopatcong. From its summit level it descends (914 feet in 53 miles) the valley of Rockaway river to the valley of the Passaic river; it locks into and crosses that river where tidal at Newark, and a mile or so further on crosses the estuary of the Hackensack river, whence it passes through salt marshes to New Jersey City, and there by a tidal lock drops into the Hudson and harbor of New York. The direct distance between the two termini of the canal is about 70 miles, whilst the length of the canal itself is 102 miles, the extra length being partly due to the general course required in order to cross the water-parting at its most favorable point, but chiefly to the way in which in the reaches between the planes a level contour has been closely followed; this has added many miles of unnecessary sinuosities to the length of the canal. After passing lifts which suggest the will and power to carry the canal with the directness of an old Roman road, it is strange to find the channel twisted as it is merely to avoid banks and cuts which would not have been formidable. It was doubtless a consideration of cost which led to this, for timidity can hardly be ascribed to the Engineers who took a canal at all over such a line. The country through which the canal passes may be roughly described as agricultural on the western, and manufacturing on the eastern, slope of the water-shed, whilst along and near the summit it is rich in minerals, chiefly iron ore. Along the western portion of the canal, therefore, we find it passes through or close to only 4 towns, the largest (Washington) of which has not more than 2,500 inhabitants, whilst down its eastern slope there are 10 towns (exclusive of "Jersey City"), and of these, one (Newark) has upwards of 105,000 inhabitants, another (Patterson) has 34,000, and the others vary from 1,000 to 6,000. Many of these towns if not actually called into existence by the canal, at all events drew from it the material of their early vigorous growth, a growth which unfortunately was not foreseen when the canal was constructed, and to keep pace with which no attempt has for the last 30 years been made, railways having of late years absorbed the attention and money of capitalists.

Terminal works.

At the western terminus the canal is dropped to the level of the Delaware river by an "inclined plane" (No. "11 West," 35′ lift) some 150 feet distant from the river, the actual entrance to which is through a masonry stop-bridge under which the water enters the lower reach of the canal and stands against the "plane" except when excluded in very high floods (said to rise upwards of 20 feet), or when the reach has to be laid dry for repairs. The stop-bridge is a masonry arch of 22 feet span with platform just above flood level, through which there is an opening of 3 feet wide, or it may be regarded as two arches with a 3 feet interval between them. A wooden groove 6 inches × 6 inches is built into the masonry of each side wall, down which, when it is wished to keep out water, are dropt baulks 13 inches × 5½ inches. At the ends of these baulks are fixed wooden pegs to which, when they have to be lifted, ropes are attached, carried over pulleys on gallows on the platform, and hauled on by mules. The whole arrangement and appliances are rough, but their use is seldom required, and they never have to be worked in haste.

At Jersey City the terminal works consist simply of a tidal lock, which never has to deal with more than 5 feet difference of level, and of two basins with timber and rubble sides, and a timber jetty.

Works for overcoming differences of level.

The works for overcoming differences of level consist of 23 locks of a total lift of 225 feet, and 23 "Inclined Planes" of a total lift of 1,449 feet.

Locks.

The locks do not merit much attention. They are from 95 feet to 100 feet clear length, and 11 feet breadth between the gate quoins. Their lifts vary from 8 to 12 feet. The upper gates are almost all ordinary closing leaves with balance beams. The lower ones are all ordinary closing leaves worked sometimes by balance beams and sometimes by a jointed double-action lever, pushed forward by rack and pinion gearing from a staging over the tail bay. The chambers are filled by culverts from the head-bays issuing in some cases in the side walls behind the gate quoins, and in others under the lift-wall. The inlet vents are closed by cast iron-turning shutters. The chambers are emptied through wickets in the lower gates. Only on
to work each lock, but he gets assistance from

Inclined Planes.

The "Inclined Planes" deserve more extended notice: they are works of an uncommon character and of great excellence in their kind. Their positions, lifts, and gradients are shown in the following list:—

Distinguishing No. of Lift.	Distance from Delaware River.	Vertical Lift.	Gradient.	
	Miles.	Feet.		
11 West	0	35	1 in 12	
10 "	3·04	44	1 — 10	
9 "	4·60	100	1 — 11	
8 "	6·32	62	1 — 11	
7 "	14·82	73	1 — 10	
6 "	17·82	50	1 — 10	
5 "	19·69	64	1 — 10	
4 "	34·08	80	1 — 10	
3 "	34·85	55	1 — 11	
2 "	36·70	70	1 — 10	
1 "	38·05	58	1 — 10	
		691	......	Total lift of Planes on Western Slope.
1 East	39·95	50	1 in 11	
2 "	41·31	80	1 — 10	
3 "	41·80	48	1 — 20	
4 "	45·25	52	1 — 10	
5 "	47·06	66	1 — 10	
6 "	52·24	52	1 — 12	
7 "	58·68	80	1 — 11	
8 "	60·42	76	1 — 11	
9 "	60·60	74	1 — 11	
10 "	64·48	56	1 — 12	
11 "	83·64	54	1 — 12	
12 "	89·72	70	1 — 10	
		758	......	Total lift of Planes on Eastern Slope.
		1,449	......	Grand Total Lift of Planes.

The boats are hauled over these planes, on trucks running on rails, by a wire rope wound on a drum driven by water-power obtained from the pool, or reach, of canal above each plane. The tracings which accompany this, and which by the courtesy of Mr. J. F. Randolph, Superintendent of the Canal, I was allowed to have made, from original plans in the office of the Company, give some of the main features and details of a "double track plane." Three of the 23 planes have such double tracks, over which two boats can be passed, one up and the other down, at one and the same time. The grades of the inclines, as already shown, are generally from 1 in 10 to 1 in 12. The rails are laid on a guage of 12 feet, on longitudinal sleepers bedded on continuous masonry walls. The tracks are prolonged beyond the ends of the incline till they reach the bed of canal, and are there laid horizontal for a length sufficient for the cradle trucks to stand on. At the summit, therefore, the inclination changes from a rising to a falling one, and the radius of the curve of change is 320 feet. On the rails run the "cradles": these are composed of strong timber frames in two portions, each 36 feet long, coupled (the boats also are hinged) by strong-hinged iron bars allowing vertical play when passing the plane summit. Each of the two portions of the cradle is carried on a truck with 4 pairs of 30″ diameter double-flanged chilled-iron wheels with ½ inch play and governed by powerful brakes which can be applied by means of levers at top of the cradle frame.

Curved "saddles," or "bolsters," between each pair of wheels also allow a certain amount of vertical adjustment of the system when passing over the summit. The boats float into these cradles or "cars" as they stand on the level at end of the tracks, are made fast to stanchions in their frames, and as they leave the water, settle down on their floors on which they rest whilst passing over the incline, floating out when they reach the end of the tracks. The traction rope, which is of wire and usually $2\frac{1}{8}''$ diameter, is supported on grooved wheels and rollers between the lines of rails, and at the ends of the incline passes round guide sheave wheels of large diameter and is taken to the engine house, where its two ends are fastened to a spiral-grooved winding drum, so that as one winds the other unwinds; the direction of revolution of the drum can, by the usual mechanical arrangements, be reversed at will. Some further particulars about the ropes used are given as an Appendix (No. 1) to these notes in a letter from Mr. H. Talcott, formerly Chief Engineer of the canal, copy of which was kindly obtained for me by Mr. L. Ward, to whom, as well as to his brother Mr. J. F. Ward, I am indebted for much kind attention.

The winding drum is worked by machinery driven by a turbine in a well near one side of the incline, and so far down it as may be necessary to obtain the required fall for the water, which is led from the upper pool through a wooden flume. The machinery is situated over the turbine and is driven by a vertical shaft from it, the whole being covered by an "operating house" raised to such a level and so arranged that the "plane tender" can from it see the upper pool and the whole of the plane, and, according to signals made by the brakesman who accompanies each boat whilst passing over the plane, he starts, stops, reverses, and otherwise controls the machinery by the movement of levers.

Where the slope of the country is very rapid, these planes take the place of flights of locks with the advantages of (1) cheapness in cost of construction and working, (2) some economy of water, (3) very great economy of time.

The actual *cost of the construction* of all the planes on the Morris Canal has been—

Class.	Number of each class.	Collective cost.	Collective rise.	Average cost per foot rise.	Remarks.
		Dollars.	Feet.	Dollars.	
Single......	20	577,974	1,229	470	Say £ 93 per foot-lift.
Double......	3	101,128	220	460	

The cost of the double track plane "No. 12 East" (included in table above) at Newark, constructed in 1855, the vertical lift of which is 70 feet, was everything complete, 33,890 dollars, or say £97 per foot-lift. This is one of the most perfect of the planes on the canal and runs through the town of Newark with level crossings at streets.

The monthly cost of working these planes is—

Single track plane—

One Plane Tender	dollars	37
„ Brakesman	„	34
Total *Single Plane*...	„	71

Double track plane—

Same as single track plane + one Brakesman = ...	dollars	105

The monthly cost of working a lock is— one Lock Tender	„	31

As the average rise of the planes is equal to that of 8 locks, the saving a month in favor of the single track planes is 177 dollars, and in favor of the double track planes 143 dollars. The cost of wear and tear of machinery, &c., connected with the planes may be taken as quite balanced by what that would be of the gates, valves, &c., for as many locks as would be required to give the same lift.

The saving of water is not easy to arrive at. It is variously estimated at from 14 to 33 per cent. of the quantity required for actual working of locks, whilst the leakage always going on in connection with those works is entirely saved.

The saving of time can be more certainly determined. The average time occupied in passing a lock is 9 minutes, that in passing a plane may be taken as 8 minutes. I found from actual timing at plane 2 west, (vertical lift 70 feet, grade 1 in 10), that it was there only 5 minutes, and 8 minutes is certainly rather over than under the average, but taking the latter time, the result is that on each trip over the canal 21 hours are saved by the use of the planes instead of locks—thus,

23 Planes (1,449′ lift) at 8 minutes each =	184	minutes.
1,449 feet lift would require say 160 locks, at 9 minutes .... =	1,440	„
Saving minutes...	1,256	

This saving is only that due to difference of time occupied in actually passing over or through the two different

kinds of works, and does not take into account the extra delays that occur when boats travelling opposite ways arrive together at flights of locks, or the retardation due to the average speed not being acquired in the short reaches unavoidable in a steep country when "flights" are not used. Nor does it take into account the saving of time due to the fact that, as I saw, it is generally so managed that after passing a plane a boat leaves the cradle with a communicated velocity of something like 2 miles an hour instead of being almost without way as she leaves a lock. Probably the time occupied by a boat in passing over the Morris Canal is less by 24 hours or 16 per cent. (taking average length of trip at present as 5 days) than it would be if locks existed where there are now planes.

Crossing Rivers and Drainage.

The Delaware (about 600′ wide) is crossed by a flying ferry worked by the current of the river itself. Across the river, at some 20′ above its surface, is suspended a $1\frac{1}{4}''$ wire rope on which travel 2 grooved wheels kept 15′ apart by a stretcher. From the tail piece of the axle-bearer of each of these wheels, a rope passes through guide sheaves on her side to a windlass in the ferry boat, and are so wound on the drum that as one is slacked off the other is tightened, and *vice versâ*. The ferry boat is a "flat," 50′ long by 10′ beam, which has on its up-stream side two "leeboards" 8′ long each, raised or lowered by rack and pinion gearing, and when the current is weak these boards are lowered below the bottom of the flat to present more surface to the action of the stream. When one rope is slackened off and the other tightened the boat travels across the river towards the bank to which the tightened rope is nearest. No rudder is required. Speed can be lessened by equalizing, and direction of travel reversed, by altering the strain on the ropes. Boats with 70 tons of coals are easily brought across the river by this flat, lashed to her down-stream side. The whole apparatus is simple, not likely to get out of order, and is easily worked by one man. I have seen somewhat similar arrangements in Europe, but never in India, and I think it well worth introducing on some of our Madras river and canal ferries, where there is sufficient current, and navigation does not necessitate the swinging of the over-head rope at an inconvenient height.

For the first 30 miles from the Delaware river the general line of the canal is roughly parallel with the main drainage, and the streams crossed being but few and very small, are taken under the canal through ordinary masonry culverts. Between 30 and 34 miles (from Delaware river) the Muscanetcong, the main drainage of the valley up which the canal rises, is twice crossed by damming and locking into the pools so formed. Between this and the descent down the eastern slope, such small streams as are met with (most of the drainage that used to flow across the line of canal near its summit level is stored in the reservoirs to be hereafter noticed) are taken into the canal. On the way down the eastern slope the first important stream that is crossed, the Rockaway (48 miles from Delaware river) is dammed and the pool, locked into, and the same river is dealt with in the same way again 9 miles further on. At 67 miles the Pompton river is crossed by a long wooden aqueduct. At 71 miles (from Delaware river) the Passaic river is crossed by the only masonry aqueduct of any size on the canal. It has a central arch of 85 feet span and two smaller side ones, and is about 80 feet above the bed of the river. The rest of the streams between this and the Passaic at Newark (93 miles from Delaware river) are crossed by culverts and small aqueducts of stone and timber. Just beyond Newark the Passaic, where tidal, is locked into and boats are towed across it from a road bridge over that river. A mile further on, the tidal estuary of the Hackensack river is crossed in a similar way. Finally the Hudson from Jersey City to New York is crossed, when necessary, by the aid of steam tugs.

Bridges. The bridges over the canal are very numerous, upwards of 200 it is said. They are all, or at least all I saw or heard of, were wooden king-post trusses (the tie very generally of wire rope) from 40′ to 50′ span and from 12′ to 16′ wide. Their standard headway is 10′, and they have a tow path under one end. The tow path abutment is generally of "dry" stone, the other one of rough rubble in mortar. The obligation to keep up many of these bridges has been got rid of by paying lump sums to the parties interested in them, and the result appears to be that the owners of such property do not keep it in anything like the good order

which they insist is absolutely necessary when it has to be maintained *not* at their own expense. At all events, when I enquired about a particularly rotten bridge, and I saw several which to drive over required boldness approaching recklessness, I was pretty sure to find it was a "private" one.

Dredging. The canal being a "still-water one" fed from reservoirs, there is not much silt brought into it; but such as does find its way in and the washing down of the sides necessitate some clearance, and to effect this two "Osgood" dredges are kept. The excavator or dredger is a powerful scoop or dipper attached to the end of a wooden arm which works up and down by means of a rack between the side framing of a projecting crane at the end of the dredge boat or flat. When the excavator is lowered it is pulled back so that the lip of the scoop enters the bed of the channel near the boat; it is then dragged forwards and upwards by chains passing over pulleys at the end of the crane, and when it comes out of the water and to the required height, the crane is swung round and the back of the scoop, which in this position is downwards, is opened by means of a line and the stuff is discharged on to the side of the canal or into boats as may be wished. Drawings and description, which will more fully explain the method of working, accompany this (Appendix No. 2). I obtained them when in Washington from the Patent Office there. This excavator cuts out very hard soil and lifts large stones with ease. The steam machinery for working each of these dredges on this canal is placed on a flat which, in order that it may be taken into the plane cars, is only 10′ 6″ beam and is therefore too "crank" to admit when floating, of the crane being swung much to either side. To steady her, therefore, there are at her ends two vertical baulks of timber ("spuds") which by rack and pinion gearing are lowered till their ends enter the bed of the canal and take a firm bearing: these "spuds" also act as anchors. The area which can be dredged in each position of the dredge boat depends (as does also the distance from her at which the stuff can be discharged) on the length of the crane and scoop arm: it may be taken as roughly, a semi-circle with diameter 2′ greater than the breadth of the dredge flat. In ordinarily firm soil these dredges take out between 200 and 300 cubic yards a day. To work them they have an Engineer, on 75 dollars a month with a comfortable dwelling-boat, and five men (one of whom is cook to the party) on 1 dollar a day each, with quarters on the dredge flat. The consumption of coal is said to be ½ ton a day.

Reservoirs.

The reservoirs from which the canal is fed are five in number, viz.:—(1) "Cranberry Pond," (2) "Bare Swamp Reservoir," (3) "Lake Hopatcong," (4) "Stanhope Reservoir," (5) "Greenwood Reservoir." Of these, I visited the first named four.

(1.) "CRANBERRY POND" is situated some 3 miles north of the canal. Its waterspread when full is 330 acres, its storage capacity about 111,000,000 cubic feet, and its drainage area is 1,162 acres. The embankment which impounds the water I found, from stepping, to be 800 yards in length, nowhere more than 16′ high and for at least one-third of its length under 12′ high, with water-slope covered by loose stone pitching. The "Bye-wash" is a length of about 60′ of natural surface of ground protected by stone pitching, which is retained in position by sheet piling of small depth. The water used to be drawn out of this reservoir through a wooden tube running through the earthen embankment, but a breach having occurred at the place an iron pipe 12″ diameter was substituted. This is some 9′ below full water surface. It is closed by a wooden shutter, working down masonry groove walls, at the inner toe of the bank; the spier of the shutter is of wood with holes in it and is lifted by a crowbar (in the same way as our old Madras sluice shutters) from a wooden foot-bridge. The pipe discharges into the natural rocky bed of a stream (the "Dragon brook") which used to drain the basin of the reservoir, and by it and the Schwartzwald stream the water passes to the pool of the Muscanetcong river, where it is dammed and crossed by the canal at "Waterloo" just below "Plane 4 west"; of course as long as any water is passing over this river-dam no water is let out of the reservoir under notice.

(2.) "BARE SWAMP RESERVOIR."—This is situated high up in a peculiar depression near the summit of the hills amongst which it lies, about 7 miles north of the canal. Its waterspread when full is between 70 and 80 acres, its drainage area 477 acres, and its storage capacity about 25,000,000 cubic feet. Its embankment is in two portions, separated by a narrow spur of a hill, one portion 80 yards (by stepping) long, averaging not more than 6′ high, and the other only 25 yards long across the gorge of the old stream, with a maximum of 12′ high. The "Bye-wash" is a length of about 40′ of natural surface of ground. The water is drawn out of this reservoir through a wooden tube 2′ 2″ × 1′ 3″, passing through the bank at about 10′ below full water surface and closed at toe of water slope by a paddle working in a wooden frame. The wood of the tube is much decayed! The water discharges into the natural bed of the old stream, cascades down the rocky side of the hill, and then runs to the "Muscanetcong" river and is "picked up" in the same way as that from "Cranberry" reservoir. It is only in exceptionally dry seasons that water has to be drawn out of this reservoir.

(3.) "LAKE HOPATCONG."—This is situated about a quarter of a mile north of the summit reach of the canal. Its waterspread when full is 2,800 acres and its drainage area 27 square miles. It is a natural lake, the surface of which has been raised 13′ or thereabouts by an embankment in two portions, one 50 yards long averaging about 6′ high, and the other 100 yards long with a maximum of 13′ high. In the latter is an opening 15′ wide with masonry side walls and closed by "guard gates" in which, at different levels, are 12 wickets (6 in each leaf) the sizes of which I could not ascertain, but believe to be about 3 square feet each. At the back of these gates is a large basin from which a lock of the standard dimensions leads to the "feeder", an artificial navigable channel of the same section as the canal proper, which it joins about midway along its summit reach. The sills of the "guard gates" and lock gates are at the same level as the bed of the canal which is 18′ below full water level of the lake, so that boats can pass to and from the lake, from the shores of which iron ore and firewood are taken in considerable quantities; the boats are towed on the lake by a steam tug. Along the back of one chamber wall of this lock runs a masonry channel 8′ wide closed at its upper end, nearly opposite upper gates of lock, by wooden gates working in wooden frames. At about ⅔rds along the channel is a wall which blocks it, in which is a vent, closed by a shutter worked above by rack and pinion gearing, through which the water passes along a continuation of the masonry channel and through the return of the tail-bay wall into the "feeder" and so to the summit reach of the canal whence it is passed as required to the eastern slope of the canal, none of it being sent to the western slope except what is used in working "Plane No. 1 West." In the outer wall of the masonry channel along the lock side and just above the block wall are two vents closed by shutters worked in the same way as one above noticed, through which water is let out as desired into a natural channel and by it to "Stanhope Reservoir" (to be next noticed), and so to feed the western slope of canal, or to surplus.

The waterspread of the lake when drawn off to level of full water in canal, or 13′ below full water of lake, is 1,500 acres and the mean area of the prism is said to be 2,050 acres, which gives as the storage capacity $2{,}050 \times 43{,}560 \times 13 = 1{,}160{,}874{,}000$ cubic feet. The rainfall from 1846 to 1869 inclusive, averaged 42·55 inches a year, the smallest yearly quantity being, in 1866, 30·06 inches and the largest in 1850, 54·61 inches. It is least in the winter and most in the summer season, the average for the seasons during the years 1846 to 1869 inclusive, being—

Winter—December, January February ...	8·260 inches.
Spring—March, April, May	10·932 "
Summer—June, July, August	11·926 "
Autumn—September, October, November.	11·424 "

There is no surplus weir or bye-wash to this reservoir, all surplus having to be passed through the wickets in the guard gate and so by the lock and channel along it to the canal from which it is discharged by surplus sluices into a natural stream which flows into the Muscanetcong river. As above stated, I was unable to get the size of or levels of the wickets (12) in the guard gates through which alone

the surplus has to be passed, but taking the size to be 4 square feet each, and I believe it to be less than this, the discharge through them with a head of 11′ would not exceed 800 cubic feet a second. This would doubtless be perilously small were not the area of the reservoir so large as compared with its catchment basin (it could absorb 1″ off the whole of its drainage area with the rise of about 6″). I gathered in conversation with the Superintendent in charge of the section of canal to which this reservoir is attached, that though the surplus arrangements have proved sufficient, they have sometimes *barely* proved so, and when there is an appearance of heavy rain he does not like to keep the lake up to its full level. It seems a pity not to provide this noble reservoir with a safety-valve in the shape of a bye-wash, which might be done at a small expense.

(4.) "Stanhope Reservoir." This lies along the canal which passes through it just below Plane No. 1 West. It is a shallow lake of 90 acres receiving the drainage direct from 3,000 acres and into it comes from the Hopatcong lake the water let out of it for feeding the western slope of the canal as above noticed, and also the surplus from that lake. It is relieved at its western end by a surplus sluice close to a "guard lock" where the canal runs into double banks, the water passing through that sluice and by natural channels to the pool of the Muscanetcong below "Plane 4," noticed in description of "Cranberry Pond."

(5.) "Greenwood Lake." Situated some 15 miles north of Canal. Waterspread 2,700 acres. Drainage area 32 square miles. Level 630′ above ½ tide. 10 feet in depth available for canal supply; that depth being drawn off is said to reduce the area of the reservoir by 200 acres. Water let out to the Pompton river and from it taken by a feeder between three and four miles long to the canal.

Traffic.

It does not appear that the projectors of the canal counted on much more traffic than that due to the agricultural and mineral products of the country through which it passes and of "lumber" (sawn timber) coming down the Delaware, but as the extensive coal mines of the Lehigh valley in Pennsylvania were developed, coals from them came in increasing quantities down the Lehigh river and canal to the Delaware river, and then naturally such as were for New York found their way along the Morris canal instead of by the much longer route of the Delaware river, Delaware bay, and the sea, which route also necessitated transhipment from the canal and river boats to coasting vessels. This Pennsylvanian coal therefore soon became the chief commodity carried on the canal, and its yearly quantity increased rapidly till the completion of through communication by railroad between the coal fields and New York harbor; since then it has gradually deserted the canal till it is now only about $\frac{3}{7}$ths of what it was in 1866. It might seem at first sight that in this kind of carriage a canal ought to hold its own against railways, and doubtless this canal would have done so better than it has, had it been much larger admitting of the use of boats of greater tonnage, had it been provided with greater facilities for tracking such as good tow-paths on both sides instead of an often obstructed one, on one side only, and had it not been closed by ice for about a third of the year. But it must be remembered that in coal carriage, especially to a port, a railway has some important advantages over a canal. At one end of its line a railway loads its trucks at the pits' mouths, at the other end it discharges those same trucks, with scarcely any expense, off stagings into storage places or into vessels. Canal boats have to get the coals brought by trucks or carts and transferred to them, and in discharging, their cargoes have to be *lifted* out of them at a considerable cost—(here 30 cents a ton). The use of a railway also renders it unnecessary for either coal dealers or consumers to keep large storage yards at the harbor where land is so valuable, for purchasers will generally wait the short time required for getting the coal by rail from dealers' depôts at the mines, whilst they will not do so for the much longer time required for getting it by canal.

The following statement gives the traffic on the canal for each year from 1860 to 1870 and for 1874 and 1875.

ARTICLES.	1860.	1861.	1862.	1863.	1864.	1865.	1866.	1867.	1868.	1869.	1870.	1874.	1875.
Bar and Pig Iron	15,815	11,970	22,203	28,949	23,402	18,407	13,334	12,984	17,064	12.612	15,473		
Blooms and Billets	481	347	440	897	1,271	481	325	112	10	......	......		
Brick	7,484	5,884	2,590	4,101	5,496	6,171	8,679	7,269	9,791	19,500	26,031		
Castings and Machinery	579	338	4,768	3,045	1,353	1,108	1,078	1,079	3,135	......	......		
Charcoal	1,236	814	471	1,035	632	978	580	332	268	......	......		
Clay, Earth, Sand, Stone, &c.	7,303	6,843	5,129	10,437	9,812	11,729	13,784	11,221	17,541	17,898	16,313	79,748	101,391
Dry Goods, Groceries, &c.	3,415	4,088	3,905	3,203	2,655	1,988	2,487	3,838	2,468	2,333	1,991		
Flour, Meal, Feed, &c.	4,630	6,058	7,219	5,018	4,122	4,677	5,316	1,484	7,516	5.705	6,032		
Hoop Poles and Rails	792	1,005	1,162	1,184	748	1,477	959	181	2,173	1,731	1,448		
Iron Rails	6	617	7	266	1,051	1,467	384	5,145	......	2,137	608		
Lime and Cement	5,545	5,376	5,839	4,532	2,899	3,019	4,682	9,019	4,828	5,092	4,459		
Lime Stone	3,946	6,833	4,179	4,245	4,526	6,163	13,378	232	10,004	2,345	4,090		
Lumber and Logs	13,809	6,948	10,107	12,519	11,055	12,953	13,209	12,748	9,760	9,631	6,692		
Mineral Coal	422,552	426,080	335,660	413,452	393,030	428,180	473,028	437,088	359,097	304,365	371,579	267,603	250,047
Nails, Spikes, &c.	7,334	6,092	7,002	7,343	6,936	6,910	8,193	869	4,486	6,416	7,973		
Ore and Forge Cinders	186,064	103,163	169,108	191,667	223,924	174,838	290,165	289,550	269,672	227,696	220,079	144,464	99,607
Plaster	2,165	2,639	2,260	2,636	1,565	1,439	2,013	2,214	486	2,267	617		
Timber and R. R. Ties	5,476	3,737	4,660	4,085	4,469	8,110	5,555	3,798	4,380	5,166	3,929		
Wood, Bark, &c.	15,147	17,952	21,898	15,985	20,058	21,108	25,833	16,606	16,993	16,835	11,386		
Sundries	3,852	2,585	3,411	3,920	4,925	5,384	6,238	4,972	4,740	8,471	8,872		
Total Tons	707,631	619,369	612,018	718,519	723,927	716,587	889,220	822,741	744,412	650,200	707,572	491,815	451,045

Boats

The boats used on the canal are of the following dimensions: *Length* overall 87′—*Depth* from gunwale to floor, amidships 5′ 5″, at ends 6′ 1″—*Beam* 10′ 5″. They are flat-bottomed and nearly straight-sided except just at stem and bow; 8′ in length at the stern are decked and made into a cabin for the boatmen. The peculiarity of these boats is, that in order to pass the plane summit curves, they are divided into two portions at exactly amidships and there hinged vertically, the interval between the two sections being 6″. These boats carry 70 tons of coal with a draught of 3′ 9″ which, though the canal is nominally 5 feet deep, is considered as much as advisable. They are built of "Georgia," white and yellow pine. Their average weight is 20 tons and their average cost 700 dollars. Nearly all the boats on the canal have been built by the company and are let or sold to the boatmen who work them. Private persons are allowed to put their own boats on the canal, provided they are built so as to be able to pass the inclined planes. The life of a boat is considered to be from 5 to 7 years.

Towing.

The towing is done by horses or mules, two or three to each boat, and from 15 to 20 miles a day is considered fair going. Mules are said to last at the work on the average 8 years; horses only 1 (one) year! whilst the former cost only $\frac{2}{3}$rds as much as the latter to keep. In 1862 it was estimated that the towing could be done "by the mile for 11 cents for loaded, and 7 cents for empty, boats", and the average expense of boats is given as "3 dollars a day."

Tolls.

The rates of tolls charged for miscellaneous articles on the canal are given on the accompanying form. For coals there are special rates which are altered frequently. *They* are not charged according to mileage but according to places, and are regulated to a great extent by the amount of railway competition to such places. Thus, whilst in October, 1875, the toll from the Delaware river to Jersey City (New York), to which there is active competition by two lines of railway from the coal mines, averaged only $\frac{3}{4}$ of a cent. per ton per mile, it averaged upwards of 2 cents to intermediate places not affected by such competition. Part of "Plane No. 6 West" is arranged as a weigh-bridge, and all boats passing over it are weighed. A register of the weight of each boat empty is kept, and this being deducted from the gross weight when passing gives that of the cargo then in her, on which tolls are collected. Boats working between points not necessitating their passing this plane, have the weights of their cargoes estimated by their draught.

JERSEY CITY, *April 1st*, 1873.

RATES OF TOLL.

From this date, until further notice, the rates of Toll on MORRIS CANAL will be as follows, subject to rules and regulations:

ARTICLES.	Rate per Mile.	Maximum.
	cents.	$ *cents.*
Bark (ground and unground)	2	1—00
Brick (common)*	1	50
Brick (fire and pressed)	2	1—00
Flour, Feed, Meal, Grain and Seeds	1½	1—00
Hydraulic Cement	2	1—00
Ice	4	70
Iron Bars and Rails	1¾	1—50
Iron Pigs and Scraps	2	1—00
Iron Ore and Forge Cinders	1¾	1—00
Lath, Heading, Staves, and Hoop Poles	2	1—50
Lime	1½	1—00
Lime Stone	2	1—00
Lumber and Logs	3	1—00
Manure	1⅛	1—00
Paving Stones	2	1—00
Plaster	2	1—00
Railroad Ties, and Posts and Rails	1½	75
Salt	2	1—00
Sand and Clay	3	75
Soap Stone	2	1—50
Stone, Flagging and Curbing	2	1—00
Wood	1⅛	50
Zinc Ore	2	1—00
Unenumerated Articles	3	2—00

* Except for distances not exceeding 11 miles, in which case the Tolls will be 12 cts. per ton.

APPENDIX No. 1

TO NOTES ON MORRIS CANAL,

(See portion of Notes "Inclined Planes.")

JERSEY CITY, *July 30th*, 1861

WM. SELLERS, Esq.,
Philadelphia.

DEAR SIR,

I am at last prepared to answer the questions propounded in yours of the 8th instant. I shall state the answer without repeating questions, but in the order stated in your letter :—

(1.) Gross tonnage up the plane.........3,830,269 tons.
„ „ down „ ....2,441,594 „
„ „ both ways ....6,271,863 „

I have taken the first plane built for wire ropes (No. 6 West) because it has a scale on it and all the tonnage is weighed as it passes. The ton used is 2,240 lbs. There are two tracks to this plane, and consequently 2 main ropes. I have taken the second set of ropes, being those put to service at opening of navigation 1855, and lasting till close of 1860—six years. The tracks were used alike, and if we allow that each rope carried half, the amount for each will be—

Ascending tonnage .... 1,915,134½ tons.
Descending tonnage ....1,220,797 „
Total both ways ....3,135,931½ „

Some other planes carried all this tonnage with a single track and one rope, which rope lasted about 4 years and carried equal to about ⅔ of the above amount (or 4,181,242 tons.)

(2.) At Plane 6 West the car moves 944 feet in distance each trip, and the total elevation to which the load is lifted is 56 feet 6 inches for the ascending, after which they are let down 5 feet 6 inches.

The descending loads are first raised 5 feet 6 inches, and then let down 56 feet 6 inches.

(3.) The inclination of the plane is one in ten, except where the boat is launched into the water, and at those places it is one in twenty.

(4.) The ropes were 2⅛ inches diameter, made by J. A. Roebling Trenton, N. J. Wire centres, as opposed to hemp centre strand.

(5.) The number of trips ascending with loads 33,290
Do. do. with empty car 16,645
Do. descending with loads............14,098
Do. do. with empty boats....19,192
Do. do. with empty car......16,645

Total number of trips...99,870

(6.) Speed in miles per hour is $3\frac{41}{100}$ ascending.
Do. do. $4\frac{55}{100}$ descending with a load, and empty car on the other track.

(7.) In the trial made at Plane 6 West in 1849, the power required to work the machinery empty was taken at $47\frac{71}{100}$ horse power of (33,000 lbs., 1 foot high per min.) Subsequent experiments made roughly at various planes indicate that, that estimate was too high. The single track planes with grade of 1 in 12 run empty by the gravity of the cars too fast, so as to require checking by the brake ; these planes have an equal amount or length of ropes in motion with No. 6 West and all the other machinery except one set of cars, and one large sheave at head of plane. The gravity of 1 in 12, at our speed ascending is $42\frac{42}{100}$ horse power, and I now estimate that 40 horse power is enough for this item on Plane 6 West. The power required to overcome the gravity of the cars on two tracks while one car is being hauled out of the upper level may be taken as equal to one car on a grade of 1 in 10, which is equal to $49\frac{28}{100}$ horse power, and the distance at Plane 6 West moved over in so hauling out of the upper level is 220 feet.

(8.) The additional power required for any definite load in the cradle is composed of two parts :—

1. Gravity of the load, with cargo of 66 tons—1 ton of water and 16 tons of boat, at Plane 6 West is $150\frac{84}{100}$ horse power.

2. Additional friction of all the rubbing parts from the load I estimate at 15 lbs. per ton, equal $11\frac{32}{100}$ horse power.

(9.) I have not made any other experiments which would answer 7 and 8.

(10.) The diameter of winding drum at Plane 6 West is eleven feet and at all the other planes 12 feet.

(11.) The smallest sheave over which the rope makes a bend is 3 feet diameter. There are 7 of these on each track at the summit so placed that the bearing points of the rope are in a circle of 320 feet radius, and are each 8 feet apart.

(12.) The sheave which reverses the direction of the motion at 6 West is 7 feet diameter. At all the other planes it is eleven feet diameter. At No. 6 West the bend is only 80 degrees, and at all the others it is about half the circle.

(13.) The diameter of the bottom of the groove of supporting sheaves on 6 West is the same as the rope for $\frac{1}{3}$ the diameter of the rope. The other planes vary from this up to 4 inches diameter.

(14.) From centre to centre of carrying sheaves is 24 feet, which is quite far enough for our ropes.

(15.) The strain should not exceed $\frac{1}{7}$ the ultimate strength, computing that strength at 73,000 lbs. per square inch of metal.

I have only to express my regret that circumstances delayed my answer so long.

Hoping that it may be in time to serve you, I am very

Respectfully yours,

(Signed) W. H. TALCOTT.

Description of second set of ropes at Plane 6 West, made by J. A. Roebling.

Main rope north track first used November 1st, 1854.

Length 1,120 feet. Weight 7,790 lbs. Weight per foot $6\frac{96}{100}$ lbs. Composed of 7 strands, each of 19 wires, No. 10 wire guage. Total wires 133. $4\frac{1}{2}$ inches lay in strand.

10 ,, ,, rope. Used 1,303 days.

Main rope south track first used April 5th, 1855.

Length 1,114 feet. Weight 7,650. Weight per foot $6\frac{87}{100}$ lbs. Formed same as rope on north track. Used 1,317 days.

Back rope. Length 1,043 feet. Weight 3,766 lbs. Weight per foot $3\frac{61}{100}$ lbs. Composed of 7 strands of 7 wires each, No. 9 wire guage. Lay in strand 3 inches. Lay in rope 8 inches. First used June 18th, 1854. Used 1,104 days.

The material of wire ropes is Norway iron: they are not however made to specification.

COST OF THE INCLINED PLANES UPON THE PRESENT CONSTRUCTION.

Comparison of the Cost of Planes East and West of the Summit.

Division.	Number of Planes	Collective Rise.	Collective Cost.	Average Rise of each Plane.	Average Cost each Plane.
East of Summit.	12	758 ft.	\$351,114·81	63 ft.	\$29,259·57
West ,, ...	11	691 ft.	\$327,987·41	63 ft.	\$29,817·04
Totals...	23	1,449 ft.	\$679,102·22	...	...

Comparison of the Cost of Single and Double Planes.

Class.	Number of each class.	Collective Cost.	Average Cost each Plane.	Collective Rise.	Average Rise each Plane	Cost per foot Rise. Average of the whole.
Single	20	\$577,973·84	\$28,898·69	1,229 ft.	61·45 ft.	\$470·28
Double	3	\$101,128·38	\$33,709·46	220 ft.	73·33 ft.	\$459·67

APPENDIX No. 2.

UNITED STATES PATENT OFFICE.

RALPH R. OSGOOD, OF TROY, NEW YORK.

IMPROVEMENT IN DREDGING-MACHINES.

Specification forming part of Letters Patent No. **157,101,** dated November 24, 1874; application filed August 29, 1874.

To all whom it may concern:

Be it known that I, RALPH R. OSGOOD, of Troy, in the county of Rensselear and State of New York, have invented a new and Improved Dredging-Machine; and I do hereby declare that the following is a full, clear, and exact description thereof, reference being had to the accompanying drawings making part of this specification, in which—

Figure 1 is a side elevation of my machine closed, and ready to be swung around. Fig. 2 is a similar view, showing the excavator in a position for dredging. Fig. 3 is a vertical central section of my machine, with the excavator in a position to be used as an anchor, or swung around to empty its load. Fig. 4 is a modification of the manner of raising the auxiliary arm. Fig. 5 is a top view of the devices used for holding the auxiliary crane-arm at any desired elevation.

The object of my invention is to render more practical and useful the well known dredging-machine having a horizontally-swinging main crane-arm, and a vertically-swinging auxiliary crane-arm, and a sliding and swinging scraper, as shown in my drawings.

My first improvement consists in means for holding up the auxiliary crane-arm while swinging the crane-post on its axis for working the scraper on either side of the post, and while moving the scraper out forward of the main crane-arm for the purpose of using it as an anchor while drawing the dredging apparatus to a new place requiring to be dredged. With the dredging-machine having the auxiliary crane-arm, so much inconvenience and annoyance from said arm being in the way, and interfering with the expeditious working of the apparatus being experienced, very little satisfaction or benefit has been derived from the use of such machines, although the auxiliary crane-arm is one of the most important attachments ever made to dredging-machines on account of its permitting the power to be applied to the scraper or against the resistance at about an angle of forty-five degrees, or in an almost direct line.

My second improvement consists in the combination of additional pulleys or sheaves with the ordinary pulley of the auxiliary arm, and in arranging the power-chain to work double or treble over these pulleys, and over pulleys in a swinging sheave-case, and on the main crane-arm, whereby the power upon the scraper is increased, and a bearing for the power-chain is secured, both when the scraper is working back and forward of the pulleys of the auxiliary arm, and thus the chain is kept in proper working tension during the whole of the sweep of the scraper over the bed of the river, whether it is being adjusted for working, or is in position for being swung around to be emptied of its load.

My third improvement consists of elastic cushions applied at a given elevation or point on the chains which suspend the auxiliary crane-arm, whereby the force of the descent of the said arm is greatly modified, and the injurious effect from shocks and strain upon the apparatus in a measure overcome.

My fourth improvement consists in a cramping contrivance combined with the suspending-chain of the auxiliary crane-arm, whereby the auxiliary arm can be cramped upon the chain, and held up out of the way at any point desired, while the crane is being swung around on its axis, or the scraper moved outward to be used as an anchor.

My invention consists, fifth, in having the elastic cushion-stop adjustable on the suspending-chain, whereby the power can be applied through the auxiliary crane-arm at any desired angle.

To enable others skilled in the art to make and use my invention I will proceed to describe it.

The crane-post A, main arm B, auxiliary arm B′, and scraper D D′ are constructed and fitted together and arranged to operate in the usual manner. C C are revolving sheaves or pulleys fitted in boxes set in between the side pieces of the main arm, and C^1 C^1 C^1 C^1 are similar sheaves or pulleys fitted in boxes set in between the side pieces of the auxiliary arm. These sheave-boxes are at the outer ends of the said arms, as shown. E is a sheave-case or pulley hinged to the part D′ of the scraper, and provided with a central pulley C^2, and chain-retaining pins C^3 C^3 and attaching-arms C^4 C^4. F is an endless power-chain passed through the pulley-boxes of the respective arms B B′, and through the pulley-case E, and in relation to the pulleys C C^1 C^2, as shown in the drawings. This chain is connected, as usual, by one end to the pulley or sheave-case E, and by its other end to a power-windlass arranged in proper relation to the apparatus. G represents one of the chains upon which the auxiliary arm is suspended. These chains are passed loosely through eyes in the sides of the arm at G^1, or at any other suitable point, and fastened by their respective ends to the crane-post and main crane-arm. This chain is loose and long enough to allow the arm to swing around over it in the arc of a circle. G^2 are tubular cushions of rubber slipped over the chains and resting down upon stops G^3, which are made in two pieces, and clamped upon the chain at any desired point by screws. A washer of metal may be interposed between the cushions and the clamp-stops. By loosening the screws of the clamp-stops the stops may be lowered or raised, and thus the cushion set at any altitude desired, and caused to arrest the auxiliary arm at any desired angle with respect to the scraper. The eyes at G^1 are formed in a rock-shaft G^4, and on this shaft is a pulley G^5, to which a cord G^6, is fastenedeccentrically, and carried back between two guide-pulleys G^7 G^7, which are attached to the inner hinged end of the auxiliary arm, as shown. By pulling the cord G^6 the rock-shaft will be moved the distance of a quarter of a circle, and the suspending-chains cramped in such a way as to prevent the arm slipping down over them, and thus the arm is held up at any point desired by this contrivance. Instead of the cramping device a beveled pivoted hook H, is provided on the side main crane-arm, and a stationary latching pin H′, provided on the auxiliary arm, and by this contrivance of the hook and pin the auxiliary arm is hooked up out of the way when the crane is being swung around for working the scraper about a corner, or on either side of the centre of the crane-post, or when the scraper is being moved to a position forward of the crane-arm for the purpose of using it as a draft-anchor while pulling the apparatus to a new dredging spot in the river or other place.

In Fig. 1 of the drawings it will be observed that the power-chain has a bearing against the two pulleys C C, and the three inner pulleys C^1 C^1 C^1, and against the pulley C^2. In Fig. 2 the same relation of parts exists, except that the scraper has moved forward and downward slightly, and the auxiliary arm has been lowered to nearly an angle of forty-five degrees with respect to the scraper; that in Fig. 4 the power-chain has a bearing against the three outermost pulleys C^1 C^1 C^1, and the auxiliary arm has been carried up by the scraper ready to be cramped or hooked up, so that it shall be out of the way while the crane is swung around to empty the scraper, or while the scraper is being moved longitudinally beyond the end of the crane in order to serve as an anchor.

In practice I may adopt only three pulleys, C^1 C^1 C^1, and arrange the power-chain as shown in Fig. 4. In this case one of its ends will be attached to the outer end of the crane-arm B, and its other end, as before, to the windlass, after being passed about the pulleys C C^1 C^2, in the manner shown, and I may only use the hook H and pin H′, or the cramping-shaft, Fig. 5, or I may use both for holding up the auxiliary arm. I prefer the hook and pin, as these make a self-acting contrivance. I contemplate using other descriptions of holding up device, and therefore do not confine myself to the special construction shown.

What I claim as new is—

1. The combination of a sustaining device with the auxiliary hinged arm B′ of the crane, for holding up the said arm out of the way while the scraper is being adjusted and used as an anchor, and while it is being worked at any angle with respect to the side of the support of the crane and at will of the operator, allowing the said arm to be swung down to apply the power to the scraper in a more direct line, substantially as set forth.

2. The combination of two or more end sheaves C C, and one or more intermediate sheaves C^1, the power-chain F, vibrating sheave-case E, auxiliary crane-arm B′, and main crane-arm B, and a scraper D D, whereby the chains are kept in position, and their power upon the scraper increased and applied in a very direct manner, substantially as described.

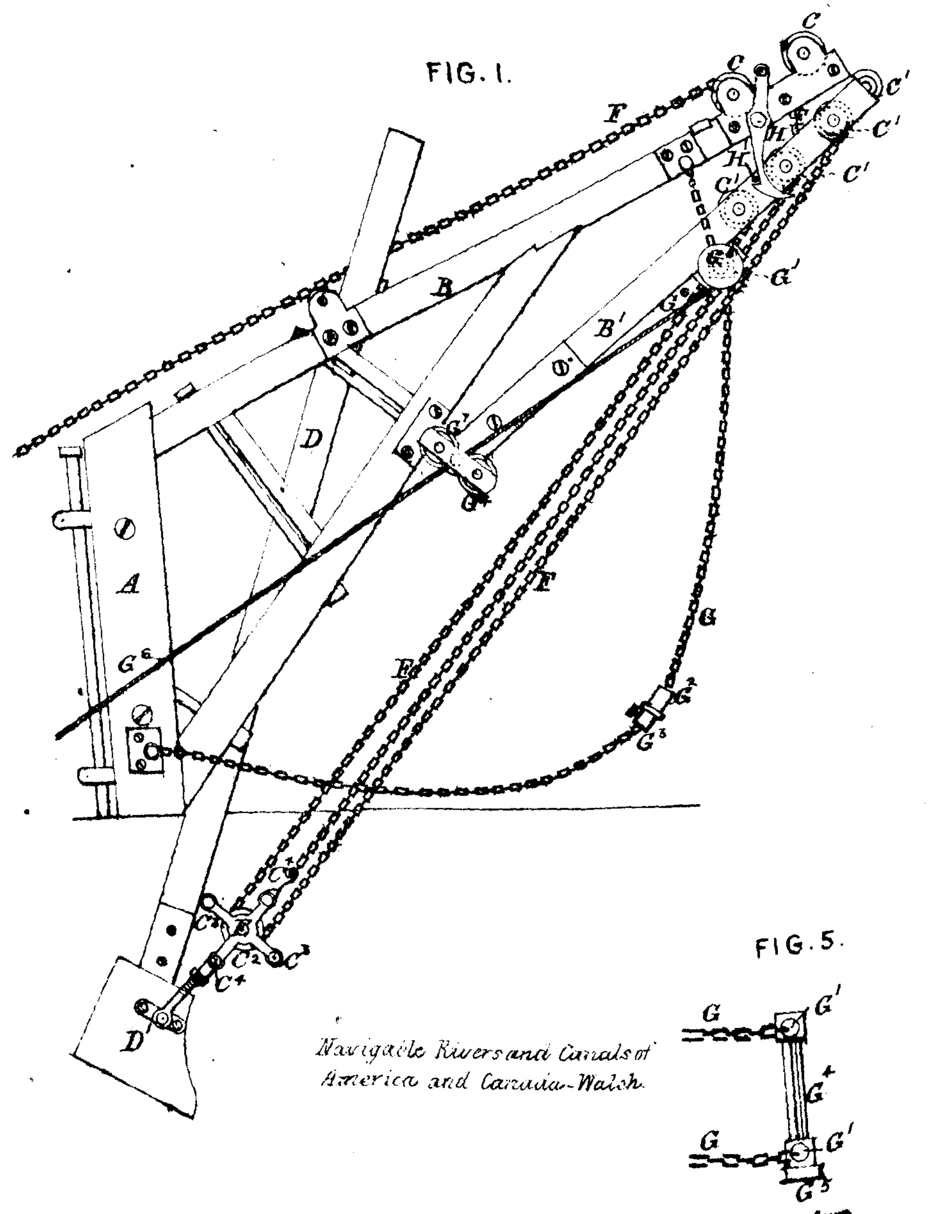
3. The combination of the scraper D D′, the yielding cushions

3 Sheets--Sheet 1.

R. R. OSGOOD.

Dredging-Machines.

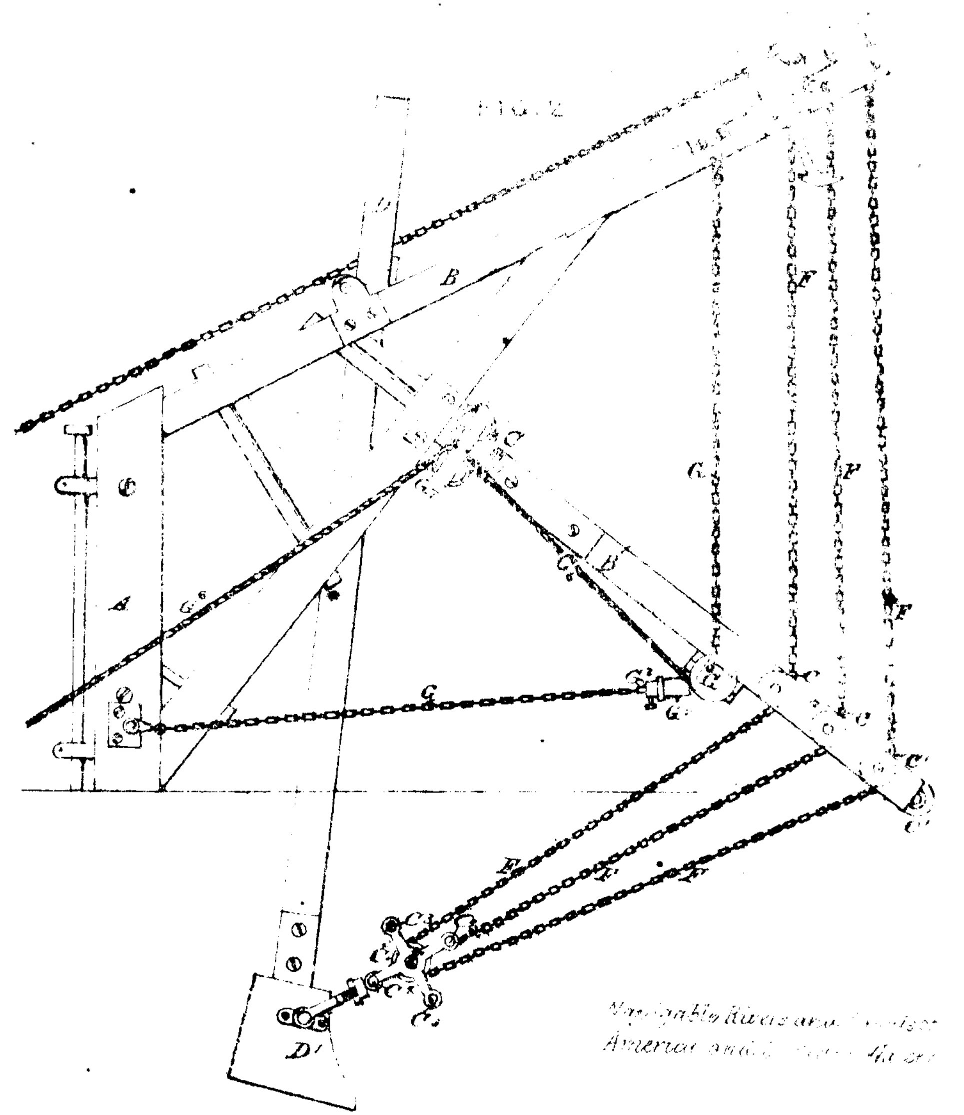
No. 157,101, Patented Nov. 24, 1874.



R. R. OSGOOD

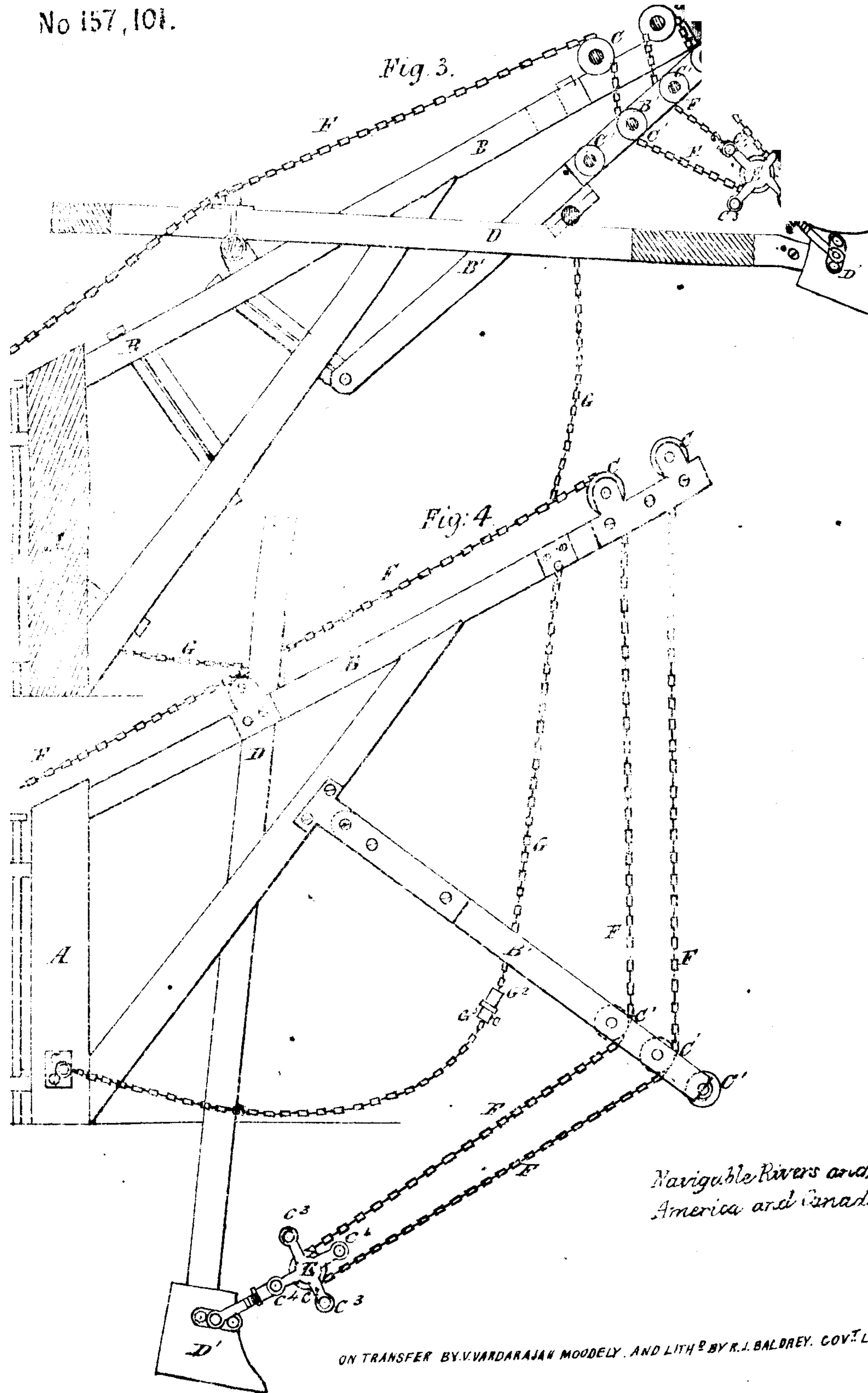
Dredging Machine

No. 157,101



H. R. OSGOOD.
Dredging Machines.

No 157,101.



Navigable Rivers and
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ON TRANSFER BY V. VARDARAJAH MOODELY. AND LITH? BY R. J. BALDREY. GOVT L

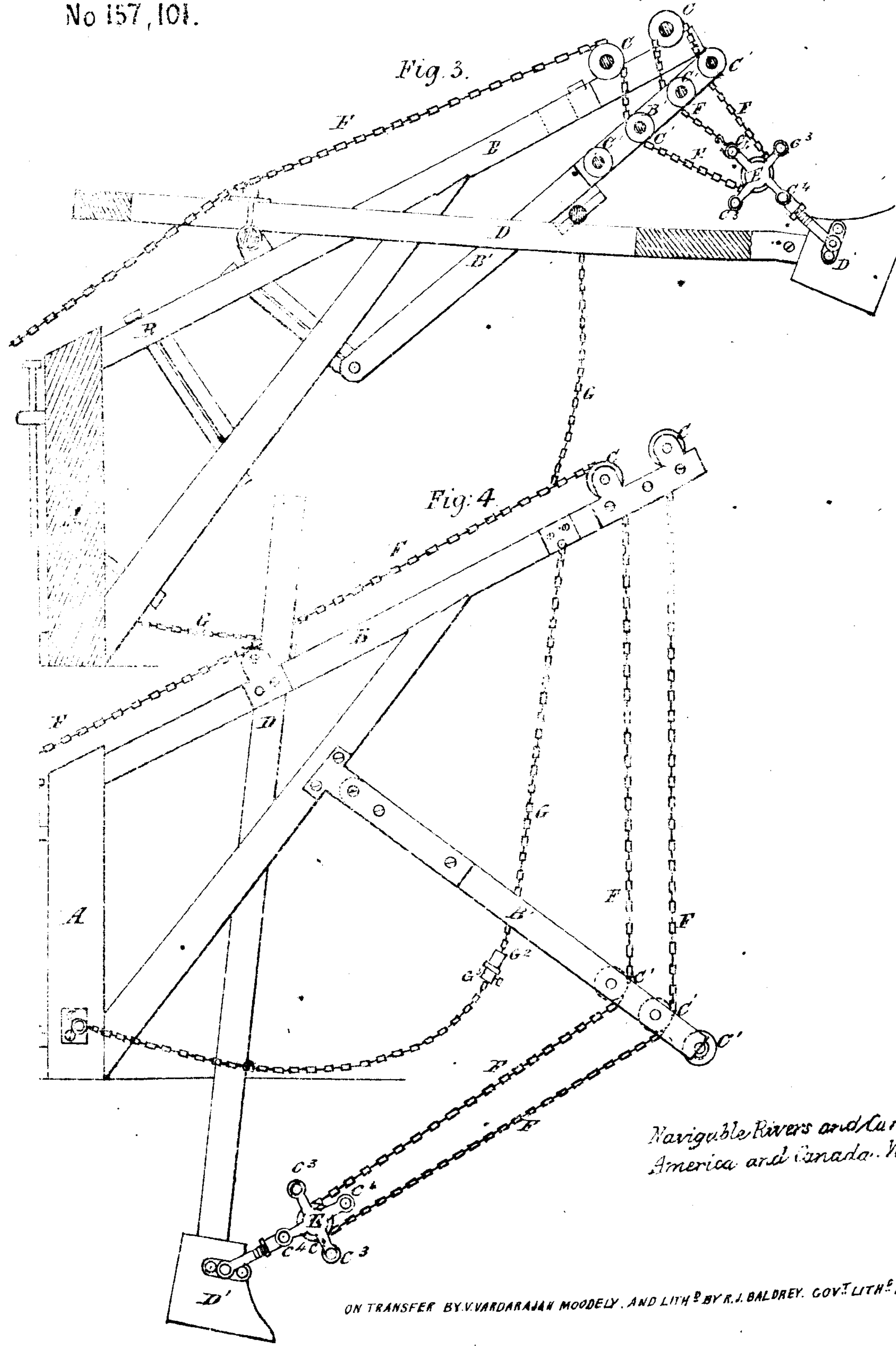
R. R. OSGOOD.
Dredging Machines.

No 157,101.

PATENTED Nov. 24, 1874.

Fig. 3.

Fig. 4.



Navigable Rivers and Canals ...
America and Canada.. Walch...

ON TRANSFER BY V. VARDARAJAH MOODELY. AND LITH^{D} BY R. J. BALDREY. GOV^{T} LITH^{C} DEP^{T} A

G^2, and the suspending-chains G, substantially as and for the purpose described.

4. A cramping device G^4, in combination with the suspending-chain G, for setting the auxiliary arm B' at any desired position with respect to the main arm B, substantially as and for the purpose set forth.

5. The adjustable stop G^3, in combination with the suspending-chain G, substantially as described.

RALPH R. OSGOOD.

Witnesses:

J. N. CAMPBELL,

JAMES MARTIN, JR.

APPENDIX No. 3,

TO NOTES ON MORRIS CANAL.

LIST OF PLANS.

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APPENDIX No. 3,

TO NOTES ON MORRIS CANAL.

LIST OF PLANS.

INCLINED PLANE,

CHESAPEAKE AND OHIO CANAL.

(Visited 17th—18th May 1876.)

WHEN at Washington (D. C.) my attention was directed to an "inclined plane" of a kind considered superior to any similar work in existence, which was being constructed from the Chesapeake and Ohio Canal into the Potomac at George Town (a suburb of Washington) to take the place of the 5 terminal locks from the canal into the river. The right to the surplus water in the canal, having been obtained by a Company, they have considered that the saving of water available for their use which will thereby result, makes it worth their while to replace the locks by the "plane," at a cost estimated at 100,000 dollars, but which will really, I believe, be considerably more. It was at first proposed to model the "plane" on the general design of the planes on the Morris Canal, but this was objected to by boat owners and those specially interested in the navigation of the canal on the grounds that by hinging the boats they are weakened, and by letting them rest on their cradles whilst passing the planes they are liable to be strained. Mr. H. R. Dodge, the president of the Company that had obtained the mill rights, then visited England on purpose to see the "inclined plane" at Black-hill on the Monklands canal, over which the boats are taken "water-borne," and it was decided to adopt the system there obtaining with modifications and improvements. The engineering management of the matter was put into the hands of Mr. W. R. Hutton of Baltimore, Engineer of the Chesapeake and Ohio Canal, who prepared the plans, of which I forward a complete set herewith, with some few notes on them, added from inspection of the work. These plans were given to me by Mr. Hutton himself on the authorization of Mr. Dodge, the president of the Company, and to both of those gentlemen I am indebted for their

Object, &c

courtesy. When I visited the work it was nearing completion.

Description.

The difference of level to be overcome is from meantide level in the river to full water in the canal, $38\frac{3}{10}$ feet. The gradient of the "plane" is 1 in 12 and its total length 589 feet. For this length are laid two pairs of rails to carry the caisson, on a guage of 4 feet 8 inches and with 4 feet 8 inches between them, making the distance from outer rail to outer rail 14 feet. These rails rest on longitudinal sleepers bolted down to continuous masonry walls, the level of the upper end of the track being 9 feet (6 feet depth of water + 3 feet height from rail to bottom of caisson) below canal water level and the lower end 16 feet (6′ depth of water + 10′ height from rail to bottom of caisson) below the water in the river. For the upper 400 feet of the plane there are alongside the two middle of the four rails ratchet or safety rails into which pawles attached to the centre truck of the caisson, can be dropped, to prevent accidental running back. At 10 feet clear on either side of this central set of rails, but for only 300 feet from near the upper end of the incline, there are similar sets of rails to carry counter-weights. The dimensions of the caisson in which the boats are to be carried "water-borne" are—

* Inside length 110 feet,
,, breadth 15 feet 3 inches,
,, depth 6 feet 6 inches.

It is constructed of iron, for the details of which the plans must be referred to. It rests on three strong timber frames 16 feet long by 17 wide, each carried by two six-wheeled trucks side by side on the parallel lines of rails. The frames on these trucks are of such heights respectively, that the caisson, though travelling on an incline, is kept horizontal. At each end of the caisson is a door or gate which pressure from within keeps tightly closed, but which when the pressure on each of its sides is equalized can be dropped inwards and lies in a depression specially provided for it below the true floor. In these gates are valves by which water can be admitted to, or let out out of, the caisson. The weight of the caisson full will be about 300 tons.

* NOTE.—Size of locks on canal 100′ × 15′ and depth of water 6′—boats 135 tons.

The caisson is hauled by two 2-inch diameter steel-wire ropes which are attached to it under the frame of the middle truck. From it they extend to two pairs of winding pulleys, one pair on the right and the other on the left of the lines of caisson rails, at the top end of the incline, and there each rope making $2\frac{1}{2}$ turns round its pulleys, passes down to a counter-weight. It then turns round a 9 feet 6 inch diameter sheave fastened under the frame of the counter-weight truck and is carried up to, and anchored at, the top of the incline. By this arrangement the travel of the counter-weights is only half that of the caisson, and they are kept from running down into water.

Counter-weights.

Each of these counter-weights is composed of two waggons ($19\frac{1}{4}' \times 15\frac{1}{4}' \times 7'$) linked together, each waggon being carried by two six-wheeled trucks side by side on the parallel lines of rails. These waggons are to have built into them solid masonry till they nearly counterbalance the full caisson. They will move up and down their rails in opposite directions of course to the caisson and, as already explained, at only half its rate of speed.

Safety-pawles.

Under the centre truck of the caisson are six wrought-iron pawles (three on each side of the truck) which are kept clear of the ratchet rails by a slight wire-rope which passes round sheaves to the counter-weights and is so kept in tension. In the event of the hauling ropes breaking this small tension rope would also snap and so release a counterpoise which would move a system of levers, and lower the pawles into the ratchet rails. It has been decided to provide for the counter-weights similar safety arrangements, which the original design did not include.

Power and Machinery.

The motive power will be obtained from a "Leffels" double turbine water-wheel placed in a well, under the machinery which it works, about 29 feet below the level of surface of canal water, from which it will be fed through a 20″ diameter pipe, the tail water flowing to the river through a culvert from the bottom of the well. The calculated power of the turbine was stated to be 68 horse-power.

The position, &c., of the machinery and gearing by which the movement and power are transmitted to the winding pulleys are shewn on the plans. In order to press the caisson home against the ends of the "head-bay," so as to make a water-tight junction, a "hydraulic ram" (so called, really a "hydrostatic press") is provided. The power for this is obtained from an "accumulator," which is a block of masonry built in an iron box or casing, 6 feet cube, carried on top of a plunger, the whole weight being 41,563 lbs. This is lifted slowly, whilst the caisson is travelling up the incline, by a hydrostatic press, the force pump of which is worked by an eccentric on the main shaft turning the winding pulleys. The pressure of this "accumulator" can at pleasure be brought to bear on the "ram" forcing it forwards and by an arrangement, which the remarks I have added to the plans will, I think, make clear, bringing such extra power to bear on the winding pulleys that the projecting sides and bottom of the front end of the caisson are, with a steady pressure, jammed tightly against the corresponding projections of the "head-bay" (or lock), and by the use of India-rubber plates, or strips, a water-tight junction is made.

Head-bay.

At the summit of the incline is the lock or "head-bay" by which exit from, or entrance to, the canal is effected. It consists simply of a chamber open towards the canal, but closed at the incline end by a gate, which pressure from the canal side keeps shut, but which when pressure on both sides of it are equal can be dropped to the floor of the chamber, and hauled up from there by the usual drop-gate machinery. The chamber or "head-bay" walls and floor project a foot beyond this gate, ending in heavy baulks of timber, into the faces of which are let broad plates, or strips, of India-rubbers which project slightly beyond the surfaces of the timbers. The caisson has end projections which fit to those of the "head-bay," and form in the interval between the gates of the "head-bay" and caisson a water-tight chamber 1 foot 6 inches wide. Water can be admitted to this chamber through either of the gates and can be let out of it by means of a drain-pipe.

The machinery will be "operated" by means of four levers covered by a small house, at the "head-bay," from which the whole of the plane is visible.

Mode of working Supposing the caisson at the bottom of the incline, and that it be required to transfer a boat from the canal to the river, the "modus operandi" will be as follows:—The caisson being full of water and its gates closed, water will be given to the turbine by moving the lever which opens its feed-pipe, and the machinery being thus set in motion the caisson will be drawn up the incline, till the projections of its forward end touch those of the "head-bay." By the movement of another lever communication will then be opened between the accumulator cylinder and the "ram," which will cause the caisson to be pressed up against the "head-bay" compressing the India-rubber plates and making a water-tight connection. Into the interval between the two gates water will then be admitted till it stands at the same level as the canal, when the "head-bay" gate will be dropped. Any difference of level between the water on the two sides of the caisson gate will then be adjusted by the valves in it and the gate will be dropped, leaving free communication between canal and caisson. The boat entering the caisson will, of course, cause a quantity of water equal to her displacement to pass from the caisson to the canal. The boat being fairly in and secured to stanchions, the gates of the "head-bay" and caisson will be lifted, the interval between them will be emptied through a drain-pipe specially provided for the purpose, the communication between the accumulator and the "ram" will be closed and the ram retired, and the caisson will be lowered down the incline till the surface of the water in it is nearly level with the river. Exact equalization of level will then be effected through the gate valves, the gate will be dropped, and the boat will pass into the river.

Time occupied. The *time* occupied by the whole operation will certainly not be more than that of one ordinary lockage, so that the time of passing 4 out of the 5 locks replaced by the "plane" will be saved, a saving of at least 40 minutes to each boat on each trip.

Water used. The *canal water* used in the operation will be only (1st) that let into the interval between the gates of the "head-bay" and caisson 15 feet $\times 1\frac{1}{2} \times 6' = 135$ cubic feet, (2nd) that used to work the turbine. What the exact quantity will be I am not sure, but approximately it will be 2,800

cubic feet. The whole quantity thus abstracted from the canal will be only about $\frac{1}{3}$rd that of a lockage, and on every passage of a boat from the canal to the river or from the river to the canal the Mill Company will save for their own uses about 6,000 cubic feet *even if both ascending and descending boats are equally laden*, but as almost all the boats going downwards are heavily laden (chiefly with coal) whilst those going upwards are either empty or light, the canal *will absolutely be replenished* by a weight of water from the river equal to the difference between the weight of the ascending and descending traffic. The bringing up an empty boat from the river and taking down in her place one laden with 100 tons will result in the supply of some 3,600 cubic feet of water to the canal so that the Company expect to entirely save the water now expended in lockages. What that quantity is expected to be for any particular period of time I am unfortunately unable to state owing to the non-receipt, probably arising from postal miscarriage, of certain documents about the scheme which I expected.

I had hoped also before writing this to have heard of the "plane" being in operation and as to its success, but have been disappointed.

The following is a list of the plans which accompany the notes on this work :—

	No. in Vol. of Plans.
General plan at site	.. 8
" " arrangement of rails, &c.	.. 9
" " and elevation of caisson	..10
Front carriage " "	..11
Middle " " "	..12
Back " " "	..13
Gates of caisson	..14
Counterweights	..15
General arrangement of operating levers ..	..16
Operating levers	..17
General arrangement of machinery	..18
Accumulator	..19
" pump	..20
Eccentric strap for do.	..21
Hydraulic cylinder (ram)	..22
Rope wheel in connection with do.	..23

NAVIGATION OF THE OHIO RIVER AND ITS TRIBUTARIES.

(Visited 22nd–31st May, 1876.)

The Ohio River. THE Ohio carries to the Mississippi the drainage of 214,000 square miles joining that river at Cairo 992 miles above New Orleans. From Cairo to Pittsburgh, where it commences to be called the Ohio, the length of the river is 963 miles and in that distance the total fall is 426 feet. At Pittsburgh two rivers unite to form the Ohio, namely, the "Allegheny" and the "Monongahela." The former rises on the southern slope of the "divide," which on its other slope sheds into lake Ontario. Its general course is a little west of south, and its length is about 300 miles, for 250 miles of which it is navigable by river steamers.

The Monongahela, the general course of which is nearly due north, is formed by the junction, at 129 miles up from Pittsburgh, of the "Tygart's Valley River" and the "West Fork River." These two streams rise about 40 miles apart on the western slopes of the Allegheny mountains and run northwards and gradually converging for about 135 miles till they unite at Fairmont.

At 15 miles from Pittsburgh the Monongahela is joined by an important tributary the "Youghiogheny River" which rises to the south-east amongst the spurs of the Allegheny mountains on the borders of the States of Maryland and West Virginia.

Taking the proposed and existing extensions and improvements of the navigation of the Ohio and its tributaries in order from their head-waters downwards they may be summarized thus—

1st.—The proposed canal joining the upper waters of the Youghiogheny with the Ohio and Chesapeake canal and so

with the Potomac river which flows into the Atlantic, and the canalization of the Youghiogheny from the proposed canal to the Monongahela.

2nd.—The existing and proposed improvements of the Monongahela.

3rd.—The proposed improvements of the Great Kanawha river.

4th.—The existing and proposed improvements of the Ohio river.

1. Proposed Canal joining the Youghiogheny River and the O. and C. Canal.—From the head of the existing "Ohio and Chesapeake Canal" (which joins the Potomac where navigable at Washington) to the head of the proposed "slack-water" navigation of the Youghiogheny, 44 miles above its mouth, is only 90 miles; but between the two points rise the summits of the Allegheny mountains. Many proposals have been made for a canal over the interval. The one recommended by the Government Engineers and spoken of as "quite feasible" would be 94 miles long and would have to overcome by locks and inclined planes 1,342 feet on the eastern, and 1,072 feet on the western, slope of the mountains and would have a tunnel $3\frac{3}{4}$ miles long at 1,944 feet above tide water. With the dimensions of this tunnel 46 feet wide and 28 feet high, those of the general trunk of the canal 70 feet at water surface and 7 feet depth throughout, and the locks 120 feet × 20 feet, the total estimate for the canal is 22,983,040 dollars. The canalization of the Youghiogheny from this canal to the Monongahela is estimated at 1,254,040 dollars making a total in round numbers of, say 25,000,000 dollars for the whole line from the Ohio and Chesapeake canal to the Monongahela at McKeesport, 15 miles above Pittsburgh.

There seems no probability of the early execution of the scheme.

2. The existing and proposed improvements of the Monongahela River.—The Monongahela has been "slack-watered," that is, converted into a series of pools, from its junction with the Allegheny at Pittsburgh to "Jacob's

Creek" a distance of 84 miles. This has been done by a Company who between 1841 and 1856 constructed 6 dams across the river, each dam having a lock at one end of it. The Company is under an obligation to the State to construct another dam and lock which will extend the slackwater navigation $8\frac{1}{2}$ miles further, to the boundary between Pennsylvania and West Virginia. The lifts of the existing dams and locks at low water are:—Nos. 1, 2 and 3 each 8 feet, No. 4, 10 feet, and Nos. 5 and 6, each 14 feet. They are all alike in character and I only visited* No. 1, just above Pittsburgh. Water was then (31st May, 1876,) going over the dam, and I could get no drawing of it, but in a pamphlet given me at the "Monongahela Navigation Company's" office the construction of the dams is thus described:—

"The dams are constructed of logs, squaring at least a foot; they are built up perpendicularly from the bed of the river to near the water level, when they begin to slope on both sides, to the comb, after the manner of an old time log cabin. They are tied together by cross timbers parallel with the line of the river, bolted to longitudinal timbers so as to form a net work, with interstices of 7 × 9 feet, filled with stone. Their breadth at the base is about 65 feet, their depth below the slopes, as originally built, is from 3 to 6 feet, though by reason of breaches, they are now much deeper in places."

The locks built in connection with the dams are of masonry 190 feet × 50 feet with 5 feet on lower sills. The dams with these locks cost on an average 90,000 dollars apiece. At dams 1 and 2 extra locks alongside the old ones have been built with chambers 250 feet × 56 feet. No. 1 cost 56,000 dollars, No. 2, 50,000 dollars. The gates of the locks were originally arranged to run on rollers and tracks, but they were found to frequently clog with silt and drift, and now the gates are swung on the entire suspension principle, resting merely on the pivot, or "acorn," at the bottom of the heel post and supported by stay rods which revolve on a pin held over the centre of revolution by a wooden block 4 feet high which is tied back and down to the masonry. The opening is done by a rope and windlass and the closing by a spar pushed forwards by another windlass and rope. The whole arrangements have a rough appearance, but work with great ease as will be seen from the following extract from my note book:—

* NOTE.—With Mr. J. P. Roberts to whom I am indebted for kind assistance and information.

"Afternoon, 31st May, 1876. Lock No. 1.—Large Chamber 250 feet × 56 feet. Difference of level above and below lock, $7\frac{1}{2}$ feet. Steamer and two coal boats entered from upper pool. Upper gates, with 1 man to each leaf, closed in 2 minutes. From commencing to open lower wickets till water level with lower reach, 5 minutes. Lower gates opened by 1 man to each leaf in 3 minutes.

"Lower gates being open 2 steamers entered. Shutting gates done in 2 minutes. From commencing to open upper wickets till lock filled, 4 minutes. Steamers passed out in 9 minutes from time of entering."

The locks were originally filled and emptied through culverts in the lock walls, but these were given up in favor of sluices in the gates. Of these, there are 5 in each leaf, closed by cast-iron turning shutters 5 feet long, $2\frac{1}{4}$ feet high, with 3 inch diameter journals on which they turn horizontally and which work in bearings or journal-boxes in the gate timbers; the arrangements being such that any shutter can be easily removed and replaced without laying the lock dry. These shutters or wickets are actuated by elbow lever rods running up through staples and between wooden guards to the top of the gate where they terminate in ratchets engaging with cog wheels, each of which can, by the depression of a lever attached to it, be turned sufficiently to force the valve rod down as much as required, about 20 inches. The ends of all the levers on each leaf (5) are connected by a chain carried to a small crab winch on the lock wall, by which means all the valves in a leaf can be moved at once by one man; without using the crab the valves can be moved separately by hand.

The cost of the works to end of 1872 has been 1,146,038 dollars, of which the large sum of 473,493 dollars is due to repairs rendered necessary by the damage done by high floods and enormous masses and fields of ice which come down the river and tear great rents in the dams. One in dam No. 2, in May 1868, scoured out the bed of the river, sand and gravel, to a great depth and is said to have required to close it "more stone and timber than were used in the original construction of the whole dam."

Tolls & Traffic. The table below gives from 1845 the yearly receipts from tolls and the quantities of coal which passed through the works.

AGGREGATES OF RECEIPTS, YEARLY,

From the several Sources.

Year.	Tolls. Coal, Coke, &c.	Tolls. Other Freights.	Tolls. Passengers	Tolls. Totals.	Total Bushels, Coal & Coke.
	Dollars.	Dollars.	Dollars.	Dollars.	
1845	5,283	15,173	8,122	28,579	4,605,185
1846	10,221	20,520	12,680	43,422	7,778,911
1847	13,241	24,345	16,674	54,261	9,645,127
1848	12,438	25,913	18,271	56,623	9,819,361
1849	13,533	24,875	15,337	53,746	9,708,507
1850	17,023	28,587	18,702	64,313	12,297,967
1851	17,850	28,824	19,299	65,974	12,521,228
1852	20,014	30,493	17,011	67,519	14,630,841
1853	21,291	25,260	16,114	62,666	15,716,367
1854	25,079	23,399	15,019	63,499	17,331,946
1855	31,050	27,250	14,753	73,054	22,234,009
1856	10,566	17,454	5,288	33,309	8,584,095
1857	37,111	31,658	12,483	81,253	28,973,396
1858	34,353	27,455	11,289	73,098	25,696,669
1859	39,085	32,635	12,077	83,798	28,286,671
1860	52,082	34,083	13,735	99,901	37,947,732
1861	30,915	20,075	10,885	62,806	20,865,722
1862	26,709	25,675	10,019	62,403	18,583,956
1863	40,532	33,560	13,081	87,174	26,444,252
1864	61,384	53,939	23,757	139,081	35,070,917
1865	69,608	60,979	22,267	152,855	39,522,792
1866	77,811	69,520	22,856	170,188	42,615,300
1867	54,855	54,854	16,677	126,387	30,072,700
1868	91,376	60,892	17,023	169,291	45,301,000
1869	104,936	72,064	18,299	195,300	52,512,600
1870	118,705	80,119	19,067	217,892	57,596,400
1871	100,338	62,239	11,672	174,250	48,621,300
1872	115,609	67,913	12,175	195,698	54,208,800
1873	116,728	......	......	......	......
1874	137,489	......	......	215,463	67,823,200
1875	133,610	......	......	194,833	63,707,500

It will be seen how greatly the coal traffic has grown of late years; that growth will continue and be even more rapid as the improvement of the rivers is extended, for the Monongahela and its tributaries run through beds 1,600 square miles in area, of easily obtainable bituminous coal, for the carriage of which to practically unlimited markets the Ohio, Mississippi and Missouri provide the cheapest of all ways; and the Monongahela water-shed is rich not only in coal, but also in iron ore of excellent quality, in limestones, and in salt. The more than local importance of the fuller development of these natural treasures having been recognized, Congress has decided on carrying out the improvement of the upper Monongahela by national funds, and the work has been commenced. It consists of the "slack-watering" of the river from the head of the existing navigation for 37 miles farther to the junction of the "Tygart's Valley River" and the "West Fork." The system adopted is like that in existence on the lower part of the river, but as the slope of the river is much steeper in its upper parts, the dams have to be closer together. The intended positions for them and lifts of their locks are— Proposed Improvements.

No.	Miles from Pittsburgh.	Lift of Locks.	Remarks.
9	94	$11\frac{1}{2}$	Being built.
10	$101\frac{1}{2}$	13	NOTE.—The dam yet to be built by the
11	$107\frac{3}{4}$	10	Company, already noticed, is No. 7,
12	$110\frac{3}{4}$	11	and it will probably be so high as to
13	$112\frac{3}{4}$	10	render unnecessary any No. 8.
14	$116\frac{1}{2}$	10	
15	$125\frac{1}{2}$	10	

The cost of these dams and locks (200 feet × 50 feet and 6 feet on the sills) is estimated at 130,000 *dollars* each.

3. The proposed improvement of the "Great Kanawha River."—The Great Kanawha River, which joins the Ohio at 263 miles below Pittsburgh, flows north-westerly from the western slopes of the Allegheny mountains through a country rich in minerals. Little has as yet been done to improve it beyond some dredging, removal of rocks, and erection of loose stone dykes, and it is only navigable for a short distance during high stages of water. It nevertheless now sends annually to the Ohio some 5 million bushels of coal and large quantities of salt. It is proposed to make it navigable at all times for river boats from its mouth to the "Great Falls," a distance of 94 miles, by converting it into a series of still-water pools separated by dams and locks. The cost of the works required is roughly estimated at from 2 to 3 millions of dollars; but nothing is yet definitely decided on.

4. The proposed and existing improvements of the Ohio. —From Pittsburgh to Louisville, a distance of 598 miles, the mean fall per mile of the Ohio is little over 6 inches and in its low stages it is obstructed in many places by gravel bars on some of which there is not more than 1 foot depth. At Louisville occur the only rapids on the river. There it is barred by a reef of limestone rock down which in low stages of the river there is a fall of 26 feet in 3 miles. Below this to its mouth, 362 miles, the river falls on an average a little over 3 inches a mile and shifting sand-bars with as little as 1½ foot of water on them are frequent. The extreme oscillation of the river between low and high water is 35½ feet at Pittsburgh, 62½ feet at Cincinatti, 65 feet below the Louisville falls, and 52 feet at Cairo. For about 100 days in the year the river may be said to be not navigable owing to the insufficient depth on the bars. To remedy this various plans have been proposed. One of the first was that of Mr. Ellett for storing up in artificial reservoirs a sufficient quantity of its flood-waters to supply the river in its lowest stages with enough to keep 6 feet on the bars. This scheme has after careful investigation been declared by several eminent Engineers to be impracticable. Another suggestion has been the construction of a canal to bring the required water from lake Erie, but that this is quite impracticable has been shown by Col. W. E. Merrill, who says of it:—

"The supply would have to be by a through cut and that through a ridge of not less than 500 feet high and fully a hundred miles wide. It could only be done by a tunnel at least 150 miles long. But suppose we

could have that tunnel? water will not run in a cut unless it has some slope, and in a narrow channel the slope could not well be less than 2 feet to the mile. You might call the distance 200 miles. It is certainly not less than that from any point which can be considered, and you could not give less of a slope to this channel, to make any kind of a supply of water than 2 feet a mile. The upper end would require to be at least 400 feet higher than the lower end. Lake Erie is 565 feet above the ocean and, consequently, would only supply a point 200 miles distant that was 160 feet above the ocean, and as the river at Cairo (its mouth) is 275 feet above the ocean it is manifest that no point in the Ohio could be reached by that method."

Extract from evidence of Colonel W. E. Merrill before Committee on Transportation routes 29th Oct. 1873.

This impossibility having been demonstrated it was proposed to pump enough water from lake Erie over the watershed. Of this wild idea Colonel Merrill says—

"I found it would take 125,000,000 dollars a year to lift the amount of water required to supply 6 feet of water in the Ohio River at Wheeling. Taking the estimates of Mr. Ellett, made years ago, I found that the first cost of the buildings and machinery would be about 625,000,000 dollars. I thought *that* was sufficient to prove the impossibility of such a scheme, but it seems somebody found a pump claiming to do better. I estimated on *that* basis which may be considered the maximum possible and even then, on that, I could not give a less annual expense than 4,000,000 dollars, and the first cost of 45,000,000 dollars. That stopped that plan of course."

The only possible way of thoroughly improving the navigation of the river appears to be to treat it as the lower Monongahela has been treated: to "slack-water" it. I cannot do better with reference to this than give Colonel Merrill's evidence on the subject before the Transportation Committee, October 29, 1873:—

"The great advantages of the slack-water plan are that it is simple; its expense can be calculated with as much accuracy as any work in water can be, and I think I ought to state here that any work in water is subject to contingencies which cannot be foreseen, and therefore exact estimates are simply impossible. A bed of a stream is itself your reservoir, and it gives all the water you need, and not one drop more. You simply retain what is needed for navigation. The stream will always supply the lockage, and even if it should not run over the dam, still you will have plenty of navigation in the pools. It is easily built; there are no excessive dangers, and it is at present in use on the Monongahela river, where it fully meets the wants of the very class of navigation which demands the improvement of the Ohio, and that is the coal-trade.

There is but one thing, however, to be said about applying it to the Ohio. The coal-trade of Pittsburgh is a unit in demanding that nothing shall be put on the Ohio that will in any way interfere with the full and free use of the stream, as they have it now when the water is high. They claim that it is impossible for them to stop at every lock, break tows, and take them through and re-form them. My own experience with coal-tows makes me think the objection is a good one. I came down from Pittsburgh to Cincinnati on a coal-tow on purpose to see how they got along. To that objection we reply that it is perfectly feasible to make an opening 200 feet wide or more, if necessary, although I think 200 would be enough in one of these dams, cutting it down 4 or 5 feet, so as to take off the lift almost entirely. Have this chute opened and shut by a hydraulic gate, manageable by one man, the force being the force of the water always to work it, and through which these boats can pass with just as much safety and with as little detention as they can in the open river. In returning they return empty, and there is no difficulty at all in their breaking up their tows, because they are light and are not so tightly held together, and can re-form their tows.

It would save time, because they now come down loaded on a rise, and they go back empty; but a boat draws about 3 feet, and very often the rise, before they can get back to Pittsburgh, is altogether gone, and the river is dead low. They sometimes have to lie by for months and months, scattered along the river, until the next rise takes them back to their harbour.

But this movable hydraulic gate, on which the whole thing hinges, is an experiment. Means for accomplishing this purpose in a little different way has been used on a small scale in various rivers in France, Germany, this country, and the East Indies, but nothing quite analogous to what we have to build for the Ohio. The matter has been under the charge of a board of engineers, consisting of General Weitzel and myself, for a long time. We sent in a preliminary report to the last Congress, which unfortunately was not published, and no action was taken. In that report we stated our positive belief that it was perfectly feasible to make such a hydraulic gate, but before committing ourselves to the great cost of applying the slack-water system with this hydraulic gate to the Ohio, we desired to make an experiment on a smaller scale to some other stream."

Having in 1874 been directed by Congress to estimate for "the radical improvement of the Ohio river so as to give 6 or 7 feet of navigation at low water," Colonel Merrill submitted, in 1875, the following estimate for providing 6 feet depth by 68 weirs across the river each with a "navigable pass" 400 feet long in it, and a lock at one end 680 feet long between the hollow quoins and 76 feet wide:—

FINAL ESTIMATE.	Dollars.
12 Locks on rock at $179,610	2,155,320
56 do. gravel at $285,168	15,969,408
8 Navigable passes on rock	522,480
60 do. do. gravel	5,445,810
6 Low Weirs on rock	332,544
62 do. do. gravel	5,259,584
3 High Weirs on rock	234,486
65 do. do. gravel	6,492,923
23 Piers on rock	116,127
113 do. gravel	604,663
68 abutments on gravel	705,500
10,840 linear feet of dam across island-chutes	847,796
Total cost of radical improvement	38,696,671

"The above estimate has been made with a great deal of care, and is about the best that is possible under our present knowledge. It is a very difficult and uncertain task to make estimates for works of such magnitude in the absence of practical experience in construction of a single one, and I would not presume to undertake it at the present time, were it not for positive orders to do so. Considering the additional difficulties that will be encountered below the falls of the Ohio, on account of the short and uncertain season for work, and the enormous masses of sand that are transported by the current, which will undoubtedly cause delays and extra work, I think it would be safer to put the whole estimate at $10,000,000, which is at the rate of $41,365 per mile, the total length of the Ohio river being nine hundred and sixty-seven miles. Bearing in mind the enormous tonnage that would be borne on the river, if it were made navigable throughout the year, it does not seem unreasonable to request appropriations for its improvement at least equal to the sum that would be required to build a railroad of equal length."

There seems a probability of this or a somewhat similar scheme being put in hand before long, it would of course take many years to complete. At present, with one exception (the Louisville and Portland canal), nothing has been, or is being, done to the river beyond spending from 100,000 200,000 dollars annually in dredging, and removing ags, and putting up rough stone dykes here and there to ntract or direct the current—all excellent measures as far they go, but that is but a little way towards appreciable provement.

* Louisville and Portland canal.

One important work on the river has been carried out, and at is the LOUISVILLE AND PORTLAND CANAL round the falls rapids at Louisville. These extend for about 3 miles, the al fall in that distance being in very low water 26 feet, ordinary freshes 14 feet, and in high floods 2 feet. To n this formidable bar to traffic, a private Company conucted, between the years 1825 and 1831, a canal on the ith bank of the river with 3 locks of 8 feet lift each, 184 t long, and 50 feet wide. The United States Government having, in 1867, acquired most of the "stock" of the Company, undertook the enlargement of the canal and the building of new locks. The work was delayed by disputes and litigation between the Directors of the original Company and the Government, but is now complete. It consists of a dam across the river at the head of the rapids,

* "Visited 22nd, 23rd, 24th May, 1876."

a canal $2\frac{1}{16}$ mile long and a "combined" lock of 2 chambers. The amount expended by the United States Government on those works has been 1,360,740 dollars. What was expended by the private Company I do not know.

Dam. The dam is 3,300 feet long; it is built of crib-work bolted down to the limestone rock, which here forms the bed of the river. The maximum height of the dam is 7 feet, its average height between 4 and 5 feet, but a navigation opening of 600 feet in length, with sill 5 feet below crest of dam, is left opposite the natural deep channel on the north side of the river known as the "Indian Chute," to allow passage of boats during moderate freshes. As in very low stages of the river it is difficult to keep the water high enough in the canal whilst there is a free passage for the water through this opening, it is intended to close it by a movable dam which can be raised or lowered as may be required, the designs for this have not been decided on, but a Committee of Engineer officers has recommended a trial of the "Chanoine wickets" in use under somewhat similar circumstances on several of the dams across the "Seine." A second navigation opening, 400 feet in length, is to be made opposite another natural channel in the river, called "Middle Chute."

Canal. The entrance to the canal is formed by a wing-dam, at the south end of the main dam, running up-stream some little distance, and down-stream gradually approaching the shore till at some ¼ mile below the dam the true canal commences, where are situated "guard gates," 19 feet high, for use if at any time it be required to unwater the canal whilst the river is low, but the top of them is considerably lower than *high* flood level. The channel from these gates is 2 miles long; it is on the average 86 feet wide with vertical masonry side walls; much of the lower portion of the channel is excavated out of the solid limestone rock. The depth of water in the canal in low water is nominally 6 feet, but actually it is occasionally less; in 1875 it was less than 5 feet for 68 days and less than 4 feet for 23 days.

Lock. The lock, which is one of the biggest canal locks in the world, has two chambers, their combined lifts being 26 feet. They are each 372 feet long between the gate quoins and 80 feet wide. They are founded on the solid rock which had to be cut out to some depth for them. The side walls, 30 feet high in upper and 27 feet high in the lower chamber, are 12 feet thick, vertical on both sides, built of limestone masonry in cement faced with sandstone ashlar, and backed up with thick *dry* stone walls. The head-bay is 120 feet long, and at 82 feet above the entrance gates of the upper chamber are "guard gates" with tops above high floods, but not above the *highest* known. Between these "guard" and the upper chamber gates an iron swing-bridge crosses the head-bay at 47 feet above its floor. The middle sill is 10 feet higher than the lowest one and the upper sill is 14 feet higher than the middle one. The plans of this work, most kindly given me at the office of the Chief of Engineers, Washington, and sent herewith, clearly show the main details of the locks, and the photograph (see frontispiece) will give an idea of the general appearance of the upper chamber.

The gates are in height—"Guard" 46 feet 11 inches; Upper $24\frac{3}{4}$ feet; Middle 31 feet; Lower 27 feet; the length of each leaf is 47 feet 8 inches from heel to mitre. They are swung in a way which appears to have been an attempt at a compromise between the system of suspension and of resting on rollers. They have at the bottom of the heel post the usual "acorn" or pivot and socket, and the top of the heel post is clasped by a collar anchored back to the wall. At the toe of the gate is a roller resting and travelling on a rail laid on the floor of the lock. But it appears as if it was not intended that this should take the full weight of the droop of the gate, for suspension rods (one on each side of the gate) are carried up from near its toe to the top of a mast 27 feet high, where they are attached to a revolving cap kept directly over the centre of revolution of the gate by a forward rake of the mast, which is held in position by iron guy rods attached to anchors in the masonry. The plans sent herewith will make these arrangements clear. This suspension gear is too light to take the whole sag of the gate, and appears to have been intended merely to relieve the roller and track of *some* of the weight, but of course this compromise is not possible in practice; the suspension rods break if the gate hangs on them, and are therefore worse Lock Gates.

than useless, the gate settling down entirely on its roller. As the Ohio often carries great quantities of silt, the tracks on which the gates travel are frequently covered with mud, and the working of the gates is thereby much obstructed. The difficulty of suspending gates of such great span as these is no doubt great, but that it might have been overcome is proved, I think, by the excellent way in which the "Henry" lock gates, nearly as large as these, are swung (see notes on the improvement of the Illinois river.) The opening and shutting of the gates is done by drag chains winding on drums in chambers in the walls and actuated from above by the spindle of a capstan worked by men, with long capstan bars. The filling and emptying of the chambers is done entirely through the gates, there being in each leaf 6 vents, 3 feet × $2\frac{1}{2}$ feet, closed by turning valves worked by rods from the top of the gates. The plans sent show the construction of the gates.

Working of Lock.

When I saw the lock worked, 24th May, 1876, the river was so high that there was no necessity to use the lower chamber as a lock, the water below and in it standing 15 feet on the middle sill. The difference of level between this and the water above upper gates was $13\frac{1}{2}$ feet. A large stern wheel steam-tug had brought down a tow of 8 coal barges from Pittsburgh, and I saw her and 5 of the barges, which were all that could get into the lock together with her, locked through. Each of the barges, measured 130 feet × 24 feet, was drawing $7\frac{1}{2}$ feet and carrying 11,000 bushels (25 bushels = 1 ton) or say 440 tons of coal, so that in the lock at one time, besides the steamer, there were 2,220 tons of coal. The three boats left to come through in the second lockage were larger (one was 179 feet × 29 feet) and contained 2,300 tons, so in her tow the steamer had 4,520 tons of coal; this was not considered a large quantity, tows sometimes being two, three, four and even nearly five times as big as this one. The opening of the swing-bridge over the upper bay was done in $2\frac{1}{2}$ minutes by two men. It took 35 minutes to break up the tow and arrange the barges in the chamber; such heavy masses with such frail casings, require very careful handling. The upper gates were closed in 6 minutes by 9 men working

hard at each leaf capstan. The emptying of the chamber took 9 minutes, and the opening of the middle gates was done with difficulty in 10 minutes by 10 men at each capstan. It is considered that under favorable circumstances the passage of the whole canal is done in two hours, of which one hour is occupied in the locks; but frequently the clogging of the tracks makes the working of the gates take longer than that. On this subject of time of lockage I append remarks by Captain Alexander Mackenzie, Corps of Engineers, to whom I am indebted for great courtesy shown me when visiting these works which are under his charge :—

TIME OF LOCKAGE.

"During the past year records have been kept to determine the time occupied in lockages. It varies so with different stages of water, that only an average can be given.

When the usual force of men are employed and both chambers are used, a lockage will occupy about an hour, or if the water is high and only one chamber is used, half an hour is sufficient.

With an extra force of men the time through two chambers can be reduced to forty-five minutes. The opening or closing of each gate occupies seven minutes, and the rest of the time is required for filling and emptying the chambers.

When the canal is clear and only being used by steam-boats, the time of one lockage will give the means of computing the daily capacity of the locks; but when the canal is being used by tows, there are so many delays entirely beyond the control of the superintendent that no computation can be made.

On December 3 it took five hours and forty-five minutes to pass the steamer Sam Brown and sixteen boats, carrying about 10,700 tons of coal. But one lock-chamber was used, and, from the size of the boats, six lockages were necessary. Not more than three hours were consumed in moving gates and filling and emptying chambers, so that two hours and three-quarters were required for moving the boats into and out of the locks.

Frequently there are as many as four or five tows, with from fifteen to twenty boats each, waiting to pass down through the canal, and, at the same time, passenger-boats and upward-bound tows are pressing their claims. Tows cannot pass each other except at the head or the foot of the canal, and ordinarily they can only pass steam-boats at one intermediate point.

From the above it will be seen that with the best of management and perfection in the movements of boats, occasional delays are unavoidable.

But the movement of boats is far from perfection. Large tows have small and frequently a very insufficient set of hands; it takes them a long time to arrange their boats and move through the canal, and often after reaching the locks no means are provided for removing the boats as they are passed through. If it is foggy, or if there is much wind, coal-boats cannot be moved, and must be held in the basin at the head of the locks. It thus happens that, at times, hours and even whole nights are lost, when it is very important that the boats should keep moving, clearing the way for those coming behind them.

During the past year extra forces have been employed whenever a pressure of work demanded it, and the lock-hands have been on hand day and night, ready for any boat that wished to pass through the canal."

Silt.

After every flood there is a large deposit of silt in the canal which has to be removed by dredges. Captain Mackenzie reported that the high flood of 7th August, 1875, left in the locks 20,629 cubic yards, averaging 11 feet thick, and in the channel 24,000 cubic yards.

Working expenses in 1875.

The necessity for much dredging of course makes the annual expense of the canal great; in 1875 it amounted, including salaries of lock department, to 56,419 dollars.

Receipts, 1875.

The total receipts in the same year were from tolls 68,664 dollars and from all sources 70,175 dollars.

Rates of Tolls.

The rates of tolls, with remarks, are given in the following excerpt from Captain Mackenzie's report, December 31st, 1875:—

RATES OF TOLL, AND CHARGES FOR DRY DOCK.

The rates of toll charged during the past year have been as follows:—

- Steam-boats, 10 cents per ton registered under-tonnage.
- Model barges, 10 cents per ton registered under-tonnage.
- Coal-boats, flats, &c., 8 cents per ton, measured capacity.
- Steam-boats of less than 50 tons and flats of less than 63 tons, $5.
- Rafts of logs, &c., measurement and rates the same as for coal-boats, &c.
- Boats belonging to the United States, free.
- Use of dry dock, $75 per week.

The above rates on steam-boats are the same as fixed by Congress May 11, 1874; the rates on coal-boats were increased from 5 cents to 8 cents by the Secretary of War last January, in order to make the rates more uniform. This small increase, which has hardly been felt, has increased the yearly receipts $16,297·96. The custom-house measurement is taken for all boats having registers, and the total tonnage of such boats being about double their under-tonnage, the rate is, in reality, about 5 cents per ton, carrying-capacity. Coal-boats, flat-boats, &c., are measured and their under-tonnage computed. This class of boats will carry about one and one-half times the amount indicated by their measured under-tonnage, so that the rate for their carrying-capacity is about the same as for steam-boats and model barges.

Examples.

Class.	Total tonnage or carrying-capacity.	*Under-tonnage or tonnage charged for.
Steamer Mountaineer	585.66	358.81
Steamer Mary Alice	559.56	248.73
Model barge Mary	706.60	362.53
Model barge, Mississippi Transportation Company, No. 51	1,012.30	417.16
Square barge, 130 by 24 by 7½	480.00	246.00

At the present rate the tolls will amount to about ⅙ cent per bushel of coal, ⅔ cent per barrel of salt, and 6 cents per ton of iron ore.

The following examples will show the great reduction in tolls under the Government management:—

Class.	Name.	Under-tonnage.	Charges under old management.	Present charges.
Steam-boat	Thompson Dean	996	$498.00	$99.60
Do	Thos. Sherlock	877	438.00	87.70
Model barge	Rubicon	390	195.00	39.00
Square barge	130 by 25 by 7	239	65.00	19.12
Produce-boat	100 by 20 by 5	105	60.00	8.40

Under the former management a distinction was made between loaded and empty barges; and I think such an arrangement of tolls would be more satisfactory than the present system of charging a uniform rate."

Traffic through the canal.

During the year 1875 there passed through the canal 664 steam boats, and 2,216 tow boats and barges of the total registered or "custom-house" tonnage of 758,359 tons, but this is far below their carrying capacity (see extract above). Of the principal commodities carried on the Ohio river, the following quantities passed through the canal in 1875:—

7,866,650 bushels of coal,
60,000 barrels of salt,
79,177 tons of iron.

The whole quantity of coal which now passes down the Ohio

* Under main deck, or "hold."

in a year is estimated at from 75 to 100 millions of bushels. The boats carrying this collect in great numbers, chiefly at Pittsburgh, during low stages of the river. They are fastened together as rigidly as possible by chains and screw clamps into enormous tows, floating islands of 2 and 3 acres in extent, which powerful stern-wheel steamers push *before* them. They start when any fresh rises sufficiently to float them over the bars and generally reach Louisville (650 miles from Pittsburgh) in 5 or 6 days; there, if the water is high enough, they go right on down the river, but if it is too low for this the tow has to be broken up, taken through the canal, and re-formed—a troublesome operation. The following extract from the Louisville Courier Journal, March 24th, 1876, given to me by Captain Mackenzie as correct in its statement of facts, will show how enormous are some of the tows managed by one steamer:—

Extract from Louisville Courier Journal, 24-3-76.

"The new tow boat "Joe B. Williams" has left with 22 boats and 7 barges of coal amounting in weight to 21,000 tons. This would be a load for 2,000 rail-road cars, estimating 25 cars to the train it would require 80 locomotives to move it, and each train being 800 feet in length, it would extend a distance on the rail-road track of more than 15 miles. This immense freight is carried by the "Williams" at an expense of 2 cents per bushel which would amount to a little freight bill of 11,500 dollars. To transport it by rail 800 miles to New Orleans, at the lowest price of rail-road freight, say one cent per mile, the freight bill would be something more than 170,000 dollars."

List of plans accompanying these notes.

Louisville and Portland Canal.	Nos. in Vol. of Plans.
Elevation and plans of new locks	..24
Transverse section ,, ,,	..25
Plan elevation and section guard gate	..26
,, ,, ,, upper ,,	..27
,, ,, ,, middle ,,	..28
Mast, stay-rods and anchors	..29
Details ,, ,,	..30
Map of part of city of Louisville, showing the Louisville and Portland Canal	..31

Cheapness of River carriage.

The following notes and extracts will give an idea of the wonderful cheapness of carriage on the Ohio system of navigation.

When I was at Pittsburgh the charges on transport to that place of a boat containing 770 tons of coal from Brownsville, a distance of 56 miles up the Monongahela and between dams 4 and 5, were—

	$ Cts.
Steamer charge for towing	80—00
Toll for passing steamer through locks	2—00
,, ,, coal ,,	59—75
Total Dollars...	141—75

or 3·29 mills* per ton per mile; this does not include interest on the cost (about 1,200 dollars) of the coal boat or the labor employed on it during the trip, which could scarcely bring the cost up to more than $3\frac{1}{2}$ mills per ton per mile. On the Ohio below Pittsburgh the cost is of course much less—

Extract from report of Mr. Thos. P. Roberts.

"The barges are brought down the Monongahela either singly or in pairs and are made up into large fleets of ten or more at Pittsburgh and then taken in tow by large and much more powerful tow-boats. Calculation of cost of towing on the Ohio will generally show that it is no more than one (1) mill per ton per mile to Cincinnatti and less in proportion as the distance is greater, as to Louisville, Meenphis or New Orleans. In this is included the cost of returning the empty barges to Pittsburgh.

Statement of Mr. R. Smith, of Cincinnatti.

"The cost of moving coal by river averages from $\frac{5}{8}$ to $\frac{7}{8}$ of one mill per ton per mile.

"From the Kanawha coal mines, to communicate by the Ohio river, the distance is 275 miles, and the charge per ton for coal transportation is 50 cents; being at the rate of nearly 2 mills per ton per mile by river and 11·2 mills per ton per mile by rail, nearly six to one in favor of the river. The river rates include the cost of returning the boats to the coal mines.

"From Pittsburgh to New Orleans viâ the Ohio and Mississippi rivers, 2,100 miles, coal is transported during good stages of water for 1 dollar 60 cents per ton or at the rate of $\frac{3}{4}$ mill per ton per mile. This is done in barges and in very large quantities."

On the lower Mississippi from St. Louis to New Orleans (1,250 miles) the actual expenses of a steamer with a tow of five laden barges (each 1,500 tons) were found to give $1\frac{4}{10}$ mill per ton per mile, inclusive of interest on cost of vessels.

* 1 Mill = $\frac{1}{10}$ cent. = say $\frac{1}{21}$ penny.

COST OF CARRIAGE.

"ACTUAL EXPENSES OF TRANSPORTATION" FROM SAINT LOUIS TO NEW ORLEANSS BY BARGES.

Extract from page 851, of part 2 of Report "Transportation routes."

"The Future City, tow-boat, and five barges of the Mississippi Valley Transportation Company: Actual *expenses* from Saint Louis to New Orleans, twelve hundred and fifty miles, (each barge is 1,500 tons capacity:)

Cost of tow-boat, new this year	$60,000
Cost of barges, $15,000 each, new also.	75,000

Interest on same at 7 per cent., six days.........	$155·00
Coal, 50 tons per day, at $2.50, six days.........	750·00
Engineers, one $3 and one $5 per day, six days.	48·00
Captain, at $5 per day, six days......	30·00
Men, ten, at $1.50 per day each, six days.........	90·00
Pilots, two, at $5 per day each, six days.........	60·00
Cook, at $1.50 per day, six days	9·00
Board per man, each day, 16 cents, six days.....	48·00
Oil, tallow, and waste, $2 per day, six days......	12·00
Maintenance six boats, $18.24 per day, six days.	109·44
Total...	1,311·44

Cost per ton moved 1,250 miles, 17.49 cents, inclusive of interest.

* Cost per ton per mile, $\frac{7}{10}$ of mill.

Cost per bushel of wheat, 1,250 miles, 5½ mills."

* Query—$1\frac{4}{10}$ inclusive—or $1\frac{2}{10}$ mill exclusive of interest.—G. T. W.

THE ERIE CANAL AND ITS BRANCHES.

(Visited 18th—23rd June and 7th—16th July, 1876.)

Introductory.

THE Great Appalachian range, or Allegheny mountains, extending from the State of Georgia on the gulf of Mexico to the river St. Lawrence, interposes a formidable barrier to traffic between the Atlantic sea-board and the Western States of North America. There is, however, in this barrier one break through which flow the Hudson river and its tributary the Mohawk; up the channel of the former river the tides of the Atlantic run for 145 miles, to Albany. From that place up the valley of the Mohawk and on to lakes Ontario and Erie there extends in nearly the most direct line, and right through the heart of the State of New York, a strip of easy country. Along this the Erie canal runs, from Albany to Buffalo on lake Erie, and to Oswego on lake Ontario, bringing by almost the shortest possible route the chain of the great lakes into direct communication with the sea, opening up a means of uninterrupted traffic by water from the very heart of the continent to the ocean, and providing the vast grain-growing regions of the Western and North-western States with cheap carriage for their produce to New York. Though lying entirely within the boundaries of one State and carried out by it without any assistance from the National Government, the canal had not long been constructed before it became the most important line of artificial communication in the whole of the United States. From the time of its opening, in 1825, till about 1850, it formed positively the only avenue by which, except at a prohibitory cost for transit, the markets and ports of the East could be reached by the products of the Western and North-western States, and to it almost entirely was due their wonderfully rapid development. Its effect upon those important States, and so upon the material prosperity of the United States generally, and its great commercial and financial results place this canal in the foremost rank of the engineering works not only of the country to which it belongs, but of the whole world. Its very importance, however, has proved injurious to it, drawing it into the whirlpool of American politics which, to say the least of it, does not conduce to steady progress, and its financial prosperity came near, being its ruin, attracting to it swarms of dishonest speculators who organized conspiracies or "rings" for its robbery. They secured, by elaborate systems of fraud, extravagant payments for badly executed and even unexecuted work, and to increase their spoils they forced on, by political intrigues, the construction of useless branches which have burdened the parent canal with debt, and are now consuming its earnings. The present Governor of New York State, Mr. Tilden, takes the greatest interest in the canal and has in the last few years done much towards dragging it out of the slough into which it had sunk. He has broken up the "rings," he has exposed fraudulent contracts, and he is doing his best to introduce a new style of management: should he be successful and the reforms now begun be extended and rendered permanent there is a future before the canal greater even than its past, but should corruption be allowed again to gather round it and the present system be continued of controlling it by politicians and constantly changing its management both commercial and engineering, according to the caprices of popular election, the treatment which it could thrive in spite of when it was without rivals, will now most certainly reduce it to a mere burden to the State, and remaining unimproved and unequal to the altered requirements of the day it will be deserted by the western grain traffic, for which prize many rivals under management of the most energetic, bold, and foreseeing character are now eagerly striving.

Original construction and enlargement.

The construction of the Erie canal was begun in July, 1817, and its main line from Buffalo to Albany, 363 miles, was opened at the latter end of 1825. Its prism was 28 feet at bottom, 40 feet at water surface and 4 feet deep. Its locks were 83 in number with a total lift of $675\frac{1}{2}$ feet, their dimensions 90 feet × 15 feet. The largest

boats navigating it were of 76 tons and the cost of carriage by them, exclusive of tolls, was ascertained to be one cent per ton per mile. The actual cost of construction was 7,143,789 dollars, nearly 50 per cent. in excess of the estimate ($4,926,738.) The traffic which crowded to the canal soon showed that its dimensions were too small, and, in 1835 its enlargement was ordered by the State to a size suitable for boats of 240 tons. During the following 27 years this enlargement was carried out at an expense of 32,008,851 dollars, about 35 per cent. in excess of the estimate ($23,402,863.) The prism was enlarged (except for a few short distances) to 42 feet at bottom, 70 feet at water surface, with a nominal depth of 7 feet, and the locks were made 110 feet × 18 feet, their number being reduced to 71 "lift" and 2 "guard" locks with a total lockage of $654\frac{1}{5}$ feet. The length of the line was shortened to 352 miles. These alterations enabled the boats to be increased in size to 98 feet × $17\frac{1}{2}$ feet, and in capacity to 240 tons with $6\frac{1}{2}$ feet draught, reducing the cost of carriage from 1 cent to under 5 mills (1 mill = $\frac{1}{10}$ cent) per ton per mile exclusive of tolls. Subsequently at a cost of 718,984 dollars all the lift locks have been "doubled," that is, have each had a second chamber built alongside the original one, and by the removal of "bench walls," or berms carrying revetment, the bottom width of the canal has, except in a few places, been increased to from 52 to 56 feet.

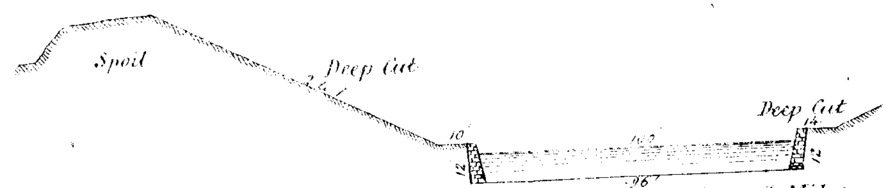
General description of line.

The main line or "trunk" of the Erie canal starts from the harbor of Buffalo at the east end of lake Erie (ordinary surface level 568.5 + tide water) just above the head of the Niagara river. It runs for $4\frac{1}{2}$ miles alongside that river, from which it is separated most of the way by an artificial wall, to Black Rock harbor, which was the original terminus of the canal. The average width of the channel for this distance varies from 80 to 140 feet. Through this the chief supply for 162 miles of the canal and that for large water-power mills at Black Rock have to pass, causing an inconveniently rapid current; it is therefore proposed to provide an entirely separate channel for the mills. I may here incidentally remark that the growth of mill rights in connection with navigable canals I have found in the United

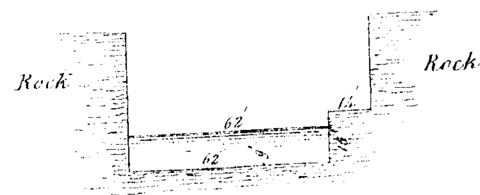
States and Canada to be a constant source of difficulty in the management of those channels and of hindrance to their improvement. At "Black Rock" is a "ship lock" (200 feet × 30 feet) for passing lake-going vessels from Niagara river into Black Rock harbor, through which harbor the canal runs, and which is therefore at the lake level (minus the slight fall in the canal), and generally from 3 to 5 feet above the river level at the place. At the end of this reach is a "guard lock," not shown on the profile, the drop of which varies from 0 to about 3 feet, according to the lake level; it is "double"* and between the chambers is a channel 50 feet wide, closed by a "bulk-head" with 16 cast-iron balance valves actuated by levers, for passing on supply water. From Black Rock for 8 miles to Tonawanda, a small port on the Niagara river, the canal continues parallel with and near to the river with a surface width of 90 feet and a depth of 8 feet. It then turns away from the river, and for $11\frac{3}{4}$ miles to Pendleton the Tonawanda creek is used, which gives a surface breadth of from 150 to 200 feet and a depth of 9 feet. From thence for 4 miles the canal is in deep earth cutting, and then enters a rock cutting of nearly 30 feet deep, through which it continues with 61 feet mean width (exclusive of tow-path—*one*—14′ wide) for $2\frac{1}{2}$ miles to Lockport.

There, down a rocky gorge, is the greatest continuous lockage on the canal, $55\frac{10}{12}$ feet being overcome by 5 "combined" chambers, below which surface level is 512·51 + T. W. The canal here turns more to the east and runs nearly parallel to the south shore of lake Ontario, and at about 10 miles from it, for 62 miles to Rochester (93 miles from Buffalo, 259 miles from Albany) without any lockage, but with a bed fall of 2·12 feet and a surface fall (theoretical) of 3·61 feet, the size of the prism diminishing gradually from 89 feet mean width and $8\frac{1}{3}$ feet depth to 62 feet M. W. and 7 feet depth. At this place the Genesee river is, at 7 miles from its mouth on lake Ontario, crossed by a handsome stone aqueduct. Directly after passing the aqueduct the canal takes a very sharp curve and runs for a short distance along the east bank of the Genesee river; it then makes a

* "Double" in connection with this canal means with 2 chambers side by side—"combined" means with chambers joined end to end in flights.



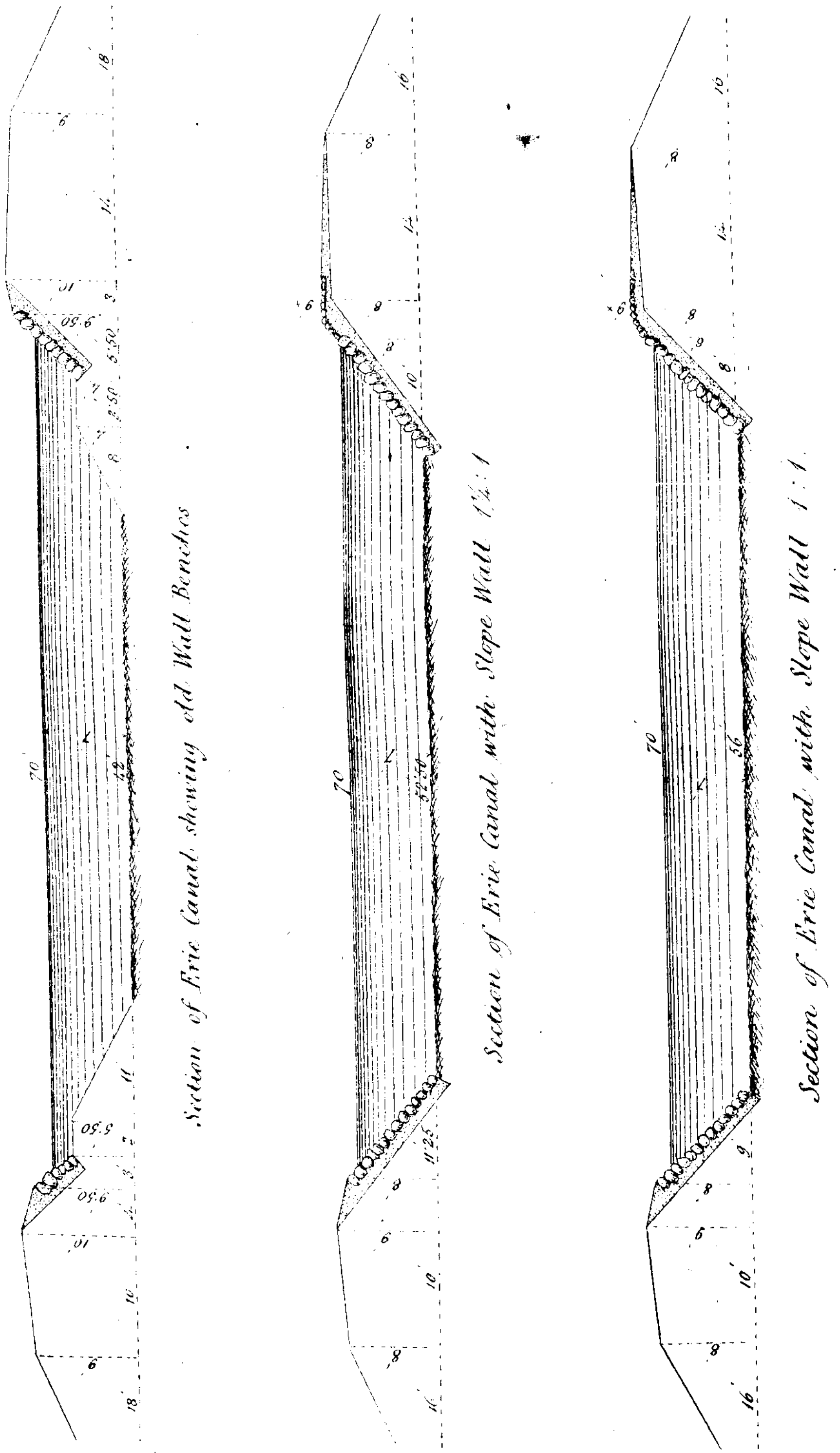
From Pendleton to a point 2½ Miles above Lockport.



For 2½ Miles above Lockport.

heavy detour to the south to avoid the low ground of the Allen and Irondiquoit creeks, and in the next 49 miles descends 118½ feet by means of 14 locks to what is known as the "Montezuma Level." This extends, with water surface, 390·36 + T. W. to Port Byron, (158 miles from Buffalo, 194 miles from Albany), and is the last reach which receives lake Erie water. It also receives surplus water from the two higher reaches east of it, and itself surpluses into the "Cayuga and Seneca branch canal" which leaves it at Montezuma (153 miles from Buffalo, 199 miles from Albany) and runs south to the Cayuga, Seneca, and Crooked lakes. Just west of this canal the Seneca river is crossed by the "Richmond" aqueduct. At Port Byron there is a lock of 11 feet, and 9 miles further on another of 5½ feet, which *lift* the water surface to 406·86 + T. W., at which level it continues for about 16 miles to near Geddes. From here to the eastern end (Albany) the general dimensions of the prism of the canal are 56 feet at bottom, 70 feet at water surface, depth 7 feet. Near Geddes the canal is dropped by a lock of 6$\frac{11}{12}$ feet to 400 + T. W., at which it continues for 3 miles to Syracuse, (186 miles from Buffalo, 166 miles from Albany), where it is again *lifted* 27 feet by 3 locks at short intervals to what is known as the "Long" or "Rome Level." At Syracuse, just west of the three locks, the "Oswego branch canal" (38 miles long) comes in from lake Ontario and at its junction is a weigh-lock. The "Long" or "Rome Level" extends to ½ mile west of Utica, a distance of nearly 56 miles. Being a "summit" reach it can receive no water from the reaches on either side of it, and is supplied by 13 special feeders with a theoretical power of supply of 26,820 cubic feet per minute (see table of Feeders of the Canal) Inconvenience is, however, sometimes felt in dry seasons from want of water, and heavy or prolonged winds blowing along this reach seriously affect the depth at its ends. In this reach, at 217 miles and 227 miles from Buffalo respectively, the "Oneida Lake" and "Black River" branch canals come in. From the end of this reach to tide-water at Albany the descent is continuous down the valley of the Mohawk. Near Utica (242 miles from Buffalo, 110 miles from Albany), there is a lock dropping the surface 3 feet to 424 + T. W., and just below this lock the Chenango branch canal (97 miles long) comes in from the south.

For the next 84 miles the canal runs near the south (right) bank of the Mohawk river to 4 miles east of Schenectady, dropping in the 84 miles by 23 locks at different places to 229·8 + T. W. It then crosses the river to its left (north) bank by a composite (wood and stone) aqueduct known as the "Upper Mohawk Aqueduct." 250 yards above this structure the Mohawk river is ponded up by a dam of masonry and timber 675′ long and 7′ 6″ high, and from this a feeder is taken off which runs alongside the left bank of the river then under the canal by a masonry tunnel 25′ span and then into the canal below the lower of 2 locks, of a total drop of 23 feet, which are situated just east of the aqueduct. The feeder is closed at its head by a double leaf balance beam lock gate, 25′ span, in each leaf of which are 3 large wickets worked by pinions engaging with iron racks fastened to wooden spiers, and it is also blocked at the entrance to the tunnel by a "bulk-head," in which are 5 large vents closed by shutters worked by screw gearing. The theoretic supply of this "Rexford Flat Feeder" is 10,797 cubic feet per minute. For the next 12 miles the canal runs along the left bank of the river at the foot of steep hills with considerable rock cutting, or "benching," in places. In this distance the channel is separated from the river only by the tow-path bank, 14 feet wide at top, and at different points there are 4 locks (including the 2 last mentioned), the water surface dropping to 188·33 + T. W. The canal then re-crosses the river by a composite aqueduct, the largest on the canal, known as the Lower Mohawk Aqueduct. When going over this part of the line I could see nothing in the appearance of the country on the right (south) side of the river, which suggested the necessity for incurring the great expense, both in construction and maintenance, of twice crossing the river, and on making enquiries I could get no more satisfactory explanation than that it was done for "political reasons." After leaving this aqueduct the canal continues on the same level for about 3 miles and then in 4 miles descends the slate rock escarpment which faces the Hudson, 163·33 feet (to level 25 + T. W.,) by 16 locks of


Section of Erie Canal showing old Wall Benches

Section of Erie Canal with Slope Wall 1½:1

Section of Erie Canal with Slope Wall 1:1

the usual double description and short distances apart. Just below the lower of these locks is the junction of the Champlain canal, by which water communication is established with lake Champlain and through it and the Richelieu river and canals, with the St. Lawrence, between Montreal and Quebec. Near the junction of this branch there is a weigh-lock. At rather more than a mile further on (eastwards) in West Troy (7 miles from Albany) is a channel known as the "Upper Side-cut" communicating with the Hudson by means of two "double" locks, of 12 feet drop each, about 100 yards apart. Half a mile or so beyond this is another similar channel known as the "Lower Side-cut," with a "combined". lock of two chambers, *not* "doubled." Further on there is a lock of 9½ feet drop, and at 352 miles from lake Erie at Buffalo, the canal ends in "Albany Basin," into which it is dropped by a "combined" lock of two chambers of 15½ feet drop. The basin is formed by an embankment about ¾ mile in length, a short distance out from the west shore of the Hudson river, wide openings being left at either end of the bank through which there is free communication between the basin and the river. This basin and its entrances require frequent dredging.

The Prism

The prism of the canal, as originally formed, was 28 feet at bottom, 40 feet at water surface, 4 feet depth of water: by the enlargement carried out between 1836 and 1862 these dimensions were increased generally to 42 feet at bottom, 70 feet at surface of water, and 7 feet depth of water, (it is doubtful if it was all taken out honestly to this depth) the revetment to take the wash of waves being founded only 3 feet below the surface on a berm or bench from 2 to 3 feet wide, the slope from which down to bed of canal was 2 to 1. This arrangement was found to interfere so seriously with the progress of boats that the removal of these "wall benches," as they are called, was decided on and they have now been all removed, excepting for a distance of about 29 miles on the tow-path side and 40 miles on the "berme" side, bringing the canal to a width of from 52 to 56 feet at bottom and 70 feet at water surface. The nature of this alteration will be understood from the accompanying sheet of cross sections of the canal.

Tow-path. The canal has only one tow-path, the bank on the opposite side being known as the "berme-bank." The top of the former is 14 feet wide, of the latter 10 feet, and they are from 2 feet to 3 feet above water surface, the water slopes being pitched on a slope of from 1 to 1 to 1¼ to 1, and the rear slopes being 2 to 1.

Cuttings. The most extensive *cuts* on the line of canal are the one through the rocky ridge near Lockport, about 2½ miles long and some 30 feet deep, and the one immediately west of this which is 4½ miles long and nearly of the same depth, but through earth.

Embankments. The heaviest *filling* is over the Cayuga marshes where the canal is carried on an embankment elevated entirely above the marsh, the average amount of earth-work being 142 cubic yards per yard run. There is also a heavy piece of embankment "2,200 feet* long and 80 feet above the bed of the Irondiquoit creek, which is passed under the canal by a stone-arch culvert of 23′ span and 324 feet in length."

Locks. The total numbers of locks on the Erie canal (exclusive of branches) are 71 "lift" locks and 2 "guard" locks on the main trunk, 4 lift locks on the "side-cuts" at Troy and West Troy, and one "ship lock", 200′ × 30′ at Black Rock harbor. All these locks, except the last named one and the two in the lower side cut at Troy are "double,"† that is, have two parallel chambers, generally about 30′ apart; each of the chambers is 110′ long between the quoins and 18′ wide, and between them runs a culvert through which, when necessary, passes the feed water to the next lower reach. There is no communication between the chambers or between them and the culvert, and they are filled generally through "wickets" in the gates and through culverts round them.

All the locks are of masonry, generally of limestone rubble with ashlar facings. In almost all cases they are built on a timber platform with transverse rows of sheet piling about 6′ deep below the sills and at each end of the work. The upper sill is kept only about 6 inches below the true bed, but the floor of the upper bay is at the same level as that of the chamber; a breast wall retains the bed of canal, and the space between it and the lift wall forms a "mud pocket.' The clapping sills are invariably of timber framed as trusses abutting on shoulders in the side walls and bolted down to the lift walls. The gates are of wood and generally "framed," worked by balance beams, but in some few cases the upper gates are "tumble" or "Heath gates," which will be noticed seperately. Under the arc travelled by the end of each balance beam is laid a rack (a plank with battens nailed across) into which a pawle near the end of the beam can be dropped to prevent the gate banging to. The anchor collars clasp the heel post without any intervening ring, and the friction therefore is great. The anchors generally have the ordinary wedges for tightening up, but sometimes have another arrangement which is simple and for small gates effective. On the gate end of each anchor strap is forged a loop through holes in which pass the ends of the collar strap terminating in screws with nuts.

* Extract from report of J. B. Fay, Esq., Division Engineer, for the year 1874.

† Locks having chambers end to end in a "flight" are on this canal called "combined locks."

In some cases the top of the mitre posts of intermediate gates of combined locks clap against a timber strutted out from wooden foot bridges crossing the locks.

The finest flight of combined looks is at Lockport; it is of 5 chambers with a total lift $55\frac{10}{12}'$. The parallel rows of chambers are 35′ apart. The masonry is of limestone, massive and handsome. The gates are ordinary-framed ones with balance beams and wickets in them, through which, as well as through culverts round them, the chambers are filled and emptied. Over the end of each chamber is a neat stone foot-bridge with iron railings and lamp post. The supply water is carried past these locks chiefly by a slope raceway.

I timed an ordinary canal boat and a steam tug in their passage through this flight of locks—the former took 36½ minutes, the latter 25 minutes, the difference being due to the steamer moving directly each gate was opened by her own motive power without delay, whilst the boat was "flushed" or "drawn" from chamber to chamber by slightly opening the wickets, a process requiring cautious movement.

Time in passing Locks

I visited many others of the locks on the canal, but there was nothing about their construction requiring separate notice; as, however, about the time occupied passing boats through locks on our Indian canals much has been said, I will here give some of the notes of my observations on the subject on the Erie canal, and in order to make the subject compact, I will include with them those made on one of its principal branches, the "Champlain Canal," on which the locks are also 110′ × 18′. I would premise that in most cases the lockmen seeing that I was timing, appeared to do their best to show their locks off to advantage, and that all my observations were by daylight and that the time required to pass boats during the night is on the average one-third longer than that required in the day :—

No. 3 Lock (the lower of a series of 14 in 4 miles, between West Troy and Lower Mohawk Aqueduct) lift 11½.′

	h. m.
Upper gates open, loaded boat going eastwards commenced to enter	4-49½
Upper gates shut	4-51
Boat lowered till deck came even with coping, then all valves shut, two mules landed from boat and the two which had been towing taken on board	4-52
Re-opened all the wickets (4)	4-53
Commenced to open the lower gates	4-54¾
Boat clear out	4-56

Total operation, 6½ minutes.

Same Lock—Upper gates being open,

Boat commenced to enter	5
Lower gates open	5-4¾

Lock 48 (with upper gates of "tumble" or "Heath" pattern, lift 10½).

	h. m.
Lightly laden boat going westwards entered.	11- 9½
Upper gates closed (actual closing did not take ½ minute)	11-10¼
Lower gate opening commenced	11-12½
Boat clear out	11-15

Complete operation, 5½ minutes.

Lock 49—Lift 6′ (gates ordinary pattern.)

	h. m.
Lightly laden boat going westwards commenced to enter	10-42
Upper gates closed	10-43½
Lower gates opened	10-46
Boat clear out	10-49

Complete operation, 7 minutes.

Lock 11—on "Glens-Falls" feeder, Champlain Canal, upper gates "tumble," ("Heath") pattern, lift 11′.

	h. m.
Boat with 113 tons of coal coming upwards commenced to enter	8- 5
Lower gates shut	8- 8
Lock full	8- 9¾
Gate opened in 30 seconds and boat clear out	8-13

Total operation, 8 minutes.

Flight of Locks (3 chambers) at north end of Champlain Canal, total lift 28′.*

	h. m.
Upper gates open, boat commenced to enter.	3-30
Upper gates shut	3-32
Second gates opened	3-35¼
" " shut	3-39¾
Third gates opened	3-42
" " shut	3-45
Lower gates opened	3-47¾
Boat clear out	3-50

Total time, 20 minutes.

The above observations would give about 6 minutes a lock, but it must be remembered that to arrive at the total effective capacity of a lock there must be added to the time actually occupied in passing a boat through it, the time which must elapse after the passing out of each boat before it is possible for another to take up its position in the entrance to the lock.

At a special trial with all preparations made for securing favorable results, 198 boats were, in 1848, passed through a single chamber in 24 hours, or one in 7½ minutes.

* (NOTE.—The two middle gates have not wickets in them as upper and lower ones have; water is taken round them only, by culvert with two vents.)

The largest number of lockages actually made in one season at double lock No. 26 (which has been described as "in the throat of the canal") was, in 1852, 42,967, and as that season was of 239 days duration the daily average was 180. The largest monthly total at the same lock was, in October, 1847, 6,930, a daily average of 224.

A lock of course delays a boat not only by the time occupied in actually passing it, but also by the loss of time in the reduced speed necessary on approaching and leaving the lock; the loss caused by the last two items increases positively with increased size and burden of boats and relatively with their increased average speed. The total delay now caused by each lock on the Erie canal is certainly on an average not much under 15 minutes or $17\frac{3}{4}$ hours on the whole trip from Buffalo to Albany, and this it is improbable will ever be reduced below 10 minutes to each lock or $11\frac{5}{6}$ hours on the whole trip.

Tumble gates. For upper gates of locks these have many advantages over the ordinary swing gates; they are worked more easily and quickly, they cost less in construction and maintenance, and they are tighter.

The accompanying plan (see No. 54 in Vol. of Plans) shows the details of one of these gates fitted to an Erie canal lock in which there had been formerly one of the ordinary double leaf swing gates. From this it will be seen that the tumble gate is in one piece across the full width of the lock, its bottom is rounded on the lower side fitting accurately into a corresponding groove in a timber bolted down to the lift wall. At the ends of the bottom beam are metal journals working in bearings fixed in the recesses in the side walls, about which the gate can revolve. When up, it claps at its sides against two vertical side posts and when down it rests on the floor of the head-bay, (which has to be as much below the level of the sill as the thickness of the gate may require), either on the truss with which in some cases it is provided at its top or on special wooden studs. The gate is planked on each side of its frame and in the space between the planking is so loaded, usually with stones, that when up against its clapping posts it has no tendency to fall away from them but being drawn forward till out of

the perpendicular a few degrees, it will sink to the bottom. To the front side of the top of the gate is attached a chain which passes down to and round a guide sheave fixed on the floor of the bay, clear of where the gate falls to, and then up to a drum actuated by a winch, round which drum it makes a turn and then passing along the side of the recess over guide wheels passes round another guide sheave and is attached to the back of the top of the gate.

When the lock is full, a few turns of the winch winding on the chain which passes through the front guide sheave drags the gate forward to the angle from which its own gravity takes it gently to the bottom, where it remains till the winch being turned the reverse way it is lifted. In practice I found that the vents for emptying the lock were generally commenced to be opened directly a boat had passed out and the current thereby created closed the upper gate itself, so that the gate was worked with but little labor and attention by one man.

In a few cases locksmen stated that they did not like these tumble gates because they frequently got out of order, but in all such cases I found on enquiring particulars that it was the valves or wickets, with which these gates were in all cases combined, and not the gates themselves, that were the sources of trouble. The style of those valves, closing vents on the floor of the upper bay through which water drops and passes into the chamber through the lift wall, will be seen from the drawing, and it is evident that the long rods with jointed elbow levers by which they are actuated are very liable to get out of order and the wickets themselves must often get jammed by drift. The universal use of these valves with the tumble gates is doubtless due to the desire to keep the depression into which the gate falls quite clear of deposit, but the same result might in most cases be obtained by vents in the side walls at, or slightly below, the floor level, and with such arrangements the superiority of the tumble gates at the upper ends of the Erie canal locks would be more marked than it now is. Whether such gates would be equally suitable on our Godavery and Kistna canals is doubtful, because on them boats are usually poled in and out of the locks.

Aqueducts. The principal aqueducts over streams are—

(1.) The Rochester aqueduct (visited 12-7-76) over the Genesee river at Rochester, 259 miles from Albany and 93 from Buffalo. This is the largest masonry aqueduct on the whole canal. It is 820′ in extreme length, and across the stream proper has 7 segmental arches of 52′ span and 10′ rise, and 3 smaller arches over mill races. The abutments and piers are only about 3′ to 6′ high from bed of stream which is of rock. It has a waterway, 43′ wide with two side paths of 12′ each, only one of which is used as a tow-path, and that is covered with planks and earth, the other path being on the coping stones of the side wall; both paths have iron railings on the outside. Through the face wall at the north-west corner pass four 2′ iron pipes closed by valves worked by screws from the tow-path, through which water can be discharged into the river. The superstructure is of well-dressed limestone, and the whole work is said to have cost 600,000, dollars.

(2.) The Richmond aqueduct over the Seneca river near Montezuma. This is what is known as a "composite" structure, being partly of wood and partly of stone. The length between ends of wings is 894½′. The tow-path with its parapets, in all 16′ wide, is carried on 31 segmental arches of 22′ span and 8′ rise. The duct or "trunk" is a wooden trough 50′ wide supported on prolongations of the piers (5′ wide.) The foundations, which are said to cover 2 acres, are bearing piles on which the piers and abutments rest, with sheet piling all along the upper and lower faces of the work, and a planked flooring carried by joists resting on the piles. The whole cost of the structure, exclusive of approaches, was 150,000 dollars. Plan* C in the book of plans accompanying the Annual Report of the State Engineer for 1859, which accompanies these notes, gives the details of this work.

(3.) The upper Mohawk aqueduct (visited 20-6-76) over the Mohawk river, 26 miles from Albany. This is a "composite" structure of 14 arches of 38′ span with a duct or "trunk" 607′ long and 40′ wide, similar in general construction to the Richmond aqueduct, but the spans being greater

* No. 35 in Vol. of Plans.

the sides of the "trunk" had to be "trussed" and supported by straining struts and beams. It is founded on rock.

(4.) The Lower Mohawk aqueduct (visited 20-6-76), 14 miles from Albany. This is the largest aqueduct on the canal. It is a "composite" structure, its tow-path being carried by 26 stone arches of 38′ span and the wooden trunk being 1,130′ long and 40′ wide, similar in design to the last noticed one. It is founded on rock and cost 331,000 dollars.

These composite aqueducts are handsome works viewed from the side on which the arches appear, but are the reverse when looked at from the other side. The timber of the troughs being thoroughly wet on one side and only moist on the other from splashing and soaking, must rot quickly, as it bears every appearance of doing, and the maintenance of such ducts probably costs more than would the interest on the extra cost of masonry ones. I am told, however, that a wooden trough is less liable to injury when the water in it freezes than is a masonry one, and is for that reason preferred by many American Engineers.

There are on the Erie canal, exclusive of its branches, 541 bridges, of which 190 are of iron, 1 of stone, and the rest of wood. The standard headway is 12 feet. There is only one tow-path under a bridge, the abutment on the other side being built in the line of the toe of the "berme" bank; the span is, as a rule, 72 feet. The width of roadway is for "Farm Bridges" 12 feet; ordinary road bridges 16 feet; more important road bridges 19 feet; street bridges, according to circumstances. The wooden bridges are almost invariably queen-post trusses, of which plans* B and P in accompanying book of plans give details. Those for roads and streets now cost, as regards the wooden superstructure, about 850 dollars each. The life of these bridges, built as they are of soft wood, is considered to be only 8 years. Bridges.

The iron bridges are of many different styles and no particular pattern has been adopted as a standard one, but I think, amongst practical men on the canal I found a preference for "Whipple's patent arch truss," in which the arch is made up of castings about 12 feet long, easily handled

* Nos. 34 and 41 in Vol. of Plans.

and put together. Of this simple and excellent bridge details will be found in plans* D and E in accompanying book of plans issued with Report of the State Engineer and Surveyor for 1859. The cost of the iron bridges (superstructures) on the canal is about 2½ times that of the wooden ones, or about 30 dollars per foot run. A *street* bridge with side walks costs about 10,000 dollars. In some of the large towns, such as Syracuse, swing bridges are provided for the chief streets; they are said to cost for working them "as much as the interest on 25,000 dollars."

Supply of water. An adequate supply of water to the various reaches of the canal to take the place of that lost by evaporation, filtration, leakage, and lockage, is of course essential, and has been arranged for by feeders from lakes, rivers, and artificial reservoirs. From the following table, (see page 72), compiled from official documents, which shows all the feeders of the canal, it will be seen that by far the greater part of the supply is drawn from various natural lakes lying above the level of the canal, and from the Mohawk river near which the line runs for upwards of 100 miles. The works connected with the feeders from the *natural lakes* are not of special interest. From the *rivers* the supply is obtained by ponding them up by dams of stone and wood similar in character to that at "Rexford Flats," of which a section is given in the margin, at page 9.†

Erieville Reservoir. Of the *artificial reservoirs*, the one at Erieville is one of the most interesting, and this I visited (11-7-76.) It is of no great size, only 340 acres in area, but it has the considerable average depth of 21½ feet and the supply is drawn off at a depth of 45 feet from the surface in a way not often adopted with such a considerable head, namely, by pipes running through the embankment, and closed at their *outer* ends at toe of the embankment; for upwards of 25 years this inexpensive method has here been in use without failure.

In the book of plans, &c., accompanying the report (I was not able to get hold of any copy of the report) of the State Engineer and Surveyor for 1859, which is sent with these notes, will be found some details of the discharge pipe arrangements.* The pipes are 22 inches in diameter, set 12 inches apart in a surrounding mass of concrete on a stone wall 6′ 8″ wide and 4 feet deep, which rests on a wooden floor or platform 7′ 8″ wide. At the front—reservoir—end of these pipes is a chamber enclosed by a strainer grating. At their outer ends these pipes are turned down and discharged into a 10 feet diameter well, 10 feet deep, from which a 4-feet diameter circular culvert leads to the open channel along which the water flows to the Cazenovia lake and so to the canal, at 152 miles from Albany. The end of each of these pipes passes through an iron casing in which slides an iron door or valve lifted or forced down by a screw shaft working through a revolving screw box, or nut, turned by multiplying rack and pinion gearing.

* Nos. 36 and 37 in Vol. of Plans.

† "This refers to the MS. notes."

The surplusing provision for the reservoir I found to consist of a waste weir with crest 10 feet below top of embankment and 30 feet in length, over which the water falls 3 feet into a chamber from which a culvert or tunnel with semi-circular arch 6′ span, side walls 9″ high, passes through a natural spur to its rear slope, and from there a masonry lined raceway runs down to the channel from the discharge pipes.

* "No. 48 in Vol. of Plans."

[*Table of Supply.*]

ERIE CANAL.—*Table of Supply of water and its sufficiency for Lockage.*

1	2	3	4	5	6	7	8
Reach.	Length in miles.	Average lift of locks.	Feeders.	Supply in 24 hours in cubic feet.	Evaporation, filtration and leakage in 24 hours at 200 cubic feet per mile per minute.	Net supply available in 24 hours in cubic feet.	Number of boats which net supply is sufficient to lock in 24 hours.
		Feet			Cubic Feet.		
Buffalo Harbor to Lockport Locks ...	31	...	Lake Erie	Supply practically unlimited.			
Lockport to Clyde...	111	9	Lake Erie.............	50,400,000			
			Oak Orchard Feeder	2,016,000			
			Genesee Canal......	1,239,840			
			Genesee River.	504,000			
				54,159,840	31,968,000	22,191,840	1,245
"Montezuma" Level.	16	...	Supply from reaches on both sides—No Locks.				
Port Byron to Geddes	25	$8\frac{1}{2}$	Owasco Lake..	5,807,520			
			Putnam Creek	288,000			
			9 Mile Creek	1,152,000			
			Carpenter Brook. ...	288,000			
			Skaneateles Lake...	10,828,800			
			Otisco Lake..........	7,440,240			
			Camillus Feeder......	2,160,000			
				27,934,560	7,200,000	20,734,560	616
Geddes to Syracuse Lock....................	3	...	Supply from reaches on both sides—No Locks.				
"Long" or "Rome" Level from Syracuse to Utica......	56	6	Butternut Creek....	720,000			
			Jamesille River......	864,000			
			DeRuyter and Limestone Creek.........	3,160,800			
			Erieville Reservoir, Chittinango Creek, Cazenovia Lake...	4,240,800			
			Cowaselon Creek....	460,800			
			Oneida Creek.........	2,160,000			
			"Delta" Feeder......	1,863,360			
			Mohawk Feeder at Rome................	16,913,040			
			Butt's Creek..........	2,016,000			
			Oriskany Creek......	6,192,000			
				38,620,800	16,128,000	22,492,800	*950
Utica to Albany......	110	$9\frac{1}{2}$	Chenango Canal.....	1,311,840			
			Ilion Creek...... ...	1,152,000			
			Mohawk River (Little Falls)...........	18,205,920			
			Mahawk (Rocky Rift)	15,266,880			
			Schoharie Creek	9,792,000			
			Mohawk River (Rexford Flats).........	16,809,760			
			" Cohoes ...	9,460,800			
				70,999,200	31,680,000	39,319,200	1,045

In column 8, 1 lockfull taken as used by *each* boat.

* Being a "summit" level, 2 lockages are required for each boat that passes through it.

Navigable capacity.

The navigable capacity of a canal is, of course, restricted to the number of boats of the largest size plying on the canal, which can be passed through its locks in a given time.

On the Erie canal, taking 300 as the number of lockages which can be made in 24 hours by each double lock (an average of 9 $\frac{5}{12}$ minutes to each lockage) and 200 tons (the average for 1874 was 197 tons) as the load of each boat, then 60,000 tons is the daily, and 12,600,000 tons the yearly, capacity of the canal for a season of 210 days. (The greatest tonnage ever actually carried on the canal *and all its branches* in one year was 6,673,370 *tons.*) But the traffic to pass eastwards is greatly in excess of that going westwards, and as boats must return, the effective tonnage passed by each lockage is reduced to the mean between the two loads carried by boats on the "round trip." For the last 5 years, the westward-going traffic has been only $\frac{1}{4}$ of that going eastward, and were the latter to increase the former would probably not do so in the same ratio; but assuming it to do so, then the 300 lockages a day would pass only 7,875,000 tons both ways a season, and 6,300,000 tons may be taken as the ultimate capacity of the canal with its present locks for passing western produce to the markets of the east. This is more than double the greatest quantity (2,917,074 tons in 1862) hitherto delivered by the canal in one season at tide-water, exclusive of that brought to it by the Champlain canal which can pass to the Hudson without using any lock on the main canal. Regarded in this way merely as a question of actual capacity, the canal is large enough not only for its present duties but also for those likely to be imposed upon it for many years to come. But there are two other elements, intimately connected one with the other, on which the usefulness and prosperity of the canal depend—they are *Time* and *Cost of transport.* These, it seems probable, could be lessened by merely making the canal *really* of the full dimensions, especially in depth, which it now is only *nominally*, and this is what Governor Tilden considers to be all that is at present required to revive the drooping fortunes of the canal. He says, in one of his messages (dated 5th January, 1875,) to the Legislature of the State of New York. :—

* * "The water-way was practically never excavated in every part to

its proper dimensions. Time, the action of the elements, and neglect of administration, all tend to fill it by deposits. I may be excused for repeating here what I said in the Constitutional Convention eight years ago;—'What the Erie canal wants is more water in the prism; more water in the water-way.' A great deal of it is not much more than 6 feet, and boats drag along a little skin of water; whereas it ought to have a body of water larger and deeper even than was intended in the original project. Bring it up to 7 feet—honest 7 feet—and on all the levels, wherever you can, bottom it out; throw the excavation upon the banks; increase the 7 feet toward 8 feet as you can do so progressively and economically."

He also says, in another part of the same message :—

* * "The question of altering the gates of the locks, or otherwise lengthening the chambers, may be safely deferred until we can be more sure of its utility."

That the action advocated by Mr. Tilden would lessen the time of transit, reduce the cost of carriage and increase to some extent the traffic on the canal, is certain; but unless the locks be also enlarged I doubt if it will be possible to successfully introduce steam as the motive power on the canal, and by steam alone can be effected the great saving in the time of transit which is necessary to enable the canal to hold its own against the competing railways. *Some* saving might be secured by expediting the lockage, but this could be but slight and immaterial.

Time of passing through canal.

The average time now taken by a fully-laden boat in going from Buffalo to New York is 13 days, of which 11 days are consumed on the canal, where the towing is done by animal power, and 2 days on the Hudson river where it is done by steam tugs, which take several boats in tow at one time. The average speed on the canal (352 miles from Buffalo to Albany) is therefore $1\frac{1}{3}$ mile an hour. Taking the time due to the lockage as 11 hours, it still leaves the average speed on the reaches between the locks under $1\frac{1}{2}$ mile an hour. The delay in passing each lock, including the loss of time in slackening speed in approaching it, and in getting way on the boat on leaving it, could scarcely be reduced below 5 minutes, and such reduction would amount to only 5 hours or a little less than 2 per cent. on the whole time of transit on the canal. It is evident, therefore, that any improvement in speed to be of importance must be made on the level reaches where 98 per cent. of the time is

consumed; and only by the substitution of steam for animal power does such an improvement seem possible.

Steam on the canal.

The State of New York, appreciating the importance of this subject, its Legislature, in the Session of 1871, passed an Act which provided for—

"The payment of a reward of 100,000 dollars for the accomplishment of certain results, under the conditions therein stated, and which appointed a commission to supervise the experiments and trials, and to make such awards, under the Act, as the results attained might justify."

A copy of that Act is given as an Appendix to these notes. The liberal offer of the State attracted public attention in several countries. In 1871, one steamer was placed on the canal for trial and in the season made two round trips between New York and Buffalo. She did not, however, fulfil the conditions laid down. In the season of 1872, twelve steamers were placed on the canal: some soon proved failures leaving only 3 to compete. The general results attained by these steamers are thus summarised in the State Engineer's Report for 1874 :—

"1. THE WILLIAM BAXTER.—This boat left West Troy, on her first trip west, on the 29th of August. 1872, and ended her third round trip at the same point on the 14th of November.

Deducting detentions, and allowing ten hours for lockages, per single trip, the average speeds and cargoes of the Baxter were as follows :—

Trips.	Tons, cargo.	Average speed. Miles an hour.
First trip west	102·25	2·89
First trip east	201·60	3·38
Second trip west	113·12	3·41
Second trip east	201·	3·06
Third trip west	114·5	3·45
Third trip east	201·	4·48
Mean speed...	......	3·29

The average coal consumption was 31·04 pounds per boat mile.

The power expended appeared to vary from about 23 to about 33 horses and the coal consumption about 3½ pounds per horse-power per hour.

The apparent slip of the screw was found to be about 12½ to 33 per cent., while the actual slip varied from 23½ to 25 per cent.

The estimates of the Engineer showed that by the Baxter system, a saving of from 26½ to 50 per cent. could be effected in the cost of canal transportation."

The Engineer, in his report, said: "As an experiment, at least, I regard the 'Baxter' as eminently successful."

2. The William Newman.—"This steamer began her three trips at Buffalo on the 31st of August, and completed them at the same point on the 7th of November. Her general performance is indicated in the following table, in which the speeds are determined as in the case of the Baxter :—

Trips.	Cargo, tons.	Average speed. Miles an hour.
First trip east	201·6	2·50
First trip west	114·	2·81
Second trip east	201·	2·64
Second trip west	127·75	2·77
Third trip east	204·4	2·76
Third trip west	101·9	2·88
Mean speed...	......	2·727

The average coal consumption was 65·21bs. per boat mile.

The power expended was from 30 to 35 horses, while the slip of the screw was about 42 per cent.

The Newman made an average of 3·26 miles per hour on her eastern trips, between Buffalo and Rochester only. On the third trip west, an average of 3·02 miles was made between Utica and Syracuse. In no other case did the Newman's speed reach three miles for any considerable distance.

3. The Port Byron.—This steamer left West Troy on her first trip, on the 3rd of July, and completed her third trip at the same point on the 19th of November.

Whilst making an average speed of 2·9 miles per hour on her last trip east, the average power expended, for the distance of 6½ miles, was 48 horses, and the mean slip of the paddle wheel was 67½ per cent. The average coal consumption was, at least, 64·4 pounds per boat mile.

The general performance of the Port Byron, as to cargoes carried, and as to speeds attained, was as follows" :—

Trips.	Cargoes, tons.	Average speed. Miles an hour.
First trip west	100·0	2·59
First trip east	200·2	2·05
Second trip west	126·0	2·53
Second trip east	200·2	2·58
Third trip west	117·0	3·45
Third trip east	198·4	2·91
Mean speed...	......	2·685

As the power required to move 200 tons westward, against the current, at the rate of 3 miles an hour, is much greater than that required to do the same work eastward, in which direction is by far the greater movement of freight, the Committee, towards the end of the season of 1872, passed 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 the 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 20 hours for each trip from Buffalo and proportional allowance will be made if the trial is from Oswego."

The time for competition also was extended for a year, and in the season of 1873, six steamers were brought to the notice of the Commission. The tables hereto attached are summaries of results of public trials between Syracuse and Utica (56 miles), from which trial, however, one of the steamers (the "City of New York" a "Baxter" steamer) was absent.

TRIAL of Canal Steamers between Syracuse and Utica, October 15th and 16th, 1873.

NAME OF PLACE.	Distance from Syracuse. Miles.	WM. BAXTER—SPEEDS. (Miles per hour.) Point to point.	WM. BAXTER—SPEEDS. From Syracuse.	WM. NEWMAN—SPEEDS. (Miles per hour.) Point to point.	WM. NEWMAN—SPEEDS. From Syracuse.	C. C. POPE—SPEEDS. (Miles per hour.) Point to point.	C. C. POPE—SPEEDS. From Syracuse.	PORT BYRON—SPEEDS. (Miles per hour.) Point to point.	PORT BYRON—SPEEDS. From Syracuse.	CENTRAL CITY—SPEEDS. (Miles per hour.) Point to point.	CENTRAL CITY—SPEEDS. From Syracuse.
Syracuse	0	......	......	......	......	......	......	......	......	......	......
Lodi	1	3.12	3.12	4.39	4.39	1.54	1.54	2.50	2.50	1.04	1.04
Limestone Feeder	7	3.82	3.70	......	......	......	......	......	......	......	......
Manlius	8	1.20	2.94	2.44	2.58	2.26	2.13	2.06	1.89	2.08	1.85
Kirkville	11	3.41	3.06	2.78	2.63	2.66	2.25	3.00	2.10	2.41	1.62
Pool's Brook	12	2.38	2.99	1.92	2.55	1.76	2.20	1.33	2.01	1.92	1.98
Bolivar	14	3.23	3.02	2.35	2.52	2.41	2.23	......	......	2.17	2.00
Chittenango	15	2.73	2.99	0.73	2.16	1.88	2.19	2.26	2.05	1.50	1.96
New Boston	17	1.79	2.77	......	......	1.54	2.09	1.60	1.99	1.41	1.96
Canastota	21	3.00	2.81	2.88	2.33	2.68	2.19	2.29	2.03	3.33	2.05
Lenox Basin	23	2.27	2.75	......	......	......	......	0.92	1.84	1.41	1.98
Durhamville	26	3.45	2.52	1.71	2.18	......	......	2.11	1.87	2.26	2.00
Dunbarton	30	3.33	2.87	......	......	......	......	......	......	1.88	1.96
New London	35	2.78	2.86	1.45	1.92	2.41	2.27	......	......	2.08	1.98
Rome	41	2.47	2.80	2.07	1.95	2.08	2.24	2.28	2.00	2.13	2.02
Oriskany	49	3.20	2.86	3.05	2.07	3.23	2.36	2.91	2.11	3.20	2.16
Whitesboro	52	3.41	2.88	3.45	2.12	3.15	2.39	......	......	2.86	2.19
New York Mills	53	2.22	2.87	3.33	2.13	2.86	2.40	......	......	2.86	2.20
Utica	56	3.89	2.91	3.33	2.17	3.89	2.45	2.97	2.19	3.65	2.25

NOTE.—In the above 8.6 minutes are allowed for each lockage. The detentions at Rome are also deducted from the total time.

SUMMARY of Results of Trial of Canal Steamers between Syracuse and Utica, on the 15th and 16th of October, 1873, under the direction of the Commission appointed under Act chapter 868, Laws of 1871.

Number.	NAME OF STEAMER.	TIMES. Total from Syracuse to Utica.	TIMES. Detentions in locks and at Rome.	TIMES. Other detentions.	TIMES. Running time.	SPEEDS. Syracuse to Utica, miles per hour.	SPEEDS. Syracuse to Rome, miles per hour.	SPEEDS. Rome to Utica, miles per hour.	SPEEDS. In still water, miles per hour.	COAL CONSUMPTION. Total, lbs.	COAL CONSUMPTION. Per mile, lbs.	PROPELLING INSTRUMENT. Speed of, miles per hour.	PROPELLING INSTRUMENT. Apparent slip, per cent.
		H. M.	H. M.	H. M.	H. M.								
1...	William Baxter	20 09	0 53.4	1 09	18 06.6	3.09	2.92	3.53	3.40	830	14.82	4.55	32.1
2...	William Newman	27 08	1 31.4	3 57	21 39.6	2.59	2.41	3.48	2.89	4,000	71.5	7.68	66.3
3...	C. C. Pope	26 35	3 44.4	0 25	22 25.6	2.50	2.29	3.29	2.77	2,520	45	5.17	51.6
4...	Port Byron	29 ...	3 25.4	3 01	22 33.6	2.49	2.29	3.25	2.77	5,425	96.9	7.59	67.2
5...	Central City	27 52	2 59.4	2 43½	22 09.1	2.53	2.29	3.52	2.77	7,080	126.43	5.72	54

NOTE.—The speeds, in still water, are determined by adding to the speeds between Syracuse and Rome (against the current) one-half the average difference between the speeds east and west of Rome.

There were some further trials in which the "William Baxter" on a dark stormy night ran from Utica to St. Johnsville, 34 miles, with the following general results:—

Average speed less all detentions...............	Miles	3.26
" " " detentions in 12 Locks.....	"	3.03
" " " " other than Locks	"	2.97
" " including all detentions.........	"	2.77

Total time occupied, 12 hours 16 minutes.

Coal consumption per mile, 18.18 pounds.

The Commission then reported, and in accordance with their recommendations the Legislature passed the following Act:—

"Section 1. The Comptroller shall pay William Baxter, or his legal representatives, upon the presentation of the certificate of the State Engineer and Surveyor, that the said William Baxter has placed during the season of navigation of eighteen hundred and seventy-four, upon the canals of this State,-seven steam boats fully equipped, and being in all respects equal in power and capacity to the steam canal boat "City of New York," to fulfil the requirements and conditions of chapter eight hundred and sixty-eight of the Laws of eighteen hundred and seventy-one, the sum of thirty-five thousand dollars. And the Comptroller shall in like manner, upon the certificate of the State Engineer and Surveyor, pay to David P. Dobbins, or his legal representatives, whenever he shall, within the season of navigation of eighteen hundred and seventy-four, have placed upon the canals of this State, three steam-boats, each fully equipped, and being in all respects fully equal in power and capacity to fulfil the requirements and conditions of chapter eight hundred and sixty-eight of the Laws of eighteen hundred and seventy-one, to the steam canal boat "William Newman," the sum of fifteen thousand dollars.

"And the Comptroller shall in like manner, upon the certificate of the State Engineer and Surveyor, pay to Theodore Davis, or his legal representatives, whenever he shall, within the season of navigation of eighteen hundred and seventy-four, have placed upon the canals of the State, one steam-boat, fully equipped, and being in all respects fully equal in power and capacity to fulfil the requirements and conditions of chapter eight hundred and sixty-eight of the Laws of eighteen hundred and seventy-one, to the steam canal boat "Central City," the sum of five thousand dollars.

Section 2. This Act shall take effect immediately."

The conditions of this Act having been complied with, the payments authorized in it were made.

The ownership of the steamers placed on the canal by William Baxter and David P. Dobbins passed into the hands of the "Baxter Steam Canal Boat Transportation Company," whose operations during the season of 1874

gave such promise of success that the State Engineer, in his report for that year, says:—

"The Baxter boats have demonstrated, beyond reasonable doubt, their ability to not only equal, but to exceed, the Estimates of the Engineer of the Commission, both as to speed (3 miles an hour) and as to economy of movement."

There is no report later than the one just quoted from, and I have, therefore, been unable to ascertain what the steamers did in the season of 1875; but I regret to state that the belief, that financially successful steam navigation of the Erie canal had been secured, has proved delusive, for at the time of my visit (June and July, 1876), I could find only one steam-boat running on the canal, and I was informed that the Baxter Company had lost money by their boats and had ceased to exist. The truth is, I believe, that the canal is too shallow for the successful working on it of boats carrying cargo and their own motive machinery, and the system of towing strings of barges by powerful tugs which obtains so largely on the rivers cannot be introduced on the canal whilst the locks are only big enough to pass one boat of a tow at a time, because the lockage delay of each boat would be increased by the time occupied in passing all the others, and *that* would be increased by the necessity of "shifting" (emptying or filling) the lock between the passing of each successive boat.

Description of the "Baxter."

A description of the "Baxter" tug taken from the report of the Engineer of the Commission, dated 18th Feb., 1873, here follows:—

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 8½ 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-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 46¼ 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 ⅝ 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.

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

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, 4½ 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."

Belgian system of steam-towing.

The "Belgian" or "Cable" system of steam-towing has also received a trial on this canal, a Company called the "New York Steam Cable Company" having laid a cable from Buffalo to Lockport (31 miles), and for two or three years kept two tugs working on it. A trial of one of these tugs is thus described in a report of Mr. B. M. Greene, dated 17th Feb., 1874:—

"At 10 A. M., the "Caleb" left Lockport light and reached Pendleton, 7 miles, at 11-45 A. M. The average speed between these points was, therefore, 5.26 miles per hour. At 12-30 P. M., 450lbs. of coal had been used in running about 11 miles. At this time a boat carrying 100 tons was taken in tow and Tonawanda was reached at 3-10 P. M.; the Caleb having made an average of 3.46 miles per hour, including detentions, with a consumption of lbs. 800 of coal in a distance of 19 miles. The last 8 miles was made in 2 hours 40 minutes with one boat in tow and with a consumption of lbs. 350 of coal. Here we have a speed of 3 miles per hour, with a coal consumption of lbs. $43\frac{3}{4}$ per mile. At Tonawanda four 200 ton boats were added to the tow which then consisted of 5 boats carrying 875 tons of cargo. The tow left Tonawanda at 3-45 P. M., and reached Black Rock, 8 miles distant, at 7-20 P. M. The average speed between Tonawanda and Black Rock was, therefore, 2.23 miles per hour. The coal consumption between the same points was lbs. 1,100, or 137.5lbs. per mile, equivalent to 27.5lbs per mile for each boat exclusive of the tug."

In the same report Mr. Greene gives the following description of the tugs :—

Description of Cable-tugs.

"These tugs are fitted up as propellers, with the ordinary engine, having a cylinder 13″ × 13″, and a screw $4\frac{1}{2}$ feet in diameter at the stern; besides which there are placed, near the centre of the tug, the boiler and the towing machinery proper. This towing machinery consists of two engines, which, upon the tug "M. M. Caleb," are 10 inches in diameter by 12 inches stroke of piston. These are connected at right angles, and upon the main shaft there is provided a gear-wheel, which admits of being so adjusted to a train of wheels that the motion of the engine may be reduced, either in the ratio of 3 to 1 or of 6 to 1, as may be required by the varying duty of the tug.

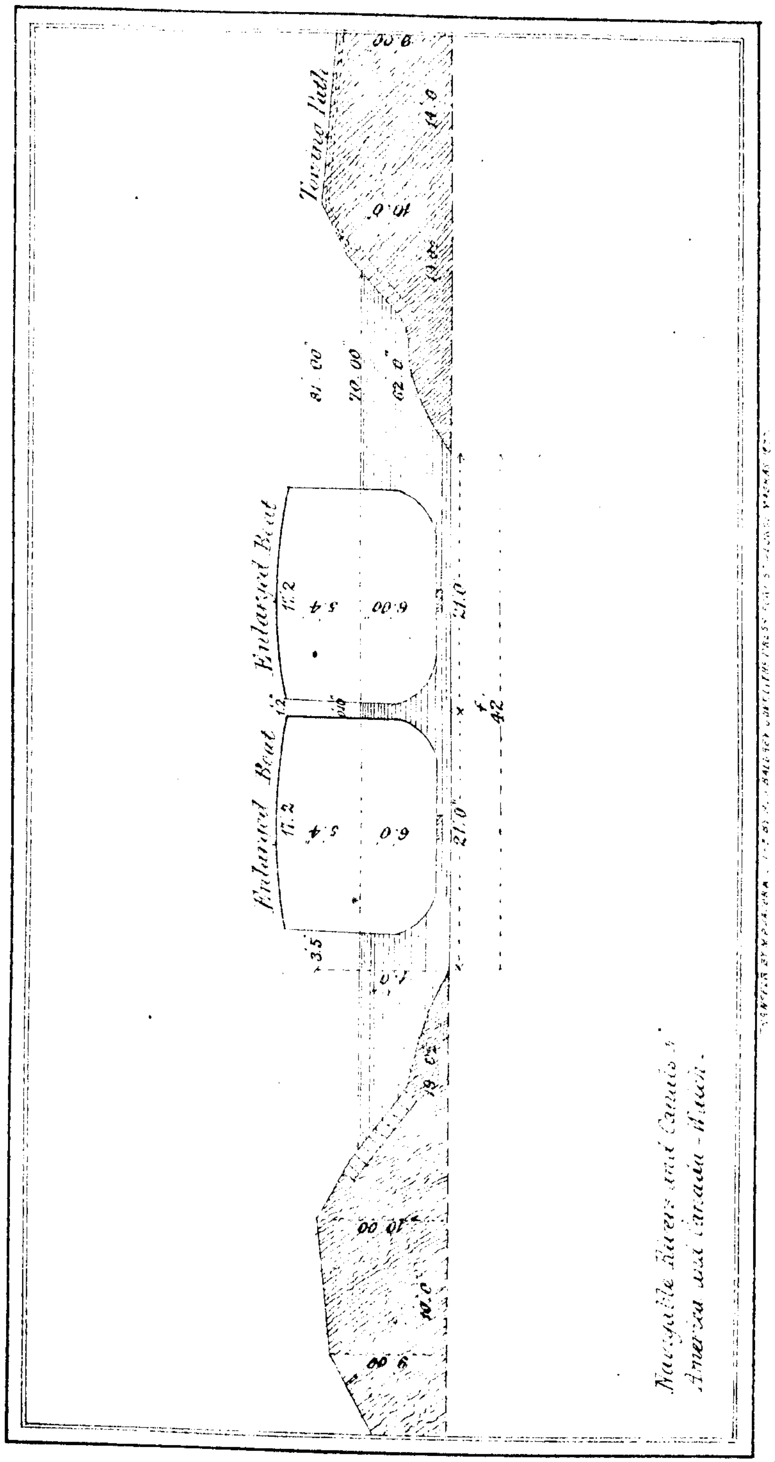
For heavy tows and low speeds, the ratio of 3 to 1 is employed; while for light tows and higher rates of speed, the ratio of 6 to 1 is employed.

Upon one side of the tug are placed, at bow and stern, guide pulleys, about 16 inches in diameter, the frames of which admit of free motion in all directions laterally. The cable, after passing over the pulley at the bow, passes under a tightening pulley about 6 feet in diameter; thence it passes over the "clip-drum," which is 6 feet in diameter, and placed nearly amidships; thence under a second tightening pulley, similar to the first, and finally over the guide pulley at the stern.

The "clip-drum" is provided with, and takes its name from, a series of clips about its entire circumference, which are so arranged that the cable, as it reaches the drum, is seized and held firmly until it is about to pass off upon the opposite side, when it is promptly released.

The boiler of the Caleb is horizontal, return tubular, about 5 feet in diameter and 11 feet long. The fire grate is 4 feet 6 inches wide, and 5 feet 3 inches long, containing 23·63 square feet. The tubes are 34 in number, $2\frac{3}{4}$ inches in diameter, and 4 feet long. The return tubes are 44 in number, $2\frac{3}{4}$ inches in diameter, and 10 feet long."

The economical application of power by this system is undoubted, but there are great practical difficulties in working it where there are many locks, and the loss of time that would be caused at each of the present sized locks by the detention of whole tows, whilst all the boats composing it passed separately, is in itself enough to prevent the success of any tug service. The system, therefore, has never been extended beyond the Lockport locks, and when I was there only one of the tugs was on the canal, and that one, I was



informed, only occasionally found employment and scarcely paid working expenses.

Boats.

The boats now in use on the canal are all flat-bottomed and generally of the cross section shown in attached sketch. The average measured tonnage of the great majority of them is bewteen 200 tons and 240 tons, and the actual cargoes carried by all boats averaged, in 1873, 213 tons and in 1874, 197 tons. They are towed by horses or mules, generally by two, which are mostly hired, but sometimes belong to the boatmen, in which cases four animals are kept, two getting their food and rest on board, whilst the other two are tracking, changes being made at locks or other convenient places. The number of boats plying regularly on the canal is between 6,000 and 7,000, and they are said to give employment directly to about 30,000 persons, and indirectly to 20,000 others.

Cost of construction.

The total cost of the construction of the Erie canal (exclusive of branches) to end of 1874 was 49,058,865 dollars.

Income from tolls.

The tolls of the canal (exclusive of branches) were, in 1826, 68,976 dollars and they increased year by year till, in 1862, they reached 4,792,535 dollars, since which they have gradually declined till, in 1874, they were 2,377,762 dollars.

Cost of maintenance.

The total cost of maintenance and total receipts to date I am not aware of, but to close of the fiscal year 1866, they stood thus :—

		Dollars.
Expenditure.	Total expenditure for construction, maintenance and repairs, together with interest	140,430,953
Receipts.	Receipts from tolls, with interest ...	181,828,604
Profits.	Net profit from Erie canal, exclusive of branches	41,397,651

The profit, therefore, to that date had amounted to nearly 30 per cent., and this notwithstanding the fraud and peculation which have added millions of dollars to the proper cost of the canal.

Abuses from which the canal has suffered.

The abuses which have enveloped the canal do not form a pleasant subject to dwell on, but without some notice of them no adequate idea can be arrived at of the inherent value and the vitality of the work which has in spite of them not only lived, but has proved a great financial success. For this reason I give the following extracts from a letter, dated 19th March, 1875, from Governor Tilden to the Legislature of New York State. They contain a few samples of the system of fraud by which for years the *direct* robbery of the canal has been effected :—

Extract.

"The constitution of the State provides that "all contracts for work or materials on any canal shall be made with the person who shall offer to do or provide the same at the lowest price, with adequate security for their performance." This requirement was intended to protect the State from extravagant contracts; but by artful bids, and in some cases by fraudulent combinations, it is made an instrument to defeat the very end had in view by its authors. I have examined more than one hundred contracts, and I find that most are so contrived that not only does the State in the end pay from two to four times the amount of the contract, but that the work is not given to the lowest bidder in fact, although it may be in form. This result is brought about by the following contrivance:

*   *   *   *   *   *

When the Engineer's estimate of quantities and kinds of material are published by the Commissioners, the contractor will find out by collusion, or in some other way, what quantities of each kind of work or material will, in fact, be required, or he will see what influence he can exert to change the contract after it is made. If it is changed, no new letting is had, but he claims the job as his right.

He then puts in his bid, offering to do such work or to furnish such material as he finds will not be required at all, or in small quantities, at absurdly low prices, at a quarter or, in some cases, at a twentieth part of its cost. The items which will be required in full, and probably in extra quantities, he will put at unreasonably high rates, and it turns out that what the contractor offers at low prices, is called for in small quantities, if at all, while those which are put at high prices are not only required in full, but in most cases in extraordinary quantities.

An example will more clearly illustrate how the State is defrauded by these devices.

The Engineer having estimated certain work and materials as follows:

100 cubic yards of vertical wall at \$ 3	\$ 300—00
3,855 ,, slope wall at \$ 1·50	5,782—50
2,400 feet B. M. white oak, at \$ 50	120—00
60,000 ,, hemlock, at \$ 15	900—00
Total estimate	\$ 7,102—50
A's bid for the job at these rates amounted to	7,102—50

B's bid for the same was, for

100 cubic yards vertical wall, at \$ 6	\$ 600—00
3,855 ,, slope wall at 30 cents	1,156—50
2,400 feet B. M. white oak, at \$ 70	168—00
62,000 ,, hemlock, at \$	180—00
and aggregated	2,104—50

The proposal of B., apparently so advantageous to the State, was accepted, and the contract awarded to him as the "lowest bidder." But afterwards, by *some influence*, it was decided to make only vertical and no slope wall, and to use only oak and no hemlock timber. There was no re-letting, although the agreement had been in fact revamped into a new and different contract, which enabled B. to collect from the State for

3,955 cubic yards of vertical wall, at \$ 6	\$ 23,730—00
62,400 feet B. M. white oak, at \$ 70	4,368—00
the sum of	\$ 28,098—00

It will be seen that in such transactions—and they are numerous—in violation of the constitution, the contractor gets the work without there having been in fact any public letting, or any chance for competition by others.

For the purpose of showing actual results of the system, I state the following ten cases, which give the amount the State has paid on certain contracts in comparison with the sum for which the contractor agreed to do the work at the lettings made by the Commissioners:—

	Amount of contract upon exhibited quantities at contract price.	Amount actually paid by the State up to February 1st, 1875.
Contract No. 1	\$ 74,183—40	\$ 458,114—72
,, 2	29,431—00	56,845—68
,, 3	37,871—00	110,320—13
,, 4	10,617—00	49,936—30
,, 5	14,397—00	78,967—20
,, 6	85,562—50	220,614—58
,, 7	31,286—00	130,217—45
,, 8	86,584—00	222,610—68
,, 9	9,504—00	41,127—55
,, 10	45,300—00	191,915—55
	\$ 424,735—90	\$ 1,560,769—84

These show that the State has already paid nearly four times the amount which was involved by the terms of the contracts, and though the excess amounts to more than a million of dollars, some of the expenditures are still going on with no prospect of completion. It also appears that of the expenditures of \$ 424,736, less than ⅓rd was submitted to a public letting."

Notwithstanding all the millions of dollars thus fraudulently added to its cost, the Erie canal itself has been, as shown above, a great financial success and commercially its value has been, and still is, enormous. With reference to this it has been said, with perhaps slight exaggeration,* "The financial results of the Erie canal, are however, of small moment in comparison with its commercial results, the grandest of any material enterprise of modern

* Extract from Report of "Select Committee on Transportation."

times. Connecting the ocean with the great lakes which interlace the heart of the continent, it developed the possibilities of the most productive area on the face of the globe, the value of merchandize transported on the canals to the end of the year 1872 having amounted to the enormous sum of 6,065,060,698 dollars."

Traffic.

The total traffic on the Erie canal and its branches from 1837 to 1874 is shown in the following table taken from the Report of the State Auditor for the year 1874 :—

STATEMENT of the tons of property moved on all the canals, comprised in the Erie Canal system.

YEAR.	Erie.	Champlain.	Oswego.	Other Branches.	Total tons.
1837	667,151	261,659	161,353	81,133	1,171,296
1838	741,848	266,553	222,697	98,913	1,333,011
1839	815,007	263,552	221,014	106,140	1,435,713
1840	829,960	245,229	219,627	121,230	1,416,046
1841	906,442	276,418	135,689	203,112	1,521,661
1842	712,310	230,844	129,498	164,279	1,236,931
1843	819,216	262,212	240,571	191,440	1,513,439
1844	945,944	269,546	326,607	274,489	1,816,586
1845	1,038,700	266,922	340,481	331,462	1,977,565
1846	1,264,408	280,480	351,511	372,263	2,268,662
1847	1,661,575	313,124	441,096	454,015	2,869,810
1848	1,599,965	293,889	490,147	412,239	2,796,230
1849	1,622,444	321,345	557,637	393,306	2,894,732
1850	1,635,089	460,219	583,346	397,963	3,076,617
1851	1,955,265	513,793	676,321	437,354	3,582,733
1852	2,129,334	531,001	648,191	518,915	3,863,441
1853	2,196,308	608,354	761,276	681,915	4,247,853
1854	2,224,008	602,913	611,533	727,408	4,165,862
1855	2,202,463	537,108	654,399	628,647	4,022,617
1856	2,107,678	611,610	657,381	739,413	4,116,082
1857	1,566,624	517,236	605,218	624,983	3,344,061
1858	1,767,004	608,918	688,960	600,370	3,665,192
1859	1,753,954	751,046	612,390	664,294	3,781,684
1860	2,253,533	681,157	1,080,076	635,448	4,650,214
1861	2,500,782	545,930	852,920	608,003	4,507,635
1862	3,204,277	647,318	1,063,413	683,777	5,598,785
1863	2,955,302	878,920	992,173	731,297	5,557,692
1864	2,535,792	846,790	765,097	705,262	4,852,941
1865	2,523,490	815,311	826,649	565,204	4,729,654
1866	2,896,027	1,001,493	990,809	906,891	5,795,220
1867	2,920,578	1,047,440	940,136	780,177	5,688,325
1868	3,346,986	1,120,585	958,444	1,016,210	6,442,225
1869	2,845,072	1,059,334	934,638	1,020,036	5,859,080
1870	3,083,132	1,143,719	917,728	1,029,190	6,173,769
1871	3,580,922	1,099,995	941,858	915,113	6,467,888
1872	3,562,560	1,449,528	832,490	828,792	6,673,370
1873	3,602,525	1,195,390	655,588	911,279	6,264,782
1874	3,097,122	1,268,292	665,408	773,766	5,804,588

The following table (from report of the State Auditor) gives the deliveries at tide-water from the Erie canal, ex-

clusive of what came over the Champlain canal, from 1837 to 1874 :—

TOTAL TONS of each class of articles that came to the Hudson river from the Erie canal, from 1837 to 1874, both inclusive, exclusive of the Champlain canal.

YEARS.	Products of the forest.	Agriculture.	Manufactures.	Merchandise.	Other articles.	Total.
1837	181,644	145,718	8,350	356	51,438	387,506
1838	198,964	174,025	7,229	258	38,773	419,249
1839	185,728	155,082	6,686	405	38,366	383,267
1840	140,584	294,423	6,655	26	25,627	467,315
1841	237,520	265,920	12,778	142	16,160	532,520
1842	156,691	287,928	10,406	143	24,981	480,149
1843	239,585	338,968	23,512	134	33,116	635,345
1844	356,874	371,326	28,132	236	42,948	799,816
1845	420,190	430,454	43,184	206	65,556	959,590
1846	407,848	612,585	34,561	222	52,054	1,017,270
1847	445,975	875,365	25,755	690	83,417	1,431,252
1848	406,982	674,194	24,514	296	78,351	1,184,337
1849	442,106	736,009	24,340	205	64,064	1,266,724
1850	597,956	692,753	23,065	201	57,884	1,371,859
1851	552,345	856,127	29,872	247	70,086	1,508,677
1852	627,466	915,367	35,874	4,891	61,101	1,654,699
1853	835,304	895,672	37,098	6,302	77,062	1,851,438
1854	738,367	826,025	27,080	6,135	105,086	1,702,693
1855	569,080	753,277	23,159	9,400	65,799	1,420,715
1856	509,405	984,311	20,207	7,369	75,838	1,587,130
1857	503,428	516,755	23,825	8,115	65,076	1,117,199
1858	538,650	857,350	36,928	6,067	57,692	1,496,687
1859	776,855	505,004	23,518	5,176	140,780	1,451,333
1860	814,392	1,297,227	20,943	3,164	140,335	2,276,061
1861	429,324	1,871,723	24,406	1,358	122,798	4,449,609
1862	706,592	2,087,347	19,589	1,948	101,618	2,917,094
1863	682,215	1,809,911	25,944	2,674	126,945	2,647,689
1864	716,017	1,243,067	56,223	1,826	129,501	2,146,634
1865	627,089	1,302,711	33,896	1,181	113,484	2,078,361
1866	808,050	1,487,068	44,940	2,083	181,523	2,523,664
1867	837,581	1,099,983	50,020	1,934	236,594	2,226,112
1868	911,588	1,187,501	63,421	2,388	213,674	2,378,572
1869	873,431	1,055,932	67,267	1,947	259,112	2,257,689
1870	956,139	1,024,458	72,345	2,832	234,924	2,290,698
1871	816,802	1,539,243	78,177	2,747	211,908	2,648,877
1872	890,140	1,480,580	60,993	3,456	235,236	2,670,405
1873	925,535	1,396,236	39,237	4,587	219,760	2,585,355
1874	655,201	1,429,544	27,590	6,240	251,722	2,370,297
Total for 38 years, 1837 to 1874	21,719,643	34,467,169	1,222,049	97,677	4,170,439	61,676,887
Yearly average	571,568	907,031	32,159	2,570	109,748	1,623,076
Per cent of each class	35.20	55.88	1.98	0.16	6.78	100.00
Average from 1837 to 1841—5 years	188,888	207,034	8,339	257	34,073	438,571
1842 to 1846—5 years	316,238	408,252	28,025	188	43,731	796,434
1847 to 1851—5 years	489,073	766,889	25,509	328	70,770	1,352,569
1852 to 1856—5 years	655,924	872,930	28,684	6,820	76,977	1,641,335
1857 to 1861—5 years	612,530	1,009,612	25,924	4,776	105,336	1,758,178
1862 to 1866—5 years	707,993	1,586,021	36,118	1,942	130,614	2,462,688
1867 to 1874—8 years	858,302	1,276,684	57,381	3,266	232,867	2,428,500

Cost of Transport. It is stated in evidence given before the "Committee on Transportation Routes" that the opening of the Erie canal immediately reduced "the transportation * * * * of a ton of merchandise between Albany and Buffalo from 70 dollars to 7 dollars a ton." Before the enlargement of the canal, when the boats were of only 70 tons burden, the cost of transport was, exclusive of tolls, about 1 cent a ton a mile; after the enlargement it rapidly fell to a little over 4½ mills per ton per mile, and for the last 5 years the average for freights both eastward and westward-going has been, exclusive of tolls, 5⅓ mills per ton per mile.

The following tables are from the "Report of State Auditor, 1874."

YEAR.	UP FREIGHT PER TON FROM ALBANY TO BUFFALO.			DOWN FREIGHT PER TON FROM BUFFALO TO ALBANY.		
	Average per year.	Tolls deducted.	Leaving freight.	Average per year.	Tolls deducted.	Leaving freight.
	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.
Average from 1830 to 1833, 4 years	18.65	9.85	8.80	8.84	4.74	4.10
Average from 1834 to 1837, 4 years	18.00	6.57	11.43	7.15	3 28	3.87
Average from 1838 to 1841, 4 years	16.10	6.57	9.53	6.94	3.28	3.65
Average from 1842 to 1845, 4 years	11 75	6.57	5.18	5 93	3.28	2.66
Average from 1846 to 1849, 4 years	7.85	4.80	3.05	5.90	2.92	2.98
Average from 1850 to 1853, 4 years	6.05	3.76	2.29	5.07	2.37	2.70
Average from 1854 to 1857, 4 years	5.05	2.92	2.13	4.86	2.19	2.67
Average from 1858 to 1861, 4 years	2.45	1.24	1.21	3.54	1.51	2.03
Average from 1862 to 1865, 4 years	2.52	1.22	1.30	4.66	2.11	2.55
Average from 1866 to 1869, 4 years	2.60	1.05	1.55	4.61	2.41	2.50
Average from 1870 to 1874, 5 years	2.60	1.05	1.55	3.31	1.05	2.26

TABLES SHOWING THE COST OF TRANSPORTATION ON THE CANALS.

The following table has been prepared to show the cost of transportation for a series of years, on down freight from Buffalo to Albany. It is designed to show the cost of carrying on the canal 216 pounds, or a barrel of flour. The first seven columns show the cost, including tolls; the eighth shows the average for the year; the ninth the tolls; and the tenth the forwarder's charge, or earnings after paying tolls:

Down Freight, per bbl., 216 lbs., from Buffalo to Albany.

YEAR	May.	June.	July.	August.	September	October.	November.	Average for year.	Total deducted.	Leaving freight.
1830	$1.00	$0.99	$0.97	$0.86	$0.99	$1.01	$1.02	$0.98	$0.55	$0.43
1831	1.04	97	91	92	90	97	1.02	96	55	41
1832	1.10	97	90	97	1.00	1.00	1.06	1.00	55	45
1833	91	82	86	83	90	91	91	88	39	49
1834	87	78	78	81	85	85	88	83	35	48
1835	70	65	66	64	61	76	75	68	35	33
1836	80	78	72	72	76	80	80	77	35	42
1837	80	80	82	72	83	77	97	81	35	46
Annual average from 1830 to 1837, 8 years	$0.90	$0.84	$0.83	$0.81	$0.86	$0.88	$0.92	$0.86	$0.43	$0.43

YEAR.	May.	June.	July.	August.	September.	October.	November.	Average for year.	Total deducted.	Leaving freight.
1838	$0.80	$0.73	$0.71	$0 68	$0.73	$0.70	$0.76	$0.73	$0.35	$0.33
1839	68	67	65	65	78	87	1.00	75	35	41
1840	80	78	74	67	76	80	1.13	81	35	46
1841	75	65	68	63	66	73	85	71	35	36
1842	72	60	60	62	62	63	76	65	35	39
1843	80	60	59	57	58	62	70	60	35	25
1844	75	61	55	56	54	57	65	60	35	25
1845	55	55	54	57	55	53	96	71	35	26
Annual average from 1838 to 1845, 8 years	$0.73	$0.65	$0.63	$0.62	$0.65	$0.68	$0.85	$0.69	$0.35	$.034
1846	$0.61	$0.61	$0.53	$0.54	$0.53	$0.58	$1.05	$0.64	$0.31	$0.33
1847	1.12	1.02	67	62	57	66	73	77	31	46
1848	54	51	54	54	52	66	72	58	31	27
1849	51	55	55	52	52	57	71	56	31	25
1850	51	51	53	54	53	59	81	57	31	26
1851	46	46	50	43	46	53	60	49	23	26
1852	47	47	51	47	54	58	68	53	23	30
1853	49	48	48	49	66	74	63	56	23	33
Annual average from 1846 to 1853, 8 years	$0.59	$0.58	$0.54	$0.52	$0.51	$0.61	$0.74	$0.59	$0.23	$0.31
1854	$0.56	$0.47	$0.51	$0.58	$0.52	$0.48	$0.61	$0.52	$0.23	$0.29
1855	47	53	46	44	51	57	65	52	23	29
1856	64	52	55	52	64	70	64	60	23	37
1857	59	44	45	43	44	50	49	46	23	28
1858	37	34	32	32	32	33	35	34	15	18
1859	27	28	30	28	31	36	37	31	15	16
1860	30	30	31	39	46	50	68	42	15	27
1861	39	32	32	35	49	59	76	46	19	27
Annual average from 1854 to 1861, 8 years	$0.45	$0.40	$0.40	$0.41	$0.46	$0.50	$0.57	$0.45	$0.19	$0 26
1862	$0.40	$0.38	$0.43	$0.46	$0.52	$0.55	$0.60	$0.48	$0.23	$0.25
1863	43	43	43	41	40	48	60	45	23	22
1864	50	56	61	66	56	57	57	47½	23	34½
1865	42	41	45	45	47	67	71	51	23	28
1866	38	51	55	50	54	53	60	52	23	29
1867	37	41	43	42	50	67	58	48	23	25
1868	45	42	42	43	51	54	62	48	23	25
1869	42	42	40	42	51	67	73	51	23	28
1870	34	31	30	29	41	40	36	33	11½	21
1871	36	31	35	37	44	45	52	40	11½	28
1872	30	39	47	39	39	47	52	42	11½	30
1873	38	32	32	33	39	40	40	36	11½	24
1874	37	35	29	27	29	29	30	31	11½	19
Annual average from 1862 to 1874, 13 years	39	$0.40	$0.42	$0.42	$0.45	$0.52	$0.56	$0.45½	$0.18⅓	$0.27

STATEMENT showing the average rate of lake freight on wheat and corn between Chicago Buffalo and Oswego; also the average rate of canal freight on the same articles between Buffalo, Oswego and New York, for each month during the season of navigation, 1874.

PERIOD.	From Chicago to Buffalo.		From Buffalo to New York.		From Chicago to Oswego.		From Oswego to New York.	
	Wheat per bushel 60 lbs.	Corn per bushel 56 lbs.	Wheat per bushel 60 lbs.	Corn per bushel 56 lbs.	Wheat per bushel 60 lbs.	Corn per bushel 56 lbs.	Wheat per bushel 60 lbs.	Corn per bushel 56 lbs.
	c. m. f.	c. m. f.	c. m. f.	c. m. f.	c. m. f.	c. m. f.	c. m. f.	c. m. f.
May	4 4 1	4 0 8	11 8 8	10 8 8	8 5 1	7 7 3	7 9 2	7 3 9
June	4 7 8	4 0 6	11 3 0	10 3 0	8 4 7	7 6 9	7 8 8	7 1 2
July	3 8 8	3 5 2	9 6 4	8 4 2	7 3 8	6 8 9	7 1 1	6 3 0
August	3 1 1	2 7 4	9 0 4	8 0 4	6 5 0	6 0 0	6 7 5	6 0 0
September	3 5 2	3 2 3*	9 5 5	8 5 5	6 8 8	4 5 4	6 8 9	6 0 9
October	4 0 4	3 8 1	9 5 5	8 5 6	7 6 0	6 6 9	6 8 8	6 3 3
November	4 4 5	4 2 3	9 8 0	9 0 0	7 6 7	6 5 0	7 8 0	7 3 0
Average for the season	4 0 3	3 6 7	10 1 1	9 1 1	7 5 7	6 6 2	7 3 2	6 6 5

The above rates include canal tolls, as follows:—

On wheat, per bushel, from Albany to Troy 03 1 0
On corn, per bushel, from Buffalo to Troy 03 0 0
On wheat, per bushel, from Oswego to Troy 01 7 7
On corn, per bushel, from Oswego to Troy 01 6 5
Highest rate, lake freight, from Chicago to Buffalo .... 4c. wheat.
Highest rate, lake freight, from Chicago to Oswego .... 7c. wheat
Highest rate, canal freight, from Buffalo to New York .... 10c. wheat.
Highest rate, canal freight, from Oswego to New York .... 7c. wheat

Rates of Grain freight. The following tables are extracted from the Report of the "State Engineer for the fiscal year 1874." The first gives the rates of freight for grain from Chicago to New York viâ the Lakes, Erie Canal and Hudson River for 13 years, from 1861 to 1874; the second gives the *actual* cost of transport of grain from Buffalo to New York (1) by railroad; (2) by Erie Canal and Hudson River, with animal power on the canal and steam on the river; (3) the *estimated* cost by steam on both canal and river.

GRAIN FREIGHTS OVER THE ERIE CANAL FROM CHICAGO.

The following table shows the average rates of freight for grain, per bushel, from Chicago to New York for 13 years:

YEARS	CHICAGO TO NEW YORK VIA BUFFALO.			
	No. of days in canal.	Highest rate, Chicago to Buffalo.	Highest rate, Buffalo to New York.	Average through rate of freight
		Cents.	Cents.	Cents.
1861	8½	26	30	27¼
1862	8½	17	24½	26½
1863	9	12½	25	23
1864	10	18	22	28¼
1865	10	19	26	26¾
1866	10	23	23	30½
1867	10	15	25	22⅓
1868	10	13½	24	23
1869	10	12	25	23
1870	10	10	16	17
1871	11	18	17	20¼
1872	11	18	17	21¼
1873	11	13	13	19
1874	11	6	12	15

MODE OF TRANSPORTATION.	TOTAL COST.*			TOTAL COST, INCLUSIVE OF CANAL TOLLS.		
	Per ton, mile.	Per bushel, wheat; Buffalo to New York.	Per cent.	Per ton, mile.	Per bushel, wheat; Buffalo to New York.	Per cent.
	Mills.	Cents.		Mills.	Cents.	
By railroad	9.235	13.85	100.	9.235	13.85	100
By Erie canal and Hudson river, with animal power on canal	5.39	8.	57.76	7.48*	11.1	80.1
By Erie canal and Hudson river, with steam on both.	2.68	3.984	28.04	4.77	7.084	51.1

Cost of transport by rail not much above that by Canal. From the above will be seen how closely the cost of transport by rail has come down to that by the canal, and when the extra speed of the former, amounting to a saving of some 8 days between Buffalo and New York is remembered, it is not surprising to find that the railways which compete

* Exclusive of tolls.

with the canal are rapidly outstripping it. Up till 1868, the Erie Canal and its branches in the 7 months of navigation carried yearly more than all the railroads of the State put together. In 1874 the tonnage of two only of them, the "New York Central" and the "Erie" railroads which are in direct competition with the canal for the carriage of Western produce, was more than double that of the canal. In 1862 the Erie canal delivered, at tide-water, 74,811,877 bushels of grain (including flour reduced to grain); in 1872 only 52,683,700 bushels, and this notwithstanding an immensely increased production in the North-western and Western States.

The chief rivals of the canal are the "New York Central" and "Erie" railways, each managed by men of great administrative abilities and enlightened boldness. The former, under the control of the celebrated Commodore Vanderbilt, has of late years been so improved and organized, that it claims to be able to move a larger quantity of freight and at a less cost per ton than any other railway in the world. It has four tracks between Buffalo and Albany, so that freight trains run on tracks devoted exclusively to them, are of the lengths, and travel at the speed, which are found to be the most economical, and are not delayed by having to shunt to make way for passenger trains. Though both these railways have their termini at Buffalo they each control, or run in connection with, other western lines running from Chicago, the great grain emporium of the lakes. The competition for the grain traffic from that centre is now so keen that whilst I was in America five railways, viz., the "New York Central"—"Erie"—"Pennsylvania Central"—"Baltimore and Ohio"—and the "Grand Trunk" were carrying grain at 15 cents per 100lbs. from Chicago to New York or their respective Atlantic termini, a rate but little over 3 mills (*say* $\frac{1}{7}$ *penny*) per ton of 2,000lbs., per mile. This, it was acknowledged, could not* pay, but it shows that

* *Extract from the "Times" 7th April* 1877.—The New York Central, the Erie, the Pennsylvania, and the Baltimore and Ohio Railways, under their new compact, put in operation on Monday the general advance of passenger rates. The new freight rates were put in operation to-day on the basis of 30c. per 100lb. on grain from Chicago and 35c. from St. Louis to New York. The rates to Philadelphia are 2c. and to Baltimore 3c. below those to New York.

the command of the trade of which till lately, the Erie Canal had virtually a monopoly, is being eagerly fought for, and that if the canal is not to be beaten out of the field it must be improved, as it may easily be, till the difference between the speed of carriage on it and on the railways is considerably lessened, and is compensated for by the greater cheapness of the water carriage.

Tolls. The rates of tolls levied on the Erie canal and its branches vary from $\frac{1}{2}$ mill to 5 mills per 1,000lbs. per mile, according to the nature of the articles carried, which are divided into 5 classes. (See Sheet of Rates of Tolls, Appendix No. 2.) Boats used chiefly for the transportation of passengers (there are scarcely any of these) pay 4 cents per mile. Wheat and corn, the chief freights, used to pay up to 1870 3 mills per 1,000lbs. per mile; they now pay only $1\frac{1}{2}$ mills, or $3\frac{1}{10}$ cents and 3 cents respectively per bushel (bushel of wheat 60lbs, bushel of corn 56lbs.) from Buffalo to tide water at the Hudson. In 1830, the toll on a barrel of flour for the same distance (345 miles) was 55 cents; it is now 11 cents. The tolls are collected by actual weight of cargoes, the boats being taken into "Weigh Locks" (of which there are 5 at different points along the canal) and weighed;—a deduction from the gross weight is made for that of the boat, which weight is kept registered, and for that of the bilge water in her, which is gauged at the time. This system causes much trouble, delay and expense, and on a State canal, where *direct* profits are not of primary importance, or indeed of great importance at all, it seems to me that the annual licensing of boats, as on the Godaveri and Kistna canals of Madras, is preferable.

Season. The canal is closed by ice generally from about the first week in December to the last week in April. The average open season may be taken as 220 days. In 1828, navigation continued for 269 days; in 1873 it was possible for only 202 days. In some years the piling up of ice in Buffalo harbor by westerly gales has virtually delayed for some days the opening of the canal after it was itself clear of ice.

Branches of the Erie Canal.—The great success of the Erie canal induced in the New York State a canal fever, which was aggravated by financial and political jobbery, and resulted in the construction of a number of branches, most of which have not paid for their maintenance and have swallowed up the large profits of the main canal, leaving the State a loser on the whole system of canals by, to end of 1866, 7,473,992 dollars, thus arrived at:—

	Dollars.
Total cost of construction of Erie canal and its branches	64,710,832
„ Interest on same	93,736,654
„ Cost, maintenance and repairs.........	24,377,108
„ Interest on same	27,268,895
Total cost...$	210,093,489
Receipts from tolls, with interest...........$	202,619,510
Net cost to the State up to 30th Sept., 1866.	7,473,979

The following table, collated from official sources, gives the main particulars about the branch canals. Of these, the only ones of importance, financially and commercially, are the "Oswego" and "Champlain" canals, and I visited them only. It is pretty certain that all the others, except, perhaps the "Cayuga and Seneca" canal will be abandoned, and I heard of no works on them of special interest.

[*Statement.*]

NAME OF CANAL.	Construction when authorized	Length of Canal, Miles.	Size of Prism. Width at bottom.	Width at top.	Depth.	Number of Lift Locks.	Size of Locks. Length between quoins.	Clear width.	Total feet of Lockage.	Average burden of boats.	Expenditrue to and inclusive of, 1866. For construction, enlargement & improvements.	For repairs, maintenance and collection.	Receipts from Tolls.	Remarks.
			Feet.	Feet.	Feet.					Tons.				
Erie Canal..............	1817	352	56	70	7	71	110	18	654.8	210	46,018,234	12,900,333	81,057,168	Erie canal expenditure, &c., separately will be found at page 85 of these notes.
Champlain Canal	1817	66	35to44	45to58	5	20	110	18	179.5	80				
Glens Falls Feeder...	1822	12	35	50	5	13	100	15	132.	80				
Oswego Canal.........	1825	38	56	70	7	18	110	18	154.85	210	3,490,949	4,639,219	9,283,230	
Cayuga and Seneca Canal......	1825	23	56	70	7	11	110	18	76.61	210	1,520,542	1,200,044	2,184,300	
Black River Canal and Feeder	1836 & 1849	50	26	42	4	109	90	15	1082.25	70	3,224,779	498,866	242,603	
Genesee Valley Canal and Dansville Branch.	1826	124¾	26	42	4	112	90	15	1127.89	70	5,827,813	1,689,303	1,305,913	
Chenango Canal	1833	97	24	40	4	116	90	15	1015.33	70	2,782,124	1,022,026	737,285	
Chemung Canal and Feeder	1829	39	26	42	4½	53	90	15	504.88	85	1,273,261	1,794,649	2,012,575	
Oneida Lake Canal ...	1832	7	24	40	4	7	90	15	62.	70	64,837	123,234	65,180	
Baldinsville Canal and Seneca River Towing-path	1838	5¾	24	40	4	1	90	15	8.	70	23,606 1,488	25,035 20	1,261 5,251	
Crooked Lake Canal..	1829	8	26	42	4	27	90	15	277.83	70	333,287	459,374	520,416	
Oneida River Improvement...........	1839	20	...	...	4½	2	120	30	7.85	...	146,944	25,005	201,288	
Cayuga Inlet...........	...	2	...	...	...	1	...	...	......	...	2,968	......	4,596	
										Dollars...	64,710,832	24,377,108	97,625,066	

Oswego Canal *—This canal might fairly be considered more as a portion of the main trunk of the Erie canal than as a mere branch, for lake Ontario, which it brings into communication with the main canal, and so with tide water, is one of the chain of lakes, to join which with tide water the Erie canal was specially constructed. It also has an importance beyond its present uses, because it is probable that when the enlargement of the Welland canal (now in hand by the Canadian Government) is completed, a large portion of the grain now transhipped to canal boats at Buffalo, at the east end of lake Erie, will be carried on by the faster and cheaper lake-going vessels to Oswego, from which port the canal distance to be traversed to tide water is 148 miles shorter, and the lockage is 43 feet less than from Buffalo, against which advantages, however, there would stand the 28 miles and 330 feet lockage of the Welland canal. Also, if ever the much-talked-of construction of a "ship canal" from the lakes to tide water should be carried out, it will probably be so by improvement and enlargement of the northern portion of this canal; its junction with lake Oneida; the enlargement of the Oneida lake canal (6 miles in length) from Higginsville at the south end of the lake to the Erie canal; and the enlargement of the latter canal to Albany. This course would give 146 miles of lake, and 208 miles of canal navigation (inclusive of Welland canal) as against 352 miles of canal by the Buffalo route.

General description. The Oswego canal leaves the Erie canal, opposite the Syracuse weigh lock, at 186 miles from Buffalo and 166 miles from Albany. Skirting the eastern shore of the shallow Onondaga lake, it runs north-westerly for 7 miles to a loop of the Seneca river at "Mud Lock," which lock drops it into that river. The river has been dredged and provided with a tow-path, and is used for about 8 miles to "Three River Point," where the Seneca and Oneida rivers join and form the Oswego river. That river is used for about 2 miles to "Phœnix," where there is a stone dam across it, 440′ long and 9′ high, and the navigation passes again into an artificial canal and so continues for about 6 miles to

* Visited 9th and 10th July, 1876.

"Ox Creek", where it is again taken into the river and continues in it for 4 miles to Fulton, at which place is a low masonry dam on a ridge of natural falls. From this there is an artificial channel for 4 miles to "Braddock's rapids," where there is a lock into the pool, about 1½ miles long, above Van Buren's dam (masonry, 662′ long, 12′ high.) From that dam there is an artificial canal for about two miles to a pool above the "Minetto" masonry dam across the river, 455′ long and 10′ high. There is then an artificial channel for about a mile which locks into the pool above the "High" dam, 368′ long and 12′ high, of which a plan is sent herewith.* Then there is a short piece of canal to the pool above the Oswego dam at the head of the Oswego rapids. From above this dam, which is in plan the segment of a circle, the navigation enters a canal through a guard lock, and passing through two drop locks in about three-quarters of a mile, re-enters the river some half mile above its junction with lake Ontario, at the town and harbor of Oswego.

Along the last reach of the canal is a separate channel for carrying water for mills, closed at its upper end by a timber bulk-head supported on three stone piers, 4′ wide each, and by raking struts between them. There are in this bulk-head 13 openings of 7′ wide, closed by wooden shutters worked by screw gearing. The surplus of this channel falls over a timber weir of 4 bays of 25′ each with about 10′ drop, and passes under the navigation canal to the river. In each bay of this weir is a vent, at the bed of the channel, closed by a shutter worked by rack and pinion.

In connection with this canal, from where it joins it at "Three River Point," the Oneida river has been made navigable for boats of 4′ draught to Oneida lake at Brewerton, a distance of about 20 miles. Two rapids in this river are overcome by short channels round them with two masonry locks 120′ × 30½′. They were built so large to admit of steamers which ply on the lake coming up to "Three River Point," and taking tows of canal boats to and from the lake ports. **Oneida River and Seneca River navigation.**

From "Mud Lock" the Seneca river has been improved, and with an artificial channel of about a mile in length ad-

* "No. 53 in Vol. of Plans."

mits the passage of canal boats for about 4 miles to the town of Baldinsville.

Chief Structures. The principal structures on the Oswego Canal are—

18 Lift Locks.	32 Wooden Bridges.
6 "Guard" Locks.	6 River Dams.
8 Iron Bridges.	

Locks. The locks are similar to those on the main Erie canal, but not "doubled:" the "lift" ones cost on an average 31,000 dollars each.

Bridges. The bridges over the canal proper are only of 50 feet span, and almost all wooden trusses.

Dams. The river dams being covered with water, I could not personally ascertain what they were like, and was able to obtain a plan (sent herewith*) of one only, the "High" dam across the Oswego river. The dam itself is a masonry wall 12 feet high, 16 feet wide at bottom, 9½ feet at top, with a gentle batter on its down-stream side, which is faced with cut-stone. It is coped with large blocks of stone, each of which run from front to back. This wall is founded on a continuous line of "crib-work," 25 feet wide sunk 10 feet into the bed of the river. At about 10 feet away, down-stream, from the end of this crib-work is another line of similar work 20 feet wide and sunk 24 feet into the bed; the interval between the two cribs being planked over. From about 2 feet below the crest of the dam there is a timber closely planked apron with a slope of 2 to 1, the toe of which strikes the last-mentioned crib-work 5 feet from its inner, and 15 feet from its outer (down-stream) edge, and this 15 feet being planked over makes another apron, horizontal. When I saw the dam (9th July 1876) there was only 1 foot going over the crest and there was a curling wave just at the foot of the sloping apron and another just beyond the level one, after the water had shot off its smooth surface, which suggested trouble.

Traffic. In the table given at page 88 of these notes will be found the total tonnage of this (Oswego) canal for each year, from 1837 to 1874, from which it will be seen that

* "No. 53 in Vol. of Plans."

it increased to a maximum of 1,080,076 tons in 1860, since which it has gradually fallen off to 665,408 tons in 1874; the falling off being in a large measure due to the construction of a line of railway connecting the port with New York. The table, given at page 97, shows the cost of construction and the returns of this canal to end of 1866.

Income from Tolls. The tolls collected arrived at their maximum for a year in 1862, when they were 157,911 dollars.

Income and Expenditure. During the years 1872-73 and 74 the total income of the canal has been 249,344 dollars, and its expenditure—

On ordinary repairs..........373,672 dollars.
On extraordinary repairs...296,116 „

Total...669,788 dollars.

showing for these 3 years a total excess of expenditure over income of 420,444 dollars, and an average yearly excess of 140,148 dollars. It should, however, be remembered that besides the returns here directly credited to this branch, some of the earnings of the main canal are due to it, but even taking them into consideration, the Oswego canal is far from being a paying one.

Commercial importance. Its commercial importance as placing lake Ontario in communication with the Erie canal is great and, as already noticed, is likely to become even greater after the enlargement of the Welland canal is completed. But if it is to increase, or even retain its importance amongst the great lines of communication of the country, this branch, as well as its parent canal, must be so improved and enlarged as to secure a considerable increase in the speed, and saving in the cost, of its navigation.

Introductory. *Champlain Canal.**—This important canal connects the Erie canal near its eastern end with lake Champlain and and so, viâ the Ours and Chambly canals, with the river St. Lawrence, 46 miles below Montreal. The traffic on it does not consist (as is the case with the Erie and Oswego canals) chiefly of agricultural products of distant States, but of products of the forests and mines of the New York State through which it runs, and of the State of Vermont which

* Visited 20th—23rd June, 1876.

skirts the eastern shore of lake Champlain. Whilst of the total tonnage brought by the *Erie* canal to tide water from 1837 to 1874, considerably more than half has been agricultural produce, and but little more than one-third the products of the forests, of the total tonnage brought by the *Champlain canal* to tide water during the same period, to agriculture has been due less than one-thirteenth, to the forest nearly two-thirds.

During the American war of Independence and the war with England of 1812, the country near the upper waters of the Hudson and about lake Champlain was the scene of important military and naval operations. Touching at its northern end the Canadian frontier, whence it is connected by river and canal with the St. Lawrence, where that is purely a Canadian river, and running far down into the "Empire (New York) State," lake Champlain would undoubtedly, in the event of war between England and America, again become of great military importance, and, recognizing this, the American Government have from time to time had under consideration the improvement of the Champlain canal and the Hudson river, so as to admit of the passage of gunboats to the lake.

The last proposition, for which surveys and preliminary estimates have been prepared, is for an entirely new "ship canal" (with prism 100′ and 150′ × 13′ deep, and locks 270′ × 45′) running near the present line from Whitehall at the south end of the lake, to the Hudson at Fort Edward, and the improvement of the Hudson river from that place to Troy to admit of the passage of vessels of 12′ draught; the estimated cost being 11,152,916 dollars.

Such a canal would have no chance of proving a commercial or financial success were not a similar one constructed from the St. Lawrence to lake Champlain. This a Canadian Company have proposed to take in hand whenever the American scheme may be carried out, but that scheme seems likely to share the fate of its predecessors.

General Description.

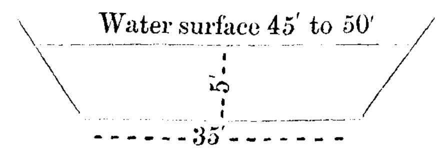
The Champlain canal leaves the Erie canal at 7 miles from Albany, and running northerly along the right bank of the Hudson river for 30 miles then crosses it in the pool formed

by a dam across the river known as the "Saratoga" dam, towing being done from a bridge specially for the purpose. A Captain of a boat informed me, that in freshes the passage was dangerous, special ropes held by many men having to be used, and even then boats are sometimes carried over the dam. A lock closes the entrance to the canal on each side of the pool. From this pool the left bank of the river is closely followed for 11 miles to Fort Edward (41 miles) where, by the twelfth "lift" lock, the surface is lifted to the summit level (146.667 + T. W.) The canal now leaves the river and continues in a north-easterly course, at the level just mentioned, for 12 miles to "Fort Ann" where, by a combined lock of two chambers, and two separate ones a short distance apart, it is dropped into the "Wood Creek" (level 121.076), which stream is used for about 6 miles. Passing out of this creek through a guard lock it continues at the same level for 7 miles to "Whitehall," and there, at 66 miles from junction with the Erie canal, it is dropped by a "combined" lock of 3 chambers into lake Champlain, the usual level of which is 93.076 + T. W.

This canal has a navigable branch* 7 miles in length (exclusive of pond above dam) from a mile north of "Fort Edward" to the Hudson at "Glens Falls," where from above a dam across the river the water is taken for the supply of the portion of the canal from Saratoga dam to the northern end at lake Champlain, a distance of 35 miles.

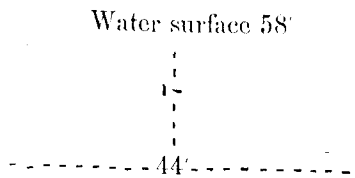
Prism.

The general prism of the canal now is—



* "Visited 22nd and 23rd June, 1876."

but its enlargement has been sanctioned, and is now in progress to—



Structures. The principal structures on the canal and the "Glens Falls" branch are—

33 "lift" and 5 "guard" locks.
118 bridges of all kinds.
3 river dams and 5 small ones across "Wood" creek.
24 culverts and small aqueducts.

Locks. The locks are similar to those on the main Erie canal, but not "doubled." Those on the "Glens Falls" branch are only 100 feet × 15 feet. Of the 13 locks on the latter, 5 are "combined" into one flight with a total lift of 50 feet. The feed-water is taken past this flight down a wooden race 10 feet 6 inches wide of 5 slopes, about 100 feet long each, between which are 5 vertical steps or drops.

Notes of times occupied by boats in passing locks on the Champlain canal and its branch are given under the head of "Locks" main Erie canal.

River Dams. Of the river dams I was not able to get any plans or descriptions, and as water was going over them I could not from inspection arrive at details.

The one across the Hudson at Glens Falls* appeared to me to be in section generally similar to the dam across the Mohawk at the "Rexford Flats" feeder of the main Erie canal, already noticed. It is, however, much longer, said to be 900 feet in length. The abutments at both ends are of stone masonry. At the back of the one at the north end, the supply water is taken into the feeder (which is navigable) through 4 large vents closed by wooden shutters worked by iron screws running through a female screw-nut turned by iron handles which fit into holes round it. Alongside this "bulkhead" is the head

* Visited 22nd June, 1876.

"guard" lock. As immense quantities of timber are floated down the river for supply of saw mills at various places below the dam a "chute" is provided about the centre of the dam for their passage. It is merely a depression about 10′ wide in the crest of the dam with the trough from it down the apron flanked with boarding to prevent the logs from swerving and knocking the apron about. Guide piles driven into the river, for some distance up, lead the logs on to the chute, and if they jam anywhere they are started by men in "scows." The greatest number of logs which I saw pass through the chute in one minute was 30, and the average of five minutes was 14 a minute. About 200 yards above the dam there are at points across the river, 6 structures of timber and stone, like the cutwaters of bridge piers, for breaking up the great fields of ice which in winter come down the river. The pool above this dam is navigable for 5 miles in length.

Bridges. The Bridges are almost all wooden trusses of 50 feet span.

Traffic. In the table given at page 88 of these notes, will be found the total tonnage of this canal for each year from 1837 to 1874, from which it will be seen that it increased with great steadiness from 261,659 tons in the former, to 1,268,292 tons in the latter, year.

Cost and Income. This canal has, for construction and maintenance, cost (exclusive of interest) 2,764,486 dollars more than its direct return by tolls. Taking the last five years as the standard, its average tolls, which have varied from $123,700 to $173,540, amount to between 20,000 and 40,000 dollars more than its ordinary repairs and collection, but are considerably less than sufficient to also pay a fair percentage (considered in America to be 7 per cent.) on the outlay. Thus—

	Dollars.
Cost of canal and improvements to September, 1874	4,099,567
,, ordinary repairs and collection of tolls to September, 1874	4,600,796
Total cost to 30th September, 1874	8,700,363
Total tolls received	5,935,877
Net cost of canal (exclusive of interest)	2,764,486

	Dollars.
The annual interest on this sum, at 7 per cent., is	193,514
Ordinary repairs and collection..................	106,486
Tolls *should be*..............................Dollars	300,000

they really have been from 123,700 dollars to 173,500 dollars, leaving an annual deficiency, ranging from 176,300 to 126,500 dollars.

Administration of the Erie Canal.—The administration of the Erie canal (and its branches) is vested in a "Canal Board," which consists of—

(1.) The Commissioners of the Canal Fund.
(2.) The State Engineer and Surveyor.
(3.) The Canal Commissioners.

"This Board meets during the sitting of the Legislature; fixes the rate of toll, appoints the Engineers, Superintendents of Repairs, Collectors of Tolls, Weighmasters, their Assistants and Inspectors, and Measurers of timber and of boats and their cargoes; directs extraordinary repairs, hears appeals from the Canal Appraisers; remits penalties and regulates the police of the canals, &c."

The Commissioners of the Canal Fund are five of the State officers, whose appointments are governed either directly or indirectly by popular vote. They are—

The Lieutenant Governor.
" Secretary of the State.
" Comptroller of the State.
" Treasurer of the State.
" Attorney General.

The State Engineer and Surveyor is annually elected, and this being the case the office is generally secured by a declared politician, and is never held for many, seldom for two, consecutive years by the same person. That under this system men of ability do sometimes receive the appointment is undoubted. The present State Engineer, Mr. J. D. Van Buren, is an instance of this, but the tenure of the office is too uncertain, or rather is too certainly short, to allow of such ability exercising much influence on the well-being of

the canal. The duties of the State Engineer are thus enumerated in an official document:—

"Prescribes duties of, and assigns divisions of canals to Engineers; visits and inspects canals; prepares surveys, maps, plans, estimates, &c., in the construction or improvement of a canal, &c., &c."

Strange to say, neither this officer nor the Engineers employed under him have any voice in the letting or execution of contracts by which all the work of the canals is done. In support of this assertion, which will seem a strange one to Engineers who may read these notes, I give the following extracts from "the State Engineer's report for the fiscal year ending September 30th, 1874:—

* * "The plans, specifications and estimates for any work, having been approved by the State Engineer, and the letting thereof having been authorized by the Canal Board, the matter passes entirely from his control; and all subsequent proceedings, up to, and including the final award and execution of the contract, are had by the Canal Commissioners.

The division, resident, and such subordinate Engineers as may be necessary, are required to be present at lettings, to perform merely the clerical duty of canvassing the bids, and of certifying to the accuracy of such canvass.

In cases where questions might properly be raised as to whether proposals are properly balanced, or as to whether they should not be rejected, for that or for other reasons, no Engineer officer is authorized to act, even though entirely conscious of the objectionable character of the proposals which he may be called upon to canvass."

* * * "It is believed that the State Engineer and Surveyor is a proper officer to advise with the Board of Canal Commissioners; to aid in scrutinizing and in determining the precise character of proposals for work; to see that work is properly advertised, and to see that contracts are properly drawn and executed. So long as this officer has neither voice nor authority in these proceedings, he cannot justly be held responsible for abuses resulting from them. It is, therefore, respectfully recommended that the State Engineer and Surveyor be constituted a member of the letting Board; and that his presence, or that of his deputy, be declared essential to the legal transaction of business by said Board."

The extracts already given from Governor Tilden's letter about the frauds in connection with the Erie canal afford a pertinent comment on the system by which its contracts have been let.

The Canal Commissioners, who form the third component part of the Canal Board, are three in number. They have "the general charge of the public works, of the construction of new canals, and of the repairs of the completed canals." They are annually elected, and, therefore, almost invariably they are "politicians."

For convenience of management, the Erie canal and its branches are divided into 3 divisions,—the "Eastern," "Middle," and "Western," each of which is under the charge of one of the Canal Commissioners, a "Division Engineer," and a "Resident Engineer." The two latter officers receive their appointments year by year from the "Board," the component parts of which are constantly changing, and are therefore themselves being constantly changed. Assistant and Subordinate Engineers also, whom it may be necessary to employ from time to time, cannot be appointed without the assent of the Canal Commissioners. Under these arrangements it is evident that the commercial, financial, and engineering management of the canals must lack steadiness. They are perfectly saturated by politics. I found persons employed on the canal in positions far below those mentioned, speaking of the probability of their retaining their appointments as dependent not on their fitness, but on the fortunes of political parties in the State Elections. The unwisdom of such a system is becoming daily more recognized by Americans, and it would be ungenerous to dwell on the subject.

APPENDIX No. 1.—(*Referred to at page 75.*)

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 dollars 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 dollars 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 dollars 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 dollars 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 dollars 30,000, payable to the owner or owners of certificate number one; and one of dollars 15,000, payable to the owner or owners of certificate number two; and one of dollars 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.

APPENDIX No. 2

RATES OF TOLL, 1876.

Established by the CANAL BOARD on persons and property transported on the NEW YORK STATE CANALS, to take effect on the opening of Navigation.

Articles paying One-Half Mill per 1,000 pounds per mile.

Ashes, leached.
Bones.
Brick of every description.
Bleaching Powder, going from tide-water.
Coffee.
Copper Ore.
Copper, pig and smelted.
Crockery.
Car axles, when cleared at tide-water.
Car wheels.
Charcoal.
Clay.
Coal, anthracite and bituminous.
Coal Oil.
Coal tar and products thereof.
Cullet, or broken glass to be melted over.
Earth.
Fire brick.
Fish, salted, going from tide-water.
Gas Pipe.
Gypsum, unground, product of this State.
Hay, pressed.
Horse shoes.
Iron, bloom and pig.
Ice.
Iron bolts, when cleared at tide-water.
Iron bridge and railing, when cleared at tide-water.
Iron articles exclusively manufactured of wrought or rolled iron, not specifically enumerated, when cleared at tide-water.
Iron, boiler, when cleared at tide-water.
Iron, in bars and bundles, when cleared at tide-water.
Iron ore.
Lead, bar and pig, going toward tide-water.
Lime stone.
Manure.
Marl.
Molasses.
Nails.
Petroleum, crude and refined.
Peat.
Pig iron.
Plaster Calcined or Plaster Paris, going froom tide-water.
Railroad chairs, when cleared at tide-water.
Railroad iron.
Sal Soda, going from tide-water.
Soda Ash.
Sugar.
Sand.
Saw dust.
Scrap Iron.
Shingles in boats, per M., per mile.
Slate.
Spikes.
Steel, in bars and bundles, when cleared at tide-water.
Stone for the manufacture of lime.
Stone, wrought, partly wrought, unwrought.
Straw, pressed, and any pressed vegetable substance used for the manufacture of paper and paper pulp.
Tin plate, going from tide-water.
Water Pipes.

Articles paying One Mill per 1,000 pounds per mile.

Acid, sulphuric.
Agricultural Implements, going from tide-water.
Articles not enumerated, going from tide-water.
Apples.
Barley.
Beef, salted.
Bacon.
Barrels, empty, transported in boats.
Bran.
Brimstone.
Castings, all iron castings.
Cheese.
Cider.
Corn.
Corn meal.
Car axles, when not cleared at tide-water.
Casks, empty, transported in boats.
Cement, fire-proof and hydraulic.
Cotton.
Domestic distilled spirits.
Domestic cotton.
Domestic woolens.
Esculent roots.
Flour.
Glass ware.
Gypsum, ground and unground.
Hemp, going toward tide-water.
Hoops, rived.
Iron, in sheets, bars and bundles.
Iron, boiler.
Iron, bridge and railing.
Iron bolts.
Iron safes.
Junk.
Lard.
Lard oil.
Lime.
Leather.
Mahogany.
Malt.
Merchandise, non-enumerated.
Oats.
Oil cake.
Oil meal.
Onions.
Pig Copper.
Potatoes.
Railroad chairs.
Rice, going from tide-water.
Rye.
Shingles, in boats, per 1,000 lbs. per mile.
Ship stuff.
Steel, in bars and bundles.
Stoves.
Salt manufactured in this State.
Staves and heading, sawed, cut and dressed or partly dressed, shooks and stave bolts and butts, not exceeding four feet and a half in length, transported in boats.
Tar.
Tobacco, unmanufactured, going toward tide-water.
Turnips.
Tobacco, going from tide-water.
Turpentine.
Varnish.
Vinegar.
Wheat.
Water Lime.
Wool.

Articles paying One and One-Half Mills per 1,000 pounds per mile.

Articles not enumerated, going toward tide-water.
Agricultural products of the United States, not particularly specified.
Ashes, Pot and Pearl.
Barytes.
Beans.
Butter.
Carboys.
Carts.
Carriages and Sleighs.
Cattle, alive.
Cabinet ware.
Clover seed.
Flax seed.
Furniture, cabinet ware & chairs.
Furniture for Stoves, not cast iron.
Grease.
Grass seed.
Hides.
Hogs, alive.
Hops.
Peas.
Pork, salted.
Rags.
Sleighs.
Sheep, alive,
Ship knees.
Tallow.
Wagons.

Articles paying Two Mills per 1,000 pounds per mile.

Buffalo skins.
Deer skins.
Furs and skins of animals producing furs.
Moose skins.

Articles paying Two and One-Half Mills per 1,000 pounds per mile.

Salt, foreign.
Tan Bark, ground, per 1,000 lbs. per mile.

Articles paying Three Mills per 1,000 pounds per mile.

Horses.
Shrubbery.
Trees.

Articles paying Four Mills per 1,000 pounds per mile.

Powder, Gun-powder.
Window sashes.

Articles paying Five Mills per 1,000 pounds per mile.

Barrels, empty, transported in rafts.
Bolts, stave, transported in rafts.
Butts, stave, transported in rafts.
Casks, empty, transported in rafts.
Heading, transported in rafts.
Hop Poles, transported in rafts.
Hoop Poles, transported in rafts.
Ship knees, transported in rafts.
Staves and heading, not exceeding four feet and a half in length, transported in rafts.
Wood used in the manufacture of salt, per cord per mile.

Lumber Shingles and Timber.

Lumber No. 1.*

c. m. fr.

Transported in boats by weight, per 1,000 pounds per mile:

White pine, white wood, bass wood, cedar boards, planks, scantling, and on all sidings, lath and other sawed stuff, less than one inch thick (except such as is enumerated in *Lumber No.* 3.) .. .. 0—1—5

Oak, hickory, beech, sycamore, black walnut, butternut, maple, ash, elm, fir, tamarack, yew and cherry .. 0—1—0

Hemlock and Spruce .. .. 0—0—7

Lumber No. 2.*

Transported in boats by measurement, per 1,000 feet per mile:

Boards, plank, scantling, railroad ties, pickets for fences and sawed timber, siding, lath and other sawed stuff, less than one inch thick, reduced to inch measure (except such as is enumerated in *Lumber No.* 3); lath, when cleared by measurement, may be estimated at *twenty feet* for each bunch of one hundred pieces; and all kinds of red cedar, cedar posts, estimated that a cord, after deducting for openings, will contain 10,000 feet .. .. 0—3—0

Hemlock and Spruce, per 1,000 feet per mile, when not weighed .. .. 0—2—0

Lumber No. 2, transported in rafts, per 1,000 feet per mile .. .. 2—5—0

Lumber No. 3.*

Transported in boats by weight, per 1,000 pounds per mile:

Sawed lath less than ten feet in length, split lath, hoop poles, hand spikes, rowing oars, broom handles, spokes, hubs, tree-nails, fellies, boat and ship knees, plane stocks, pickets for fences, railroad ties, last blocks, stuff, manufactured or partly manufactured for boxes, chairs and bedsteads, hop poles, brush handles, brush backs, looking-glass backs, gun stocks, plow beams and plow handles .. .. 0—1—5

Sawed stuff for window blinds, not exceeding one-fourth of an inch in thickness .. .. .. 0—4—0

Timber per 1,000 cubic feet, per mile, transported in boats:

Square and round, other than hemlock .. .. 0—5—0

	c. m. fr.
Square and round, hemlock	0—3—0
Square and round (all kinds) transported in rafts	1—0—0
Sawed Timber (see *Lumber* No. 2), per 1,000 feet per mile	0—5—5
Shingles in boats, per 1,000 pounds per mile	0—1—5
Do. in boats, per M. per mile	0—0—5
Do. in rafts, per M. per mile	0—4—0
Posts, split and round, not exceeding eight feet in length, carried in boats, per M. per mile	1—5—0
On the same, if carried in rafts, per M. per mile	8—0—0
Rails for fences, not exceeding fourteen feet in length, carried in boats, per M. per mile	1—5—0
On same, if carried in rafts, per M. per mile	8—0—0

Boats and Passengers.

On boats *used chiefly* for the transportation of passengers, upon *all canals*, per mile	4—0—0
On the same, if they elect to commute for tolls upon passengers	3—0—0
On boats *used chiefly* for transportation of property, per mile	2—0—0
On the same, if they elect to commute for tolls upon passengers	2—3—0
On boats registered before July 1st, 1862, whose bows do not conform to regulation No. 40, per mile	2—0—0
Boats used exclusively in the towage of boats on the canals, together with the machinery and fuel necessary therefor,—exempt from toll.	
On all persons over ten years of age, per mile...	0—0—5

APPENDIX No. 3.

THE CANALS OF CANADA.

(Visited 25th June to 7th July and 15th to 22nd July, 1876.)

THE canals of Canada may, for the sake of convenience, be divided into four groups:

1. The canals constructed to improve the navigation from lake Erie to Montreal, with which are intimately connected the improvements of the St. Lawrence between Montreal and Quebec.

2. The canals to improve the navigation of the Ottawa river.

3. The "Rideau" (military) canal from the Ottawa river at Ottawa to the St. Lawrence at Kingston.

4. The canals to improve the navigation of the Richelieu river from the St. Lawrence to lake Champlain.

The first of these groups is by far the most important. It establishes navigation between the ocean and the grand system of lakes which stretch away into the interior of the continent through some of the finest districts of the United States and Canada, providing them with facilities for internal and external traffic, such as are enjoyed by no other inland region of equal size. Before noticing the artificial links in this great chain of inland navigation, extending for 2,000 miles westward from the gulf of St. Lawrence, it will perhaps be as well to give a slight description of those portions which nature herself has formed.

Commencing then at the western end—

(1.) LAKE SUPERIOR—Lies between 93° and 85° West Longitude and between 47° and 49° North Latitude. It is nearly 400 miles long from west to east, and covers an area of 32,000 square miles, with a surface level of 600 feet above the sea, and a mean depth of 900 feet. It is bordered on its western coast by the State of Minnesotta, on its southern by the States of Wisconsin and Michigan, and on its northern by the Canadian province of Ontario. Its upper (western) end, known as "Fond du Lac," is 1,950 miles from the gulf of St. Lawrence. At its eastern end it narrows into a river called the "Sault St. Marie," which carries its surplus waters to lake Huron through a course of 55 miles, in which is a rapid overcome by a canal 1 mile in length with 2 locks of 19 feet total drop.

(2.) LAKE HURON—Lies between 48° and 43° North Latitude and between 84° and 81° West Longitude. It is about 270 miles long from north to south and covers an area of 23,000 square miles, with a surface level of 574 feet above the sea, and a mean depth of 450 feet. It is bordered on its western coast by the State of Michigan, and on its northern and eastern coasts by the Canadian province of Ontario. At its southern end it narrows into a channel which carries its surplus waters to lake Erie; this channel is known for its first 33 miles as the "St. Claire" river, then for 25 miles, in which it widens out, as "Lake St. Claire," and then for the remaining 18 miles of its course to its junction with lake Erie as the "Detroit river." A channel has been dredged and is kept open through the sand flats of lake St. Claire, of sufficient size to pass the largest lake-vessels.

(3.) LAKE MICHIGAN.—This forms a separate branch, as it were, of the main line of lakes. It joins lake Huron at its head, just below the mouth of the channel from lake Superior, to the general line of which lake it is almost at right angles. It lies between 42° and 47° North Latitude and between 86° and 88° West Longitude. It is about 300 miles long from south to north and covers an area of 22,400 square miles, with surface level of 578 feet above the sea, and a mean depth of 1,000 feet. Its waters are entirely American (United States), the boundary between Canada and the United States, running north of it along the middle of lake Huron and of the Sault St. Marie river. Its eastern and northern coasts are bordered solely by the State of Michigan, its western and southern coasts by the States of Wisconsin, Illinois, and Indiana. At its southern end is the celebrated city of Chicago, one of the most important railway centres in the country, with 450,000 inhabitants, owning a fleet of upwards of 400 vessels and exporting annually about 90 millions of bushels of grain besides great quantities of other products of the field and forest. Chicago is 1,806 miles by water from the gulf of St. Lawrence; 1,411 miles by way of the lakes, Erie canal, and Hudson river from New York; and 961 miles from the same place by rail.

(4.) LAKE ERIE. Is 232 miles long from its western end where the waters from lake Huron join it, near the large town of Detroit, to its eastern end at Niagara river. It lies between 79° and 84° West Longitude and 42° and 44° North Latitude. It covers an area of 10,000 square miles, with a surface level of 564 feet above the sea, and a mean depth of 90 feet. It is bordered along its southern shore by the States of Ohio, Pennsylvania, and New York, and along its northern shore by the Canadian province of Ontario. The eastern end of the lake overlaps the western end of the one next to the east lake Ontario and through the peninsula thus formed is the Welland canal. At the extreme eastern end of the lake, just at the head of the Niagara river, is the important city and harbor of Buffalo, from which the Erie canal runs to the Hudson, and from which railways radiate in many directions. The surplus waters of this lake, and all west of it, are carried on to lake Ontario by the Niagara river which, in a course of 35 miles, falls 330 feet. Half of this fall is accomplished by means of rapids, half by a vertical drop at Niagara, where upwards of 400,000* cubic feet of water a second, plunge over a perpendicular lime-stone cliff.

(5.) LAKE ONTARIO.—The most eastern of the series, lies between 76° and 79° West Longitude and between 43° and 44° North Latitude. It is 170 miles, long from west to east and covers an area of 6,700 square miles with a surface level of 234 feet above the sea, and a mean depth of 412 feet. It is bordered on the south by the State of New York and on the north by the Canadian province of Ontario. On the southern shore, near its eastern end, is Oswego, a considerable town and lake harbor from which a canal runs to the Erie canal at Syracuse. On the northern shore, near the western end, is Toronto, one of the chief cities of Canada, with 56,000 inhabitants. On the northern shore, at the eastern end of the lake, is Kingston, formerly the capital of

* Sir Chas. Lyell puts the quantity at 150,000,000 cubic feet per hour.

Canada, but now chiefly of importance on account of being situated at the head of the St. Lawrence, where lake navigation ends and river navigation commences, and much transhipment has to be done. From Kingston the "Rideau" canal runs northwards to Ottawa.

(6.) THE RIVER ST. LAWRENCE.—The accumulated waters of the great lake plateau, some 400,000 square miles in extent, flow out of lake Ontario by the river St. Lawrence, which carries them for 723 miles to the gulf of the same name. For the first 178 miles of its course, as far as Montreal, the river is crossed at several places by rocky barriers, which act as dams and divide the river into a series of long nearly still-water reaches, separated by rapids. Into these rapids are concentrated about 214 out of a total fall of 223 feet. Below Montreal, the river, with a total fall of 11 feet, flows on unobstructed by rocky bars but widening out at intervals into broad expanses of shallow water, till at 86 miles from Montreal and 74 above Quebec it meets the tidal flow and from there continues broad and deep to the gulf of St. Lawrence, a further distance of 459 miles.

This noble river is the natural outlet for the foreign traffic of the lakes, providing the only route for a continuously descending channel from them to the ocean. Such a channel Canada has for years possessed and is now improving, and the works on it are those that form GROUP 1.

Taking the works of this group in order *ascending* the river they are—

(*a*). Deepening the St. Lawrence between Montreal and Quebec.

(*b*). The "Lachine Canal" on the island of Montreal, overcoming the St. Louis rapids.

(*c*). The "Beauharnois Canal" on the south side of the St. Lawrence, overcoming the "Cascade," "Cedars" and Coteau" rapids.

(*d*). The "Cornwall Canal" on the north side of the St. Lawrence, overcoming the "Long Sault" rapids.

(*e*). The "Williamsburgh Canals" (three) on the north side of the St. Lawrence, overcoming the "Farran's Point," "Rapide Plat" and "Galops" rapids.

(*f*). The "Welland Canal" from lake Ontario to lake Erie, overcoming the rapids and falls of the Niagara river.

(*a*.)—DEEPENING THE ST. LAWRENCE.—Between Quebec and Montreal, a distance of 160 miles, there are several shoals, the chief of which is where the river widens out into the expanse, 40 miles × 8 miles, known as lake St. Peter. Up till 25 years ago there was not water enough on these shoals to float craft of more than 11 feet draught, but since 1850 a channel 300 feet wide and deep enough for vessels drawing 22 feet, has been dredged through all obstructions. The result of this work has been to move the terminus of ocean-going ships 160 miles further into the heart of the country, greatly facilitating and cheapening foreign traffic.

Port of Montreal.

The effect on the port of Montreal has been most marked. Its imports and exports have increased from 15,120,321 dollars and 2,692,086 dollars in 1857, to 44,027,704 dollars and 22,045,455 dollars in 1874, and the tonnage of its sea-going vessels from 67,740 tons to 423,425 tons in the same years. The channel is now being deepened to 25 feet, and Montreal is busy extending her wharves and making her harbor worthy of the great commercial advantages of her position.

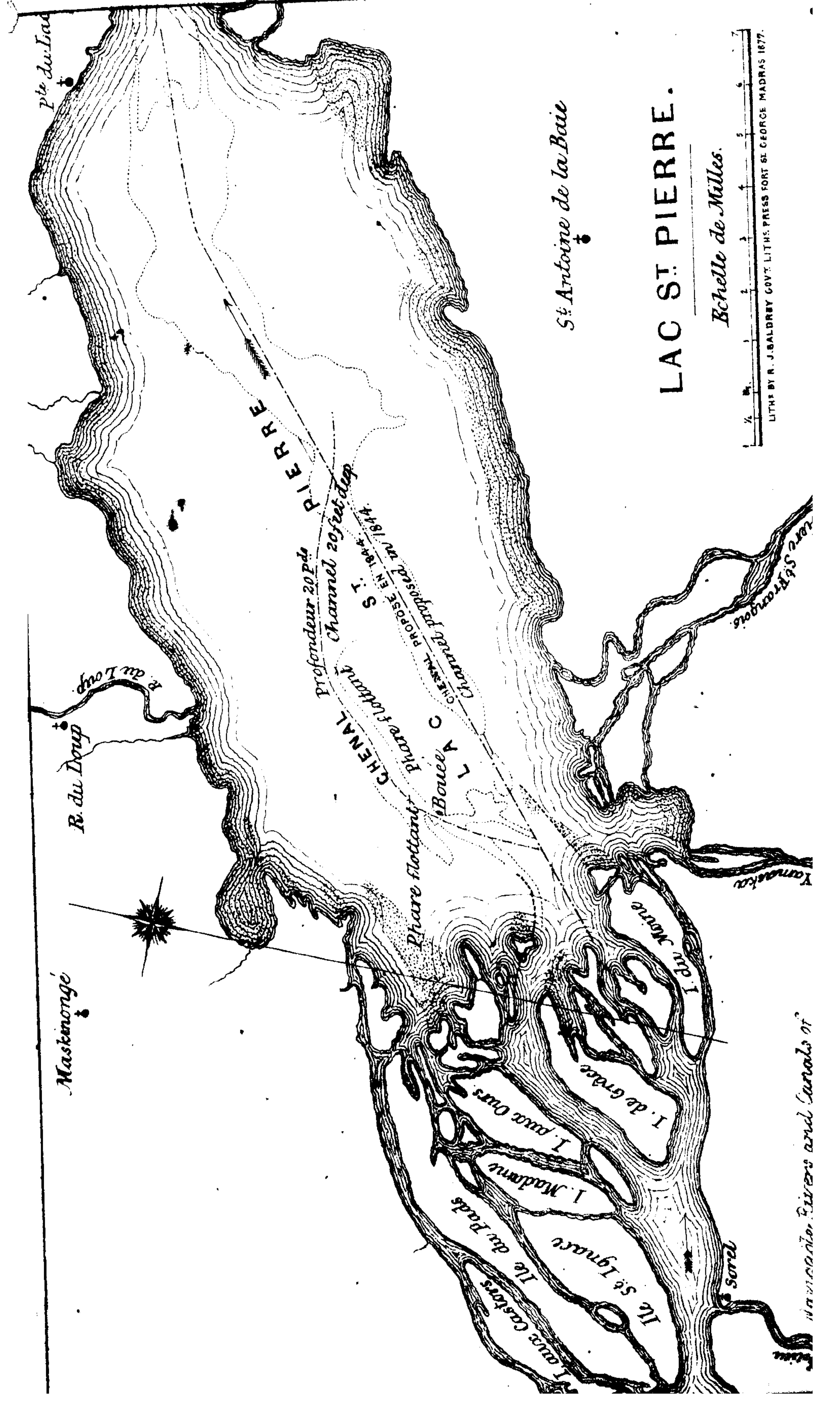
On the *River Improvements* there is now employed the following plant:—

	Value, dollars.*
6 "Clyde" built elevator dredges, each $65,000...	390,000
1 do do ...	45,000
1 do do ...	20,000
1 Paddle wheel tug	26,000
6 Screw tugs	48,000
1 Stone lifter	2,000
24 Barges, Scows, &c.	57,000
Total ...	$588,000

Dredging.

The cost of dredging, raising, towing and depositing is stated to vary "from $1.79½ cents per cubic yard of small and large boulders, to 11½ cents per cubic yard of soft clay."

* Note.—The dollar in Canada is worth 4 shillings.



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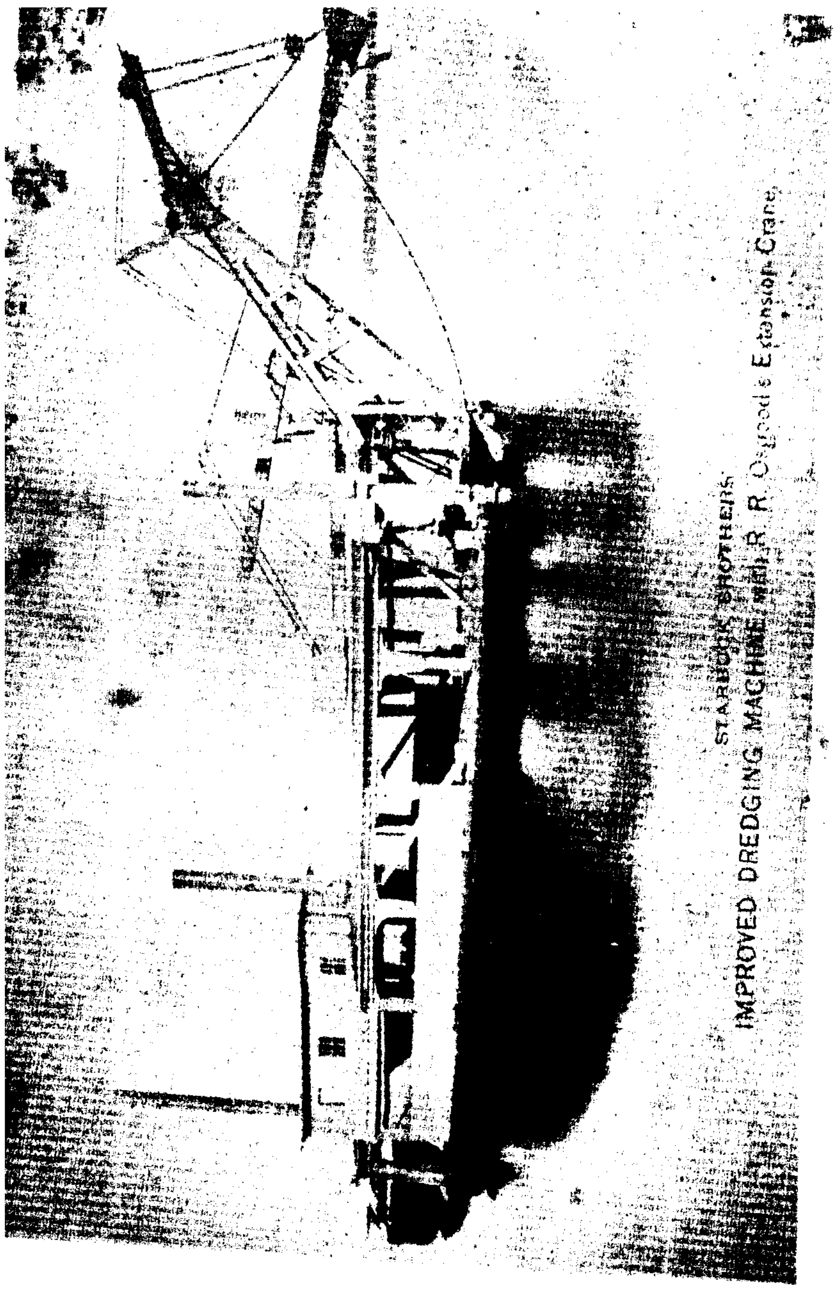


STARBUCK BROTHERS.
IMPROVED DREDGING MACHINE with R. Osgood's Extension Crane.

For the *Harbor Improvements* the plant is—

1 Elevator dredge, capacity of bucket..... 4 cubic feet.

5 "Spoon" dredges do do ... 40 ,,
known in the United States as "Osgood" dredges (see photograph attached, and see drawing with separate plans.)

3 "Clam shell derricks," chiefly used in taking the stuff off the "scows" and placing it on the shore where the water is too shallow to allow of the scows going alongside.

3 Tug boats.

17 "Dumping Scows."

Extract from Report of Harbour Commissioners, 1875.

"The total quantity of dredging done (in season of 1875) was 169,419 cubic yards, and the gross cost 76,807 dollars, or an average of 45⅓ cents per yard for dredging, towing and unloading by derricks, including *all* expenses of the year for repairs, working and maintenance of the plant, but not including depreciation, nor interest on first cost."

Dredges.

On the 27th June, 1876, I saw the dredges at work. Three of them were excavating foundations for a line of wharves in between 25 feet and 30 feet of water, the bottom being very stiff clay mixed with boulders, known as "hard-pan." The ends of the "scoops" or "spoons" were armed with large teeth and the engines had to be so worked as to bring these to bear with jerks, which, of course, racked the dredges and severely tried the engines, but the work was being done at the rate of a scoop about ¾ full, say 30 cubic feet, every two minutes.

Wharves.

The wharves are being constructed of crib-work, the cribs, however, being filled with clay, excavated out of the bed of the harbor, instead of, as is usual, with stone. There are now 20,585* lineal feet of such wharfage which length is to be considerably increased.

City of Montreal.

The city of Montreal is situated on the south-east side of the island of the same name lying at the confluence of the Ottawa river with the St. Lawrence, and is on the left

* For vessels to 10' draft 5,665.
,, ,, 18' to 20' ,, 11,270.
,, ,, 24' ,, 3,650.

bank of the latter river. Its situation, at the junction of two great rivers, and where there is a break from ocean to inland traffic, makes it the most important commercial centre of the dominion. Its population is now 108,000, which is rapidly increasing. At Montreal, the St. Lawrence is spanned by the celebrated "Victoria" tubular bridge.

Season.

The navigation of the St. Lawrence is closed to sea-going vessels by ice for about 5 months of the year, generally from commencement of December to commencement of May.

(b.) *The Lachine Canal.** —Immediately above the city of Montreal occur the first rapids that bar the ascent of the river, known as the "Lachine" or "St. Louis" rapids, the fall in $8\frac{1}{2}$ miles being nearly 45 feet, the greater part of which is concentrated into about 3 miles. To avoid these rapids the Lachine canal was constructed across the southern corner of the island from the city of Montreal to "lake St. Louis," a wide portion of the St. Lawrence. It was commenced in July, 1821, and in 1825 the first vessels were passed through. It was then 8 miles, 718 yards in length (including channel formed in the river by "wing-dam" above the "guard" lock), with a water breadth of 38 feet and a depth of 5 feet, and had 7 cut-stone locks 100 feet × 20 feet with $4\frac{1}{2}$ feet on the sills. Its cost was £109,601, of which £10,000 were contributed by the Imperial Government to secure free passage of its vessels and stores.

Original canal.

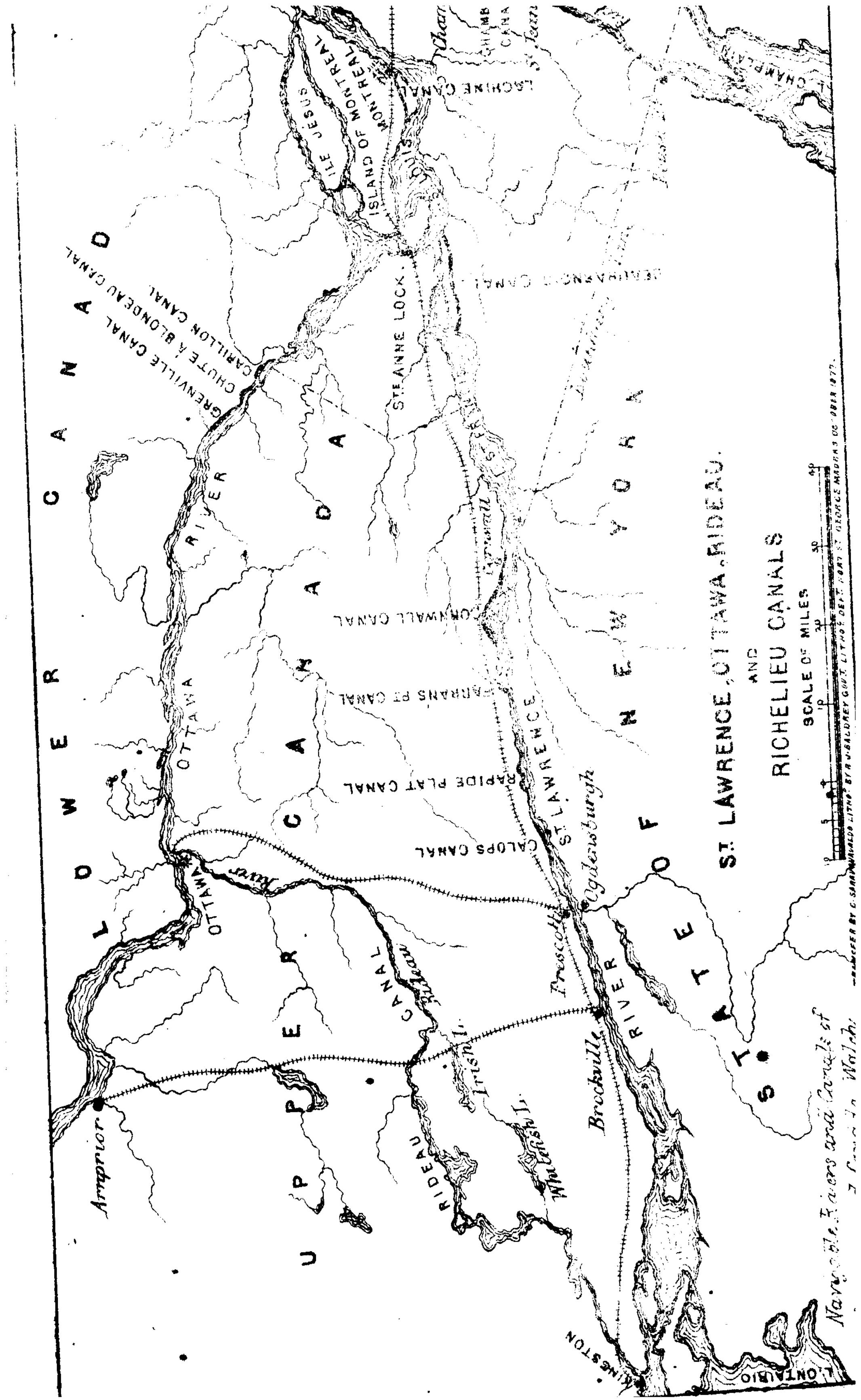
Former Enlargement.

The enlargement of the canal having been found necessary was commenced in 1843 and finished in 1848, the channel being the same length as before, the breadths at bottom 80 feet, and at water surface 120 feet; the depth 10 feet. The number of locks was reduced to 5 with a total lift of $44\frac{3}{4}$ feet, their dimensions being 200 feet × 45 feet, the three upper ones having 9 feet on their sills, and the two lower ones 16 feet; this greater depth being given to admit the largest sea-going vessels, which it was then thought would come to Montreal, to the basins which were constructed in connection with the canal.

Cost.

The total cost of the new canal from its commencement to 1867 was £527,282.

* Visited 27th to 30th June, 1876.



Description of existing canal.

The canal commences at the harbor of Montreal. The entrance is formed by a pier of crib-work, extending from the south wing of the lower lock into the river for 250 feet, to which vessels can moor.

Lock 1 has an extreme lift of 13 feet, and between it and Lock 2 is a basin, 580 feet × 180 feet, with dressed stone walls, along the northern side of which is a wharf. Lock 2, similar to Lock 1, lifts (13 feet) from this basin into anothe one (No. 2) which is 2,200 feet in length, and has a superficial area of nearly 14½ acres; it is lined with masonry walls and has extensive wharfage. Out of this basin, at its north-western end, open two others (Nos. 3 and 4) which run parallel to each other and about 130 feet apart, their superficial area being 32,450 square feet and 50,000 square feet, respectively, with an aggregate of 3,590 lineal feet of docking. At 100 feet and 700 feet, respectively, above this basin (No. 2) two "slips" or basins with ordinary slopes "pitched" open out of the canal and afford about 150,000 superficial feet of accommodation to small craft and timber rafts.

From Lock 2 the canal continues through the town for nearly a mile, flanked by mills and warehouses, to Lock 3, which has a lift of 8 feet 9 inches.

Lock No. 4, which is 9,400 feet above No. 3, has a lift of 9 feet. Near this lock are several mills, manufactories and elevators, worked by water from the canal.*

Lock 5, (the "guard" lock), is about 4½ miles above No. 4.

* "The propriety of leasing the surplus water of the canals is questionable. It has been urged in its favor, that manufactures are, by this means placed in immediate connection with the navigable waters, that it is a great advantage to mill owners to find ready to their purposes, an available water-power; and that it gives, at once, a direct revenue to the Government, in the shape of rent, as well as an indirect revenue arising from the increased general posperity.

Admitting these advantages, there are, on the other hand, certain drawbacks. One of the greatest of these is the increased current created in the canal, and the consequent inconvenience to vessels passing through. This inconvenience is so much felt at the present time, that the evil far outweighs all the advantages—yet how much more must it be as the traffic through the canal increases."—(General report, Commissioner Public Works, 1867).

It opens into a channel formed by a crib-work pier or "wing-dam" 4,650 feet long, which extends up the river roughly parallel with the shore; this was constructed to raise the water at the entrance to the canal, and is used for mooring vessels to; it has a small lighthouse at its extreme end. This channel leads into the expansion of the St. Lawrence, known as "lake St. Louis," where the chief channel of the Ottawa river comes in. The Lachine canal, therefore, accommodates the traffic of both rivers.

Locks.

All the locks are 200 feet in length and 45 feet in width between the quoins; the two lower ones, as already stated, having 16 feet depth on their sills, and the three upper ones 9 feet. They are built of stone in hydraulic mortar and are founded on timber platforms under which, when the bottom was soft, a bed of concrete was laid. The water is admitted and let out of them through wickets in the gates only, there being four, 4 feet × 2 feet in each leaf, closed by cast iron turning valves worked by screw gearing at the top of the gate. The sills of both gates are at the same level, a "breast" wall near the entrance to the upper bay retaining the bed of the canal. This system is adopted because elevated sills are unable to stand the shocks given to gates by heavy vessels. The gates on these locks are not unfrequently rammed away by large vessels, but as no masonry below water is thereby injured the damage done is easily repaired.

All the sills are timber trusses. These are bolted down to large cross timbers lying in trenches 8 feet below the floor, the space between them and the flooring being filled with rammed puddle. The gates (two leaf) are not "framed," but are built up of solid longitudinal timbers, from 18 inches to 20 inches thick, bolted together by large iron bolts running through the whole height of the gate, and strengthened by vertical posts, or binders. There are no separate "heel" or "mitre" posts, the ends of the longitudinal gate timbers being shaped to the quoins and mitres. The gates move on a pivot at the heel and are suspended by a wrought iron strap on each side, attached by "turn-buckles" to a wrought iron strap passing round an iron pin held directly over the centre of revolution

by a timber which lies on, and is bolted to, the side wall. This system of entire suspension is found very superior to that of letting the gates rest on rollers travelling on tracks, which frequently get obstructed by deposits. As a provision to enable them to be worked in case of breaking of the suspension bars, the gates are sometimes provided with rollers which, whilst the gates are in suspension, are kept clear of the tracks. The tops of the gates are held in position by the ordinary arrangement of collars and anchors. They work with a smoothness and ease not often found with such large gates. The gates are opened and closed by drag chains worked by crabs, except in two cases, namely, the upper gates of Locks 1 and 3, to which the pole arrangement, so much in favor in Holland, has been fitted and acts most satisfactorily, two men working the ponderous gates with ease. The pole, which is a piece of hard wood, 8 inches broad × 5 inches thick, is fastened to the leaf about 10 feet from the mitre on a vertical pin or pivot, round which it can move. It travels over 3 friction rollers (1′-3″, 2′-4″, and 3′-5″ long, respectively,) on the coping. A chain fastened to each end of the pole is passed round the drum of a crab, which stands on the coping across the pole, so that when wound one way the pole is forced forwards, and when wound the other way it is dragged back, turning, as it travels, horizontally on the pin on the gate and accommodating itself to the varying directions due to the curved path of the gate. Under the crab the pole passes between two check pieces, 1 foot 3 inches apart, which keep it from swinging wildly and also act as stops to a pin running through the pole at exactly the place which will bring the gate to its mitreing position; these are useful in holding a leaf if the other gets bumped open forwards, as is sometimes the case, by a heavy vessel against a pressure of water, assisting the clapping cell in holding the leaf till the other one springs back into position. This pole arrangement if used for lower gates is very liable to injury from boats in the chamber.

Times in working Locks.

I made some notes of the times of working the locks, of which the following is an abstract:—

Lock 1.—Three large barges, fully laden with sawn timber, entered from above and

	h. m.
Gates (with pole arrangement) commenced to be closed, one man to each leaf	11-39
Gates quite closed (some delay caused by one of the boats getting in the way)	11-41
Owing to some arranging among the boats, wickets in lower gates were not commenced to be opened till	11-50
Wickets fully open (one man to each).. ...	11-51½
Commenced to open lower gates, 2 men to each crab	11-52¾
Gates fully open	11-54½

As the river was very full there was a drop of only about 6 feet.

Lock 2.—Lift 13 feet. Two boats, lightly laden, one (capacity said to be 10,000 bushels of grain) 110 feet × 22 feet at broadest part, the other (capacity said to be 20,000 bushels of grain) 150 feet × 26 feet entered the lock from below and

	h. m.
Lower gates shut	4-25½
Commenced to open upper wickets, each hard work for one man	4-28
Wickets fully open...	4-30
Commenced to open upper gates, 2 men to each crab	4-33
Upper gates fully open	4-34½
Lock 3.—Lift 8'-9". Grain boat, carrying 21,000 bushels of wheat, entered from above	11-12½
Upper gates shut (pole arrangement)... ...	11-14
Commenced to open lower wickets	11-16¼
Do. do. do. gates	11-19
Lower gates fully open	11-20¾
Boat clear out	11-23¾

Swing Bridges

As the canal is used by schooners with high fixed masts, and by steamers with hurricane decks, all the bridges on it have to swing open. There are six of them belonging to the canal, (and one wrought-iron girder bridge of the Grand Trunk Railroad), three of them over locks. They are all timber trusses, varying from 79 feet to 86 feet in length and from 11½ feet to 15½ feet width of roadway. One, over lock 2, is worked by water-power from the canal, one by horse-power, and four by gearing worked by hand. Their general construction is thus described by Mr. J. G. Sippell (in his report of 31st August, 1867):—

"The timber bridges are formed of string pieces, braced horizontally with timber and iron cross braces, the side of the bridge forming a vertical truss, composed of diagonal cross braces of timber, placed between the stringers and top rail, held in their places by iron tie bolts, with nut and screw at each end. A ballast box is formed at the heel of the bridge to counterbalance the weight of the toe. There is a gallows frame erected at the pivot beam, over which the suspension chains pass, for supporting the toe of the bridge, when open. The length of these chains is graduated by means of screw buckles. There are two rollers attached to the heel of the bridge, traversing on an outer segment of cast iron, secured to a stone foundation. Rollers are also placed near the centre of the bridge, traversing on an inner segment, secured to the stone pier, for supporting the pivot. On the smaller bridges this pivot is placed in the centre of the pivot beam, and 8 feet 8 inches from the face of the abutment wall; but, on the two larger bridges, at Montreal, they are placed at the side, about two feet from the face of the wall, and secured to the under surface of the corbel below the stringer."

Season.

The canal is closed by ice generally from the commencement of December to the commencement of May; the average length of the open season for the last 25 years has been 219 days.

Enlargement of Canal.

For some years past the advisability of enlarging all the St. Lawrence canals to dimensions which will allow the passage of the largest vessels navigating the lakes, has been under discussion. On one side it has been urged that such a step is unnecessary because the present system of transhipment from large vessels into smaller ones or barges at Kingston for transit to Montreal is, and will continue to be, the most profitable, as return cargoes are light and as it is not advisable for sailing vessels to proceed further than where they can use their sails to. On the other side it is contended—(1.) That "large vessels are more profitable than small ones on all channels between places that are considerable distances apart." (2.) That sailing vessels are rapidly being superseded by steamers ("screw propellers"), and that it is not judicious to restrict the latter to six-sevenths of the voyage between Chicago and Montreal. The matter is not settled yet as regards the whole of the St. Lawrence canals, but as the Lachine canal has to accommodate the traffic of the Ottawa, as well as of the St. Lawrence, and as its lower portion has to be increased in size to enable ocean-going vessels to get to docks and wharves, it has been decided to enlarge this one of the canals at an estimated cost of nearly six millions of dollars (£1,500,000) and part of the work is now in hand.

It was intended to use in the enlargement only the portion of the existing canal which is within the limits of the city, and beyond that to make an entirely new channel near the present one, but the land over which such a line would have passed having suddenly gone up in value from $120 to from $11,000 to $18,000 an acre, that scheme had to be abandoned and the enlargement of the existing canal for its whole length (except between Locks 1 and 2) has been decided on.

A new entrance is to be made from Montreal harbor. From this, a Lock (No. 1) with 18 feet of water on its upper sill (or rather "breast wall") will lift into a masonry lined basin 540 feet long and 19 feet deep, from which another of similar dimensions and parallel with it will open. From the former of these basins a second Lock (No. 2), like No. 1, will lift into existing basin No. 2 (see description of existing canal) which will be enlarged, and through it a wide channel 19 feet deep will be made, all other parts of the basin being deepened to full 13 feet. Out of this basin a new one is to open, on the south side, to be known as the "Wellington Basin." It is to be 1,250 feet × 225 feet and 19 feet deep, and surrounded by masonry dock walls. Westwards of basin 2 the existing canal is to be enlarged to 200 feet mean width and 13 feet depth as far as Lock 3, where a new lock will be built close to the existing one. Between Lock 3 and Lock 4 (new one to be built close to existing one) the existing canal will be enlarged to 175 feet mean width and 13 feet deep, and between Lock 4 and "Guard" Lock (new one to be built near existing one) at Lachine to 150 feet mean width and 13 feet deep, giving a sectional area of nearly double that of the present canal. A new entrance channel, 200 feet wide and 15 feet deep, is to be constructed at Lachine, and will be formed by a continuous line of "crib"-pier about 6,200 feet in length.

The total estimated cost of these new works is a little under £1,500,000.

Masonry works on new canal.

Docks and Basins.—Basin No. 1 and "Wellington Basin" were commenced last year (1875). When I visited them (25th and 26th June, 1876), work which had been suspended during the winter was just being recommenced. The walls, which are of limestone masonry in hydraulic cement mortar, are founded on platforms of 3 inch pine planks laid obliquely on 5 rows of timbers or joists 12 inches square, the spaces between which are filled with puddle or concrete. They are to be 4 feet wide at top, 3 feet above water surface, to have a front batter of ½ inch to a foot, and a rear one for the top 5 feet, of 4 feet; this latter is called the "frost-batter" because it is specially provided to permit the portion of the ground liable to be frozen, to travel up instead of pressing out, the wall. Below this "frost-batter" the rear of the wall is to be plumb with counterforts 6 feet × 3 feet at 12 feet intervals. The face of the walls for the lower 17 feet is of "coursed" work, the courses not less than 9 inches in height, the stones not less than 2 feet in length of face, and the alternate courses 20 inches and 30 inches or thereabouts in depth of bed, with headers at every 12 feet running back 4 feet or more into the wall. The face of the upper 4 feet is to be of "cut-stone," of which the stretchers are to be at least 3 feet long on face and not less than 2 feet and 3 feet in length of bed on the alternate courses, and the headers, 11 feet apart, at least 2 feet on face and 4½ feet depth back of bed. All "backing" is to be of stones not less than 6 inches thick and 4 feet area of bed. Coping stones to be 15 inches thick, the full width of the wall, and at least 4 feet long, dowelled together by pieces of 1½ inch rod iron, 4 inches long, inserted 15 inches back from the face and 6 inches down from the top. At the back of these walls, and at level of their coping, wharves will be formed, 26 feet wide of 3 inch planking, resting on sleepers 10 inches thick, the spaces between them filled with rammed broken stone.

Locks.

All the new locks, which will be built of the same lifts as, and not far from, the existing ones, will be 270 feet long between the gate quoins and 45 feet wide at the floor. They will have both sills on the same level, the bed of upper reach of canal being retained by a breast wall, the top of which in locks 1 and 2 will be 18 feet and in the other locks 14 feet below water surface. They will be built on timber platforms, and the masonry will resemble in general character that of dock walls already described. The sills will be wooden trusses like those described on existing locks. A drawing of the gates, most kindly given me by Mr. J. G. Sippell, Resident Engineer, is sent herewith. (See. No. 56 in Vol. of Plans.)

Regulating Weirs.

In connection with each lock will be a regulating weir. It will, like all the masonry works on the canal, be built on a timber platform which, in this case, will be laid $5\frac{1}{2}$ feet below surface of lower reach water, the portion between the rear wings being covered by an extra course of two inch planking as a floor. Four ranges of sheet piling, 5 feet deep, will run across the foundations. The "breast wall" will be 4 feet wide at top and 9 feet at bottom; crest 1 foot 3 inches below upper reach level and 49 feet in length, divided into two bays by a centre pier, $3\frac{1}{2}$ feet wide at top, to carry a platform foot-bridge. There will be eight rectangular vents in the weir, each 5 feet high × 4 feet wide, with their sills at level of bed of upper reach. These will be closed by wooden gates revolving vertically on centre pivots and worked by turning rods, 3 inches diameter, running up through clips built into the face of the wall, to 6 inches above the level of the wooden platform, which will be placed over the weir just in front (up-stream side) of the breast wall. The gates will clap against an oak frame, 6 inches thick and 12 inches wide, fastened to the sides and lintels of the vents. The masonry will be massive and all coping of through stones. In the upper wings and bridge pier will be cut "checks" or grooves for the reception of stop planks which will be useful in the event of repairs being required to the weir.

The "race-way" above and below the weir will have side walls of "random coursed" masonry, "that* is to say, that both beds of the face stones must be level, but continuous courses will not be required."

For a distance of 70 feet below the end of the weir these race-way walls will, for 7 feet in height, have a lining of planking fastened into a recess or panel, 2 inches deep, in each wall. This is a peculiar instance of the great favor in which timber is held by Canadian engineers for use in hydraulic works. The whole of the bed of the lower race-way will be covered by a planked flooring which will run under and form the foundations of the side walls, and under this flooring will be several cross rows of sheet piling, 6 feet deep.

The culverts, none of which will be of great size, will be of masonry and built so as to admit of a future deepening of the bed of the canal by 2 feet, *i.e.*, to 15 feet depth of water. Culverts.

(*c.*) *The "Beauharnois Canal."*†—The length of "Lake St. Louis," from where the Lachine canal enters it to where the river again narrows is $15\frac{1}{4}$ miles. In the next 11 miles there are three rapids; the first, ascending the river, is called the "Cascades," the second the "Cedars," and the third the "Côteau." Into these is concentrated, in a distance of about 7 miles, a total fall of $82\frac{1}{2}$ feet leaving between them two short nearly level reaches. Navigation round these rapids was, till the completion (in 1845) of the existing canal under notice, effected by four short canals which, at the commencement of the century, had locks with only 6 feet breadth and $2\frac{1}{2}$ feet on the sills. These were, in 1817, enlarged to 12 feet in breadth with $3\frac{1}{2}$ feet on the sills. In 1843 the construction of the present canal was begun, and it was opened at the end of 1845. Its cost, with improvements and additions to 1867, was £402,856. It begins at the foot of the Cascade rapids, the entrance being formed by piers, 535 feet long, of crib-work below water level, and a continuous superstructure of timber. The canal runs for its whole length, $11\frac{1}{4}$ miles, close to the south bank of the river, entering it again at the

* Extract from Specification.

† Visited 5th July 1876.

eastern end of the widening known as "Lake St. Francis, just above the Coteau rapids. Its prism is 80 feet at bottom; 120 feet at water surface with 10 feet depth. It has 9 locks, like those of the Lachine canal, 200 feet × 45 feet with 9 feet on the sills, with a total lift of 82½ feet.

Time occupied in passing Canal.

The locks on this canal are so like the existing ones on the Lachine canal, already described, that no separate description is necessary, but as possibly of interest I will give my notes of the time occupied in passing each of them and through the whole canal, in a steamer. The vessel "The Passport" is a side-wheel steamer, 181 feet in length over all, 44 feet in breadth over paddle boxes, and of 346 tons register under main deck. She carries at some 10 feet above her main deck another one on which are passenger saloons and cabins ("State-rooms"), and the roof over these forms another deck from which the steering is done.—

5th July, 1876.

	h. m.
Entered *1st Lock*, (lift about 11 feet) ...	1-46
Commenced to open upper gates... ...	1-52
Out of lock	1-56
Entered *2nd Lock* (11 feet lift), 1,130 feet above 1st	1-59
Out of lock	2-9½
Entered *3rd Lock* (10⅞ lift), 900 feet above 2nd	2-13
Out of lock	2-25
Entered *4th Lock* (10½ feet lift), 1,380 feet above 3rd	2-28½
Out of lock	2-37½
Entered *5th Lock* (10 feet lift), 1,320 feet above 4th	2-41
Out of lock	2-54
(NOTE.—Total time in passing 5 locks, and about ¾ mile between them, 1 hour 8 minutes.)	
Entered *6th Lock* (8 feet lift), 5,440 feet above 5th	3- 6
Out of lock	3-17

	h. m.
Entered *7th Lock* (10⅙ feet lift), 5,490 feet above 6th	3-30
Out of lock	3-40½
Entered *8th Lock* (9½ feet lift), 10,200 feet above 7th	4- 7½
Out of lock	4-14½
Entered *9th Lock* (2 feet lift), 6 miles above 8th...	5-17½
Out of lock	5-27
From this (9th) Lock to head of canal is 3,160 feet.	
Clear out of canal	5-45

Ten minutes were occupied above Lock 9 in taking in firewood, exclusive of which the total time occupied in passing through the 11¼ miles of canal and its 9 locks was 3 hours 50 minutes. The speed of the steamer on the river was 11 miles an hour, so that the delay caused by this canal was 2 hours 48 minutes. Of this one hour was due to the lessened speed necessary in the canal, 5½ miles an hour being the highest average speed attained to in its long reaches; 1 hour 32½ minutes were due to the time actually occupied in passing through the locks; and 15½ minutes were due indirectly to them, from the necessary extra reduction in speed in approaching and leaving them. The total delay due to all the locks was, therefore, 1 hour 47½ minutes, or say, 12 minutes to each one.

Other chief Structures enumerated.

The other principal works on this canal are—

13 Weirs.

9 Timber swing bridges (8 of them over locks).

10 Culverts under the canal.

All of these are in general construction like those noticed on the Lachine canal.

Ferry Scows.

I noticed two "Ferry Scows," very like our Godavery "ballakats," plying across the canal, for which recesses in the banks with planked vertical sides were provided.

General Description. (*d*.) *The Cornwall Canal.**—The entrance to this canal is at the town of Cornwall at the head of "Lake St. Francis," $32\frac{7}{8}$ miles above the head of the Beauharnois canal. It runs close alongside the north edge of the river, except in two places, of about ½ mile each, where it cuts across projecting points of land. The total length of the canal is $11\frac{1}{2}$ miles, in which it overcomes by 6 lift locks (besides which there is one "guard" lock at its head) the 48 feet of fall in the "Long Sault" rapids.

Cost. The canal was constructed between 1834 and 1843, at a total cost, exclusive of repairs and management, of £483,288 to 1867.

Prism. The prism of the canal is, bottom width 100 feet, water surface 150 feet, depth 10 feet.

Locks. There are 6 "lift" and 1 "guard" locks, each 200 feet × 55 feet, with 9 feet depth on sills. The three lowest of these locks are only about 200 feet apart, and it took 49 minutes to pass through them in the steamer above-mentioned, part of the time being due to a delay caused by a large grain steamer ("screw-propeller"), which was going downwards, being in the middle lock when we were ready to enter it. When passing through these locks it was blowing hard in gusts, and though the steamer was well handled she bumped heavily against walls and gates, and I saw how necessary it was to have solid gates.

Channel. The north side of the canal is everywhere in cutting, but on the south side the water is retained and the tow-path formed by an artificial bank, founded chiefly on the bed of the river, protected on the river slope by stone-pitching and on the canal side by dry-stone facing for 2 feet above and $2\frac{1}{2}$ feet below water surface to take the wash of waves. This embankment is said to have given frequent trouble by settling and sliding. The general construction of the locks and weirs in connection with them is like that of those on the Lachine canal.

Bridges and Road tunnels. *Land* traffic across the canal is provided for by one timber swing-bridge, 10 feet wide, $56\frac{1}{2}$ feet span between abutments,

* Visited 5th July, 1876

and by four "Road Tunnels" *under* the canal. These are 12 feet wide, 6 feet high at the side walls and 10 feet high at the crown of the arch. Of them, it is stated "they* are *generally* passable for foot travellers and carriages;" also "they* have to be cleared out once a month"; and also "the* river backs up into them," from all of which it is evident that like most works of a similar character they are not very satisfactory passage-ways.

It is estimated that the cost of improving and enlarging this canal to the same capacity as the new Lachine canal would cost £540,000. Estimated cost of enlarging.

(*e*.) *The 'Williamsburgh Canals."*—The channels known collectively under this title all lie on the north side of the river. They are—

(1.) "Farran's Point Canal," 5 miles above the Cornwall canal, ¾ mile long, overcoming by 1 lock the fall of 4 feet in the rapids of the same name.

(2.) At $10\frac{1}{2}$ miles higher up the river the "Rapide Plat Canal," 4 miles long, overcoming by 2 locks the fall of $11\frac{1}{2}$ feet in the rapids of the same name.

(3.) At $4\frac{1}{2}$ miles higher up the river the "Galops Canal," $7\frac{5}{8}$ miles long, overcoming by 3 locks the fall of $15\frac{3}{4}$ feet in the rapids of "Point aux Iroquois," "Point Cardinal," and "Galops."

All the locks on these canals are 200 feet × 45 feet, with 9 feet on sills, and they and the other works being similar to those on the Lachine, Beauharnois and Cornwall canals, I did not inspect them. Locks.

These Williamsburgh canals were constructed between 1843 and 1847, and with subsequent additions cost to 1867, exclusive of repairs and maintenance, £330,164. Canals when constructed and cost.

Descending vessels of moderate draught and ascending passenger steamers do not use the Williamsburgh canals.

"Passenger† steamers ascending from end of Cornwall canal to the head of the Galops rapids, keeping altogether in the channel of the river, make

* Extracts from official reports.

† Extract from official report, 1875.

the trip in 4½ hours, and those which pass up through the canals and parts of the river between them occupy generally about 6½ hours; and loaded propellers bound upwards require from 9 to 10 hours between the same places."

Estimated cost of enlarging.

It is estimated that the cost of improving and enlarging the Williamsburgh canals to the same capacity as the new Lachine canal would cost £527,000, and that the necessary deepening of a channel through the river-reaches between them would cost £131,250.

Navigation of the river above the Galops Rapids.

From the Galops rapids to the head of the St. Lawrence proper at lake Ontario, a distance of 66 miles, the navigation of the river is unobstructed though the channel is somewhat intricate especially where it winds amongst the lovely "Thousand Islands."

Passenger and lightly-laden steamers, with powerful engines, descend the St. Lawrence "shooting" or "running, the rapids," without passing through any of the canals, but they have to make use of them all (except the Williamsburgh canals, as already noticed,) in ascending. I went (4th July, 1876,) *down* the river from Prescott to Montreal on a large passenger steamer, which "shot" all the rapids and took only 8½ hours in doing the distance (119 miles), and I went (5th July) *up* the river in her between the same places, using all the canals except the Williamsburgh ones, the voyage occupying 22 hours.

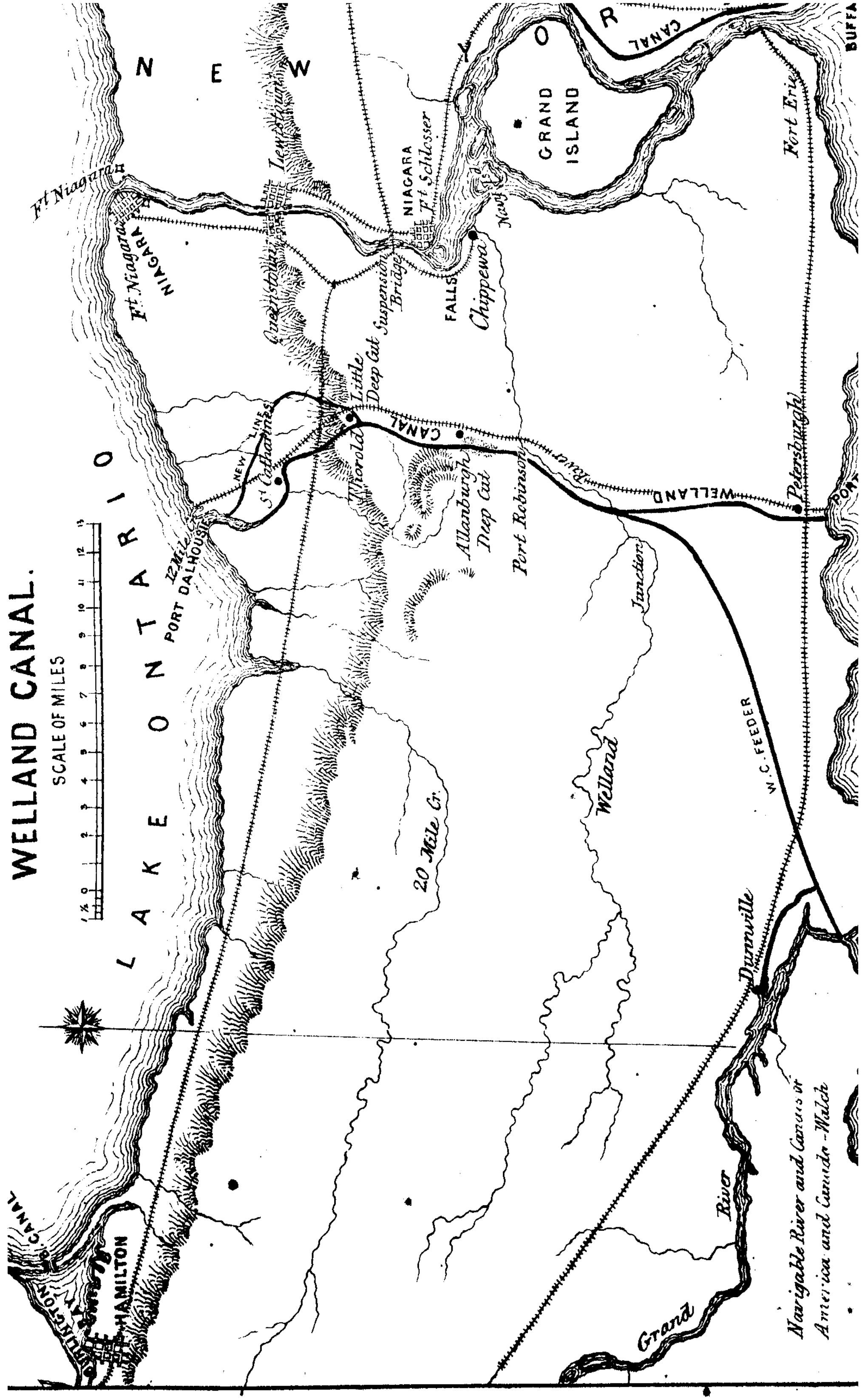
Situation.

(*f*) *The Welland Canal.**—The surplus waters of all the great lake basin west of lake Ontario flow into it from lake Erie by the Niagara river, falling 330 feet in its course of 35 miles. West of that river there is, between the overlapping ends of the two lakes, a narrow neck of land; through this is cut the Welland canal. It runs nearly north and south, its southern entrance at Port Colborne on lake Erie being 18 miles west of the head of the Niagara river, and its northern entrance at Port Dalhousie on lake Ontario being 11 miles west of the end of that river.

Original Canal.

The original canal did not run directly from lake to lake, but from lake Ontario to the Welland river just above its junction with the Niagara river. It was constructed by a

* Visited 17th to 22nd July, 1876.



Company, assisted by the Government, and was opened in November. 1829. It passed vessels of 85 tons barden. In 1831, the Government granted a loan of £50,000 for improving the canal and continuing it from the Welland river for $6\frac{1}{2}$ miles to Port Colborne, and in 1833 was opened what may be considered as the present canal, which, however, has since that time been considerably improved. The locks then were all of wood and varying from 110 feet × 22 feet to 130 feet × 32 feet. In 1841, the Government, having previously made various loans to the Company, bought all the stock and acquired sole possession of the canal, the total cost to the Government of the works being £462,857. Between 1843 and 1845 enlarged stone-locks, 150 feet × $26\frac{1}{2}$ feet, with 9 feet on the sills, were constructed, and at various times improvements have been carried out at a cost of £1,266,675, which have brought the canal to its present condition.

Enlargement to present canal.

Description of existing canal going northwards.

The entrance from lake Erie is formed by piers of crib work, the western one running in a south-westerly direction for 1,600 feet and the eastern one in a southerly direction for 500 feet from the shore line, where they are 150 feet apart. From the land end of these piers there is a basin, 1,475 feet long, with an average width of 265 feet and a depth varying according to the level of the lake from 11 feet to $18\frac{3}{4}$ feet. At the end of this basin is the "Port Colborne Lock (No. 27), with an ordinary *lift* of 8 feet to what is known as the "summit-level" It will thus be seen that the canal is not a continuous descent to lake Ontario and cannot, therefore, draw its supply from lake Erie. In order to lessen the depth of cutting (*now* 45 feet) through the highest part of the dividing ridge between the lakes, the supply for the canal was arranged from the "Grand River," which empties into lake Erie at port Maitland, 17 miles west of port Colborne. This river is dammed about 5 miles above its mouth, its waters being thereby raised to a level which admits of the canal surface being maintained about 8 feet above the ordinary lake level. The channel down which the supply water is brought is, from its head at the town of Dunville to the Welland canal, 21 miles long and is navigable, with depth 9 feet, for its whole length. Five miles from its upper end is a navigable branch which locks into the lake at port Maitland. The supply obtained by this existing arrangement is in dry seasons found to be barely enough to keep navigation going. The "summit-level" extends from Lock 27 before-mentioned, for $14\frac{1}{2}$ miles to the Allanburgh Lock (No. 26). For $1\frac{3}{4}$ miles from Lock 27 there is a heavy rock-cutting through stratified limestone. The feeder joins at 7 miles along this reach, and about a mile beyond it the "Welland" (or "Chippewa") river is crossed by a masonry aqueduct of 4 arches of [illegible] feet span and 7 feet rise. As the river is navigable by light lake-going craft for some 10 miles higher up than where the aqueduct crosses and blocks it, a short branch canal, with a lock of 17 feet drop, communicates with it. For $3\frac{3}{4}$ miles beyond the aqueduct the canal keeps close to the left bank of the Welland (Chippewa) river to port Robinson, where there is another short side-cut and lock into the river $8\frac{1}{4}$ miles above its mouth at Chippewa, a small port on the Niagara river 15 miles from its head on lake Erie and about two miles above the falls.

Thus the canal has three separate navigable entrances from lake Erie, viz., port Colborne, port Maitland and Chippewa; the first, however, being the only one much used by navigation. At port Robinson a deep cutting commences and continues for $2\frac{1}{4}$ miles to Allanburgh Lock (No. 26), about $1\frac{3}{4}$ miles of the distance being known as "The Deep Cut," in which the bottom of the canal is 45 feet below the original surface of the ground and about 60 feet below the *present* surface, that having been raised by spoil. This cut is through stiff clay resting on an unstable sub-stratum resembling quicksand, and numerous slides have caused great trouble and expense. At 500 feet above the Allanburgh lock there are guard gates which serve to retain the water in the "deep cut" at a uniform level, and thereby lessen the liability to slides; they also prevent any serious catastrophe from the emptying of all the water in the long "summit-level" and feeder when, as is sometimes the case, the gates of the drop lock are torn away by ill-managed steamers. These guard gates are not allowed to be open when any vessel is in the lock or approaching it from the upper reach. The Allanburgh lock drops the level $15\frac{1}{4}$ feet to a reach $3\frac{1}{2}$ miles long, which crosses the "Beaver Dams Creek" valley between high embankments, then passes through a natural sheet of water known as "Marlatt's Pond," and ends at Thorold Lock (No. 25), just before which are guard gates similar to those above Lock 26. The canal then passes through the village of Thorold, and in the next $5\frac{3}{4}$ miles descends 306 feet, by means of 24 locks, to the "12 mile Creek." This creek having been dammed at its outlet into lake Ontario a "pond" has been formed, $3\frac{1}{2}$ miles in length, reaching up to the town of "St. Catharine's." Into this "pond" the canal drops, as above stated, and *from* it a Lock (No. 1) passes the navigation out of an "inner basin" of some 40 acres in extent into the "outer basin" and lake Ontario at "Port Dalhousie." This outer basin is 8 acres in area, and from it crib-work piers, 1,800 feet long and 200 feet apart, run into deep water, the channel between them being kept dredged to the required depth.

"The harbor is easy of access and egress in almost any wind. There is no perceptible current to contend with, and inside it is well sheltered by the high lands on the east and west sides."—(Extract from Chief Engineer's Report, 29th April, 1872,)

Size of vessels using existing canal

The present canal is regulated throughout for the passage of vessels of 145 feet long, 26 feet broad and 10 feet draught. The largest vessels which use it are of about 400 tons, but seldom carry more than 300 tons, or 4,000 barrels of flour, or 18,000 bushels of grain.

Breadths of canal.

The bottom breadth of the canal varies from 50 feet to 70 feet; in the rock-cutting, where the sides are perpendicular, it is 58 feet; through the remainder of the "summit-level," including the "deep cut," it is 50 feet.

Locks.

The locks are all 150 feet × $26\frac{1}{2}$ feet, except Nos 1 and 2, which are 200 feet × 45 feet, and No. 27 which is 230 feet × 45 feet; the least depth on sills is 10 feet. A detail description of these locks and other existing works is considered unnecessary as they resemble generally those on the Lachine canal, and the new locks, &c., now being built, will be fully described.

Time occupied in passing through locks.

I will give, however, some notes of observations of passage of vessels through Locks 3 and 2, the former 150 feet × $26\frac{1}{2}$

feet and about 12 feet lift, and the latter 200 feet × 45 feet and about [illegible] lift.

A large 3-masted schooner "Oliver Mowatt," 400 tons, drawing 9 feet, loaded with "lumber" going downwards (northwards), towed by 4 horses, entered Lock 3 at 9 hours 18 minutes. Her jib boom was run in and her bow-sprit lifted by tackle attached to the foretop by an arrangement common to all the craft which use the canal.

(22nd July, 1876.)

	h. m.
Upper gates of lock closed	9-19¼
Commenced to open lower valves (2 in each leaf worked by screws)	9-20¾
Commenced to open lower gates (1 man to each leaf)	9-30¼
Schooner clear out	9-42

The time occupied in passing out of the lock after the gates were opened may appear extraordinarily long, but no time was unnecessarily lost about it. The getting way on such a vessel, with 4 horses straining even to their utmost, is slow work, and there being but two or three feet clear on either side for water to pass back into the lock to take her place as the vessel moved forward, the rush along her sides was so great as to drag her back, and to prevent more than very gradual movement.

Between Locks 3 and 2 some of the twists in the channel (the natural course of the "12 mile creek") are so sharp, that in order to turn them the schooner above-named had to get hawsers out to bollards ("snubbing posts"). She arrived at Lock 2, 47 minutes after leaving lock 3, the distance is a mile, and she was towed by 4 horses:—

	h. m.
Fairly in *Lock 2*	10-31½
Upper gates shut	10-33¼
Commenced to open lower valves (3 in each leaf)	10-33½
Lower gates fully open	10-40
Schooner clear out	10-47

There being in this wide lock (45′) a fair space for the water to flow back between the side walls and the vessel, she

moved out of this lock with much greater ease than she did out of the smaller one.

Through the same Lock (No. 2).—Large 3-masted schooner "R. Norwood" going southwards light, drawing only 4 feet, (but when *fully* laden* drawing 10′-3″ as water-mark showed) came up to the lock just as the "Oliver Mowatt" was entering from above, and therefore had to make fast to bank below lock and wait.

	h. m.
She unmoored and 4 horses commenced to pull at her at	10-50
Got fairly into the lock	10-58
Lower gates closed	10-59¼
Clear out of lock	11-9

Same lock, screw steamer "Empire," drawing 9½ feet, going northwards with, it was said, 20,000 bushels—

	h. m.
Entered the lock and gates shut	11-14
Lower gates open	11-20
Fairly out	11-21¾

It will be seen that it takes a steamer only about a quarter of the time that it takes a vessel towed by horses to get out of a lock. The delay caused by each lock on the canal is generally stated as 20 minutes, but as all the locks but three **Towing.** are of the same size as No. 3, I consider that, including reduction of speed on approaching and leaving, each lock delays large sailing vessels not less on an average than half an hour.

Though the towing on the short reaches between the locks is generally done by horses, on the long reach from Port Colborne to Allanburgh, 14½ miles, it is generally done by steam tugs. One of these I saw on that reach towing one large 3-masted schooner and two 2-masted schooners, all fully laden going towards lake Ontario. Another tug I saw take a large 3-masted schooner, lightly laden going towards lake Erie, from the guard lock to Welland, 6½ miles in one hour and 10 minutes, with heavily laden vessels the same distance takes, I was told, upwards of 2 hours, and the

* Said to carry 18,000 bushels on lake and 16,000 on canal.

trip through the whole canal takes laden sailing vessels towed, from 30 to 48 hours, and steamers from 20 to 24 hours.

Increase in size of lake vessels.

For some years after the construction of the existing locks the Welland canal could be used by all craft on the lakes, but as it has of late years become recognized that freight can be carried over the thousand miles from the head of lake Michigan to the foot of lake Erie far more profitably in large than in small vessels there have been gradually placed on the trade numbers of vessels, chiefly "propellers" (the local name for screw steamers) which are too large to pass through the canal, and now, it is said, three-fourths of the tonnage employed on the lake traffic cannot pass to lake Ontario. Arrived at the eastern end of lake Erie and unable to proceed further without transhipment, it is not surprising that the greater portion of the contents of these vessels goes to New York from Buffalo by the railways which centre there, or by the Erie canal, the eastward going freight of which is double that of the Welland canal. Canada is determined to alter this, to turn the immense and daily increasing stream of western traffic more into Canadian channels and to make Montreal instead of New York the great grain exporting port of the North American Continent. With these objects in view she has undertaken, at an expense estimated at £2,310,000, the fitting of the Welland canal for the largest vessels navigating or likely to navigate the lakes. The splendid works by which this is to be accomplished, I had by the great courtesy of Mr. Munro, the Resident Engineer, every facility for inspecting. They were in all stages of progress and, therefore, particularly instructive, and I spent some days on them. Before noticing individual works it will be advisable to give a general view of the improvements intended.

Enlargement of Canal.

Prism.

The *prism* of the canal is to be made with an average bottom width of 100 feet and a depth of 13 feet.

Locks.

All *locks* are to be 270 feet × 45 feet, with least depth of 12 feet on sills.

Port Colborne Harbor.

The Erie lake harbor "Port Colborne" is to be improved by means of a breakwater, and a secure harbor of 40 acres formed. The inner basin from shore-end of the piers is to be made 2,200 feet long with an area of 11½ acres. At the end of this will be situated the new "*guard*" lock and *supply* weir, for the whole supply for the canal is to be drawn from lake Erie, so that there can never be any scarcity of water, and the lockage will be reduced by about 16 feet, as it will be continuously descending instead of having a "summit-level," as is now the case. The existing line of canal will be increased to the required dimensions as far as "Marlatt's Pond," (see description of existing canal), which is situated just above the edge of the "Niagara Escarpment," that faces lake Ontario. There the existing canal is left, and an entirely new one is being formed to lake Ontario. It passes through a ravine forming the head of the "10 mile creek," then descends the escarpment above-mentioned by means of 23 locks dropping 308 feet, and after a course of 8⅔ miles (about ¾ mile less than by present line) re-joins the existing line at the pond above the Lock (No. 1) at Dalhousie harbor. This pond is 12 feet above lake level, covers 40 acres and makes a secure inner harbor; it is to be deepened where necessary. A new lock close to the existing one will drop from this inner into the outer harbor or "basin," which is to be increased from 8 to 16 acres, and from it a channel, 200 feet wide, runs between crib-work piers for 1,800 feet into deep water. The estimated cost of all the new works is £2,310,000, and it was anticipated that they would be finished in about 4 years from time of commencement; but this anticipation was undoubtedly too sanguine, and by the time the whole undertaking is completed it will probably have been in hand nearer 8 than 4 years.

Lake Erie to be source of supply.

Estimated cost of new works.

Location of entirely new piece of the line.

The location of the new line, the difficulty of which was increased by the necessity for crossing the "Great Western Railway," and the "Welland Railway" twice, is that selected by Mr. Munro, and approved and supported by Mr. Page, the Chief Engineer of the Dominion. It was not finally determined on till after a warm discussion between Mr. Page and a Commission of Engineers appointed by the Government to report on the subject. The laying out of this diffitrip through the whole canal takes laden sailing vessels towed, from 30 to 48 hours, and steamers from 20 to 24 hours.

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(1). The keeping the locks separate, as "combined" locks delay vessels waiting their turn more than do single ones, and because accidents to "combined" locks are more serious in their results, especially with large heavily-laden vessels, than are those to single locks.—All the locks will be single.

(2). The keeping the locks such distances apart that the reaches between them may not be much affected by the drain when the lock at lower end of the reach is being filled, and may have room for waiting vessels. The shortest reach is 660 feet long; there are five reaches between 700 feet and 800 feet long; 7 between 800 and 900 feet long, and the rest are considerably more.

(3). The provision of "side reservoirs" or "pockets" to all short reaches in order still further to reduce the variation of depth caused by lockage.

Such side reservoirs are provided to all the reaches but five; they are situated immediately below the regulating weirs which stand nearly opposite their respective locks. The channels leading to the weirs and from the reservoirs have their openings in the canal bank some distance above and below the locks, and over these openings the tow-path is carried by bridges. The 5 reaches which have not side reservoirs have a separate channel or "race-way" through which to pass on water.

The works of the *new* portion of the canal from Marlatt's pond to lake Ontario were commenced in August, 1873, and when I visited them, in July 1876, were in full swing. They are being carried out in 12 sections by contractors under the immediate supervision of Mr. Munro and a staff of inspectors. The estimated quantities and those done to date were given me as—

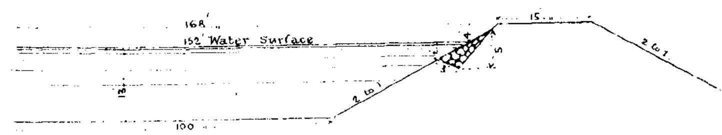
Progress of work to date of visit.

	Cubic yards.		Cubic yards.
Earth-work—estimated	3,500,000	—done	2,579,719
Rock „	175,000	„	68,306
Masonry „	330,000	„	98,742

	Cubic feet.		Cubic feet.
Timber—estimated	1,000,000	—done	399,996
	*Board measure.		Board measure.
Planking „	4,000,000	„	1,306,105
Cost „	£1,295,000	„	£650,000

Prism of new canal.

The general prism of the canal is shown in the sketch below.



The side slopes in earth-cutting are 2 to 1, the made bank being carried up at the same slope and without being set back on a berm or "cess." There is a tow-path on each side of the canal, 15 feet wide at top and 4 feet above water surface, the natural ground being cut down to that level and width when the excavation is more than 17 feet deep. The water faces are not to be revetted from the bottom, but at 2 feet below water surface a nick 3 feet wide is cut, from the back of which the earth is sloped till it meets the true face of the bank 3 feet above water, and the triangular notch thus made is to be filled in with large-sized quarry chips. This inexpensive protection against wash has, I was informed, been found to answer well on canals, but I should have thought that it was founded too little below the surface to be secure from the action of "under-tow," and it probably would not last long on a steeper slope.

"Excavators."

In all earth excavations I found ploughs used to loosen the soil which was then removed in various ways. One of these was by a wooden scoop like a wheel-barrow with a strong curved bottom, with no wheels and no front board, but having an iron protected front edge. This is dragged through the ploughed-up soil by 2 horses, its handles being

* 1 square foot superficial by 1 inch thick.

held by the driver who thereby directs the edge into or keeps it out of the soil, and tips the scoop when the "dumping" place is reached.

Another contrivance was an "excavator" dragged through the ploughed-up soil by 4 horses and when filled taken to the "dumping" place by 2 horses, the leaders having been unhitched and put on to another excavator. This consists of two deep iron scoops, one behind the other, attached to a frame on wheels by chains and gearing, arranged so that the scoops can separately be turned on their axes and so have their cutting edges brought to bear on the ploughed-up surface, or lifted clear of it, or be turned completely upside down and emptied. One scoop being filled is raised and the other one is brought to bear and filled, and that being raised the whole machine is taken off to the dumping ground. The driver sits on the pole of the machine and another man has to attend to the lowering and raising of the scoops, but the upsetting is done by the driver. It is said that one of these "excavators" worked by one team of horses will remove 50 cubic yards a day with short lead, and I think that possible in dry loose soil; the soil was wet and sticky when I saw the work, and 4 strong horses could drag the machine only slowly and with frequent rests.

In deep cuttings where a face could be obtained the "Osgood" (or "Otis") scoop, already described, worked by a portable steam engine on a platform running on rails, was doing capital work, tearing down the earth in masses and loading into carts and trucks with great rapidity. The same machine was also working in the heavy rock-cutting at the summit of "the mountain," (local name for the "Niagara Escarpment,") the stratified limestone being shaken and shattered for it by small blasts put into holes made by steam drills to which steam was supplied from the boiler of the engine working the scoop. The contractors' agent told me that where the rock is "shelly" this is by far the cheapest way of getting it out, but that where he was then working, he considered the rock too solid for satisfactory working of the machine, and this certainly appeared to be the case, the racking of the whole apparatus being

severe and the scoop seldom fairly filling itself. I saw one of these "Osgood" (in Canada known as "Otis") dredges deepening the channel in the Dalhousie harbor. The depth was about 13 feet, and the bottom stiff clay which she was bringing up and loading into "scows," or mud barges, rather faster than a dipper a minute. Each dipper held 2 cubic yards, and it is said that her ordinary work a day in such soil was 1,000 cubic yards. The dredged stuff was being used for backing the docking cribs or being towed by a steam tug into deep water and there discharged into the lake.

Description of Locks.

Of the 24 locks, 3 only were not commenced, 1 was quite finished as regards the masonry, and the others were in various stages of progress, from excavation of foundations to putting on of coping. They are all, even those founded on stratified limestone, being built on wooden platforms extending under the whole work, chambers, bays, and walls. These platforms are made thus. Pine timbers 12 inches square running across the full width of the work are laid 6 inches apart, and the spaces between them filled with puddle or concrete, except under the gate sill trusses where for 14 feet in breadth they are placed side by side and screwed together by 5 wrought iron screw-bolts passing horizontally through them all and ending in double nuts and washers, by which a connection is formed with shackle bolts secured to the anchor timbers at the bottom of the sheet pile trenches. On the timbers or joists (except for the 14 feet under the sill trusses) is laid, a carefully fitted flooring of 3 inch pine planks extending over the whole area of the foundation, with a second course of 2 inch planks between the side walls and forming the floor of the chamber and bays. A row of sheet piling 5 feet in depth is placed across the work, at the lower end of the tail bay and at the upper and lower ends of each sill. At the foot of each row of these piles at the sills is laid a baulk of timber 12 inches square, through which run vertical bolts to anchor down the sill platforms already described. The trenches in which these baulks are laid are filled up with rammed puddle. On sound rock these rows of sheet piles are replaced by timbers, called "stop-waters" 12 inches wide, let 4 inches into the rock, and the sills are bolted down to the rock. When the bottom is very soft there is placed under the whole wooden platform one of concrete composed of 1 cement and 2 of sand made into mortar and then mixed with 3 of broken stone, all the materials being run down slides and mixed in the foundations.

The chamber walls are 10 feet wide at bottom with a front batter of ½ inch in a foot, plumb at back to 5 feet from top when the "frost batter" run in to coping width, 4 feet. Counterforts 3 feet deep and 6 feet long in line of wall are placed at every 12 feet and carried up to the bottom of the frost batter. The walls of the gate recesses are 11 feet wide at bottom and have no counterforts, and for 11 feet at each end the frost batter is done away with to allow of chain wells and to strengthen for thrust of gates. The wings, which are carried up to the same height (2 feet above water level of upper reach) as the lock walls, have a curved splay which gives a width of 60 feet to entrance of each bay; they are only 25 feet long, but from their ends separate wings or retaining walls will be built with curves spreading to the full width of the canal. The whole floor, tail-bay, chamber, and head bay, is at the same level, viz., 13 feet 1 inch below surface of lower water and both clapping sills are 12 inches above the floor, so that both gates will be of same height. The bed of the upper reach is retained by a "breast" wall 13 feet 7 inches high above flooring built across the head of the upper bay, but not bonded with the lock walls—this breast wall is 7 feet wide at bottom and 3 feet at top, plumb up-stream, battered in rear. At 6 feet behind this wall a line of planks, slipped into grooves or "checks" in the walls, is placed across the bay forming a "mud pocket" between it and the breast wall. All the side walls are carried up to 2 feet above high water and are therefore 27 feet, 29 feet or 30 feet high above floor according as the lift of the lock is 12, 14 or 15 feet, of the first there will be 8 locks, of the second 15, of the last 1.

The sills are timber trusses of white oak, 19 inches × 19

inches let 3 inches into the timbers of the sill platform and therefore standing 11 inches* above the floor.

The tie beam is let 2 feet into the side wall at each end. All the timbers of the truss are joined by iron straps 3½ inches wide × ⅝ inch thick let in flush and the whole sill is bolted down, by 1½ inch bolts 2 feet 4 inches long and "ragged" at the end, to the sill platform which, as already described, is tied down to the anchor timbers. The first course of flooring planks is checked into the sill trusses. The masonry of these locks is massive and handsome. The mortar used is composed of one part hydraulic cement, made from stone obtained near at hand, and two parts of coarse sand. The stone is generally a blue limestone quarried near the line where it ascends the steep face of the escarpment, but a lighter grey limestone brought by the Welland railway from the bank of the Niagara river is being used in the lower locks, and many of the massive coping stones are being brought from point "Pelée" on lake Erie. From the lower end of a lock to 6 feet above the lower gate recess quoins and from the upper end to 12 feet below the upper gate hollow quoins the face work is of "Cut Stone" with true arrises, joints about $\frac{3}{16}$ inch, laid in regular courses varying from 12 inches to 30 inches in thickness, the thickest courses at the bottom and no course thicker than any below it, a system which, whilst allowing the use of stones of many different thicknesses, gives as finished an appearance as if all the courses were of the same thickness. In this "cut-stone" work the stretchers are not less than 2 feet in depth of bed, back from face, nor less than 3 feet length of face. The headers which are not further apart than 11 feet from centre to centre are not less than 2 feet length on face and 4½ feet depth of bed, no vertical joints are allowed nearer to each other than 12 inches.

Between the portions faced with cut-stone the chamber walls are faced with work very similar but not quite so

* 3 inches into timbers.
3 inches 1st course planking.
2 inches 2nd course planking.
8 inches from 19 = 11.

finished or massive, called "coursed-work." Stones 2 feet length of face and 20 inches in depth of bed, 9 inch courses and ⅜ inch joints being allowed. The hollow and recess quoins are formed of alternate headers and stretchers, the former at least 4½ feet on face and 5½ feet depth back of bed, and the latter 5½ feet face and 4½ feet bed, the top stones being not less than 6½ feet square and 2 feet thick.

The coping stones are all through stones (4 feet) on the chamber walls and not less than 4 feet long and 15 inches thick. I measured some of these splendid slabs and found them upwards of 24 square feet in area and 1½ foot thick. All "backing" consists of stones not less than 4 square feet in area and 6 inches thick, laid level, no "pinning" being allowed. The stones used on these works are too large to handle by manual labor and are lifted and placed by derricks of different descriptions, some running on rails along back of walls, some with double arms along floor of chamber, some worked by men, some by horses, and some by steam. Three feet thickness of puddle is put in at the back of the walls.

Gates.

The gates are to be generally like those of the Lachine canal already described and of which a drawing is sent. They will be worked by drag chains attached to them near the ends of the second bars from the bottom, and running through and up shafts to crab winches bolted to the coping. In each leaf between the lower oak bars there will be two openings, 8¾ feet long + 2½ feet high, in which will be fitted wrought iron frames with centre vertical bar dividing the openings into two which will be closed by a pair of cast iron valves turning on horizontal axes, each pair being actuated by a branched cranked rod, running up through guides on the face of the gate to a screw shaft working in a screw box attached to the top of the gate. These valves will provide the only means of filling and emptying the locks, the Chief Engineer having decided against the use of culverts through the side walls. On this subject he says in a letter, dated 12th March, 1873, to the Secretary of Public Works,—

"The plan first mentioned (tunnels in side-walls) was adopted in the locks on the Ottawa Canals, upwards of forty years ago; but it was found that the action of the water, together with that of frost, injure the walls to such an extent, that in order to save them from being entirely destroyed, it became necessary to fill up the tunnels, and introduce the water through sluices placed in the gates. Although tunnels no doubt answer well in some countries, they are nevertheless found to be quite objectionable where the action of frost is so trying and severe as in Canada.

On the St. Lawrence and Welland Canals, which were constructed long after those above referred to were in use; the water for filling or emptying the locks is passed wholly through sluices in the gates. This mode of effecting the object has been found to answer a very good purpose, besides possessing the advantage of being rapidly overhauled and repaired."

Regulating Weirs.

In connection with each lock, and at a short distance from it, there is to be a "regulating weir," to which a channel taken off some distance above the lock will convey the water to be passed on. In rear of the weir is the "side reservoir" or "pocket," and from this there will be an opening into the lower reach below the lock. The weirs were, when I visited them, like the locks, in all stages of progress. They are built on wooden platforms, the timbers being laid 5 feet below surface of water of lower reach.

The mortar and stone used in these weirs are of the same kind as those in the locks, and the general character of the masonry similar to that of the chamber walls of those structures.

The crest of the breast wall is 9 inches below full water-level of upper reach, and is 4 feet wide; the wall is plumb on the upper side and on the lower has a batter of 4 inches in a foot. The length of "spill-way" is 58 feet, divided into two equal portions by a pier 4 feet wide, extending 17½ feet up-stream, on which rests a wooden platform bridge, from which will be worked the sluice gearing. The side walls and pier will be grooved above crest of breast wall for reception of stop planks. There are 6 vents in the breast wall, each 4 feet square, with sills 2 feet above the floor (floor 3′ below bed of upper reach), in which will be fitted turning sluice-gates; none of these were fixed when I visited the works, and I did not see any drawings of them, but the following is a copy of the specification, according to which they are to be made and fitted :—

"*Sluice Gates.*—To be built of the best quality, of white oak plank, 6 inches thick at the centre, and gradually rounded off on both sides to 3½ inches at the end. Each gate to have a top and bottom plate of cast iron, connected with bolts of wrought iron seven-eighths (⅞) of an inch in diameter, passing through the gate; and to have straps of wrought iron 3 inches wide and three-eighths (⅜) of an inch thick on both sides of the gate, within three inches of each end; the straps are to be let in flush, and fastened at distances not more than 6 inches apart, with rivets ½ an inch in diameter countersunk into the strap. The top plates are to be 2½ inches deep, and those at the bottom 6½ inches deep, each to have a flange from the centre outwards on opposite sides.

The gates are to revolve on the centre, on pivots working into the bottom plates of the gates, and on the top of each a disk of steel or hard brass is to be placed, and have a brass collar and lining. The pivots are to be 3½ inches in diameter, connected with plates 9 inches square and 2 inches thick, let into the sills of the sluice way and secured to them by fox bolts.

The gates are to be arranged in a framework of oak timber, 6 inches thick and 12 inches wide, fastened with fox and key bolts to the piers and lintels of the sluice way.

The vertical posts of the frame are to be bevelled so as to form a bearing for the sides of the gates when closed, and stops are to be placed in the interior as directed. The turning rods are to be of wrought iron, 3 inches in diameter, of sufficient length to pass through the gates, and stand 6 inches over the side timbers of the platform to be formed over the weir. They are to be keyed into the plates on the gates, and secured into the masonry with suitable iron brackets, the upper end of them to be made square, on which a movable handle is to be fitted; and they are further to be connected with racks on the platform, made so as to secure the gate in the position required."

Bridges.

All the bridges over the canal will be swing bridges. There will be 4 for roads, of which 2 will be over locks and 2 over reaches, and 2 for the Welland Railway. There will also be a tunnel under the canal for one road and another tunnel for the Great Western Railway.

The designs for the superstructures of the bridges were not out, and the masonry for one only was in progress; it was nearly finished when I visited the works. This was just above Lock 9, to carry the St. Catherine's road.

The "pivot" and "rest" piers are in the middle of the canal in the alignment of its axis, and have each an archway, 6 feet wide and 8 feet high, from end to end for the passage of water. At the *toe* of each slope is a pier 8½ feet wide at bottom, with side batter of 1 in 24. At 20

feet back from these piers are the abutments which are founded 5 feet above the canal bottom, and the slopes of the sides of the canal are carried along the faces of the abutments and revetted up from the toes at the piers. All the foundations are on timber platforms, and the character of the masonry is similar to that of the locks. The roadway is to be 15 feet wide, that being, I was informed, the regulation width for 1st class road bridges, and 12 feet that for second class ones.

Road Tunnel.

The road tunnel under the canal between Locks 16 and 17 was finished; it is 310 feet long, 14 feet span, with a semi-circular arch, to crown of which from floor is 14 feet. Its foundation is 22 feet and its floor 18 feet under bottom line of canal.

Tunnel for passing the Great Western Railway.

The tunnel for passing the "Great Western Railway" was in progress. It is on a diversion, 1½ mile in length, which it has been found necessary to make in the line of railway. It is 665 feet long, on a radius of 1,430 feet, passing under the channel leading to the "side-reservoir," as well as under the canal. It is 16 feet wide, and to have a clear height above the rails of 18 feet in the centre, the arch being semi-circular. The side walls or abutments are 8 feet thick at bottom, 6½ feet at springing, with counterforts 10 feet long and 5 feet thick under the centre of each of the banks which pass over the culvert. The whole work is to be of massive limestone masonry, the voussoirs 2 feet 2 inches in depth.

Drainage Culvert.

The new line is for the most part nearly parallel with the chief drainage of the tract over which it runs, and by the use of diversion channels the necessity for all drainage culverts, excepting one, has been avoided. That culvert is an inverted syphon of two 8-feet arched vents. The foundation, which, as usual, are of timber, are laid 10½ feet below the bottom line of canal. The top of the retaining or "breast" wall of up-stream well is 3 feet higher than that of the down-stream well. A bed of puddle, 2 feet thick, covers the whole length of the culvert.

Works on the portion of canal from Marlatt's Road to Port Colborne. The chief works of the improvement of the existing canal from the branching off of the new portion (just described) to Port Colborne on lake Erie, are :—

(1.) Widening the existing channel to 100 feet bottom width and deepening it to 13 feet below water level.

(2.) The construction of a lift lock and regulating weir at Allanburgh; of guard gates near south end of the "deep cut" and of a "guard" lock and supply weir at Port Colborne.

(3.) A new aqueduct over the Welland river.

(4.) A new swing-bridge to carry the Buffalo and Lake Huron railway over the canal.

(5.) The improvement of basin and harbor at Port Colborne.

Estimated cost. The estimated cost of these works and the minor ones connected with them, is £1,015,000. None of them were in progress when I visited the canal, excepting No. 1, and that only in portion. As the closure of the canal cannot be allowed all work below water level has to be done by dredges. Several of these I saw at work; they were all of the Osgood (Otis) pattern, and very generally were delivering into boxes slung from shore derricks with long arms which swung and tilted them far back.

Enlarging the "Deep Cut." The widening of the "deep cut" is in itself a great undertaking. It is upwards of 9,000 feet long, with, for most of the distance, a depth of 60 feet from existing bed to surface, of which the top 15 feet or so are due to old spoil. It has to be widened from 50 feet to 100 feet bottom width, the new bottom being 11 feet below the present one and, as already noticed in the description of the existing canal, the the strata cut through are treacherous. It is hoped, however, that when the mountains of spoil which now overload the surface are moved back, slides will no longer occur. Sloping back above water level was being done generally by the horse scoops before described.

Locks and Weirs. The locks and weirs will, in general arrangements and character, resemble those described on the new portion of the canal.

Welland Aqueduct. The present canal crosses, as already stated, the Welland (Chippewa) river by an aqueduct. This is 45 feet broad and of 4 arches 40 feet span and 7 feet rise, the voussoirs being $2\frac{1}{2}$ feet deep; the floor of the duct is a timber platform; the depth of the water over this is $18\frac{1}{2}$ feet. When lake Erie is made the source of supply it will leave only $10\frac{1}{2}$ feet depth on this duct, or $2\frac{1}{2}$ feet less than full depth in canal and $1\frac{1}{2}$ feet less than on lock sills. As the closure of the canal cannot be allowed for, at the most, more than a few days, this structure cannot be pulled down and re-built to the required levels. A new one cannot be built above (up-stream on Welland river) present one without destroying the existing side-cut and lock into that river, nor can it be built any distance on the other (east) side without the approach to it, running through the chief part of the town of Welland, and to build quite close to the present work would, in the soft bottom on which it is founded, be very risky. How to overcome the difficulty has not been decided. One proposition is to remove the existing woodon floor of the duct, cut down the crowns of the arches 1 foot for 20 feet wide, strengthening the weakened portion of the arch with iron, and so obtain a navigable passage 12 feet deep and 20 feet wide, passing the supply water, which could not go through this, across the river by an iron tube. Mr. Monro's idea, which will probably be adopted, is to construct an iron aqueduct on pneumatic tubes close against the east face of the existing structure.

Swing Bridge. The plans for the railway swing bridge were not out.

Basin in Harbor. The basin at Port Colborne is to be extended 725 feet, making it 2,200 feet long, with an area of $11\frac{1}{2}$ acres and depth at lowest water of $13\frac{1}{2}$ feet. The entrance channel between the piers will be 14 feet deep. An outer harbor, of 40 acres area, is to be formed by constructing a breakwater, 2,000 feet in length, along a reef which runs out from the shore from 1,500 feet west of the eastern pier of entrance channel to 800 feet south-east of the end of the western pier.

Remarks. The new Welland canal is by far the finest example of canal engineering west of the Atlantic, and the Old World can boast of but few works of a similar character which deserve to rank before it.

The clearness of view and decision shown by Canada in dealing with the subject of inland navigation, and the wise way in which she is concentrating her expenditure and energy on the works of greatest importance to the whole country, are in pleasing contrast to the way in which the subject is being dealt with in the United States. There, unfortunately, the constant struggle by "politicians" for appropriations to be spent in their own particular districts results too often in a frittering away of large amounts of public funds on petty objects and in the niggardly treatment or utter neglect of works of great national importance.

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*Group 2.—The Canals to improve the Navigation of the Ottawa River.**—The Ottawa river has its sources, at about 250 miles south of Hudson's bay, on the southern slopes of the water-parting which sheds northwards to that bay and southwards to the St. Lawrence. Its upper waters are collected in the basin of lake Temiscamingue, from which they issue in one channel, and, joined by several tributaries, flow in a south-easterly direction till they reach the "Chaudiere Falls" at the city of Ottawa, the capital of the Dominion. At that place the Ottawa river is only about 45 miles in a direct line from the St. Lawrence, but turning eastwards, it flows on for 100 miles more, in the course of which it is joined by many large streams, and swells into noble dimensions. The junction with the St. Lawrence is effected by 4 branches at the island of Montreal, to which, from its sources, the Ottawa river is 700 miles long. Above Ottawa city, the river runs in many places down rapids, and at that place it is precipitated over a fall of about 30 feet. Below that, however, to its mouth, the obstructions to the navigation of the river are few. The canals to overcome them form group 2. They are,—

(*a*). The Ste. Anne canal.
(*b*). The Carillon canal.

* Visited 30 May, 1876.

(*c*). The Chûte á Blondeau canal.
(*d*). The Grenville canal.

THE STE. ANNE CANAL.

The Ottawa joins the St. Lawrence by four separate channels between which lie three large islands,—(1) Ile Jésus, 20½ miles long, 7 miles broad; (2) Island of Montreal, 32 miles long, 10 miles broad; and (3) Ile Perrot, 7½ miles long and 3½ miles broad.

The last-named of these lies at the north-west end of the expansion of the St. Lawrence, known as "Lake St. Louis," and the channel between this island and that of Montreal is the best suited for navigation. As, however, the reach of the Ottawa above the island is 3 feet higher than lake St. Louis, and the whole of this fall is concentrated into a rapid, the difference of level has to be overcome by artificial means. These consist of a lock, built in the river near its north shore, and "wing dams" and piers connected with it.

Approach to lock from below it. The approach to the lock below it is made by a pier on the land side, extending down-stream about 1,000 feet and one on the river side 67 feet long. They are both constructed of crib-work, and have their tops 9 feet above water level.

Lock. The lock itself is a masonry one, 190 feet long between the gate quoins and 45 feet wide. It is built on a timber platform resting on poor sandstone. The mitre sills are of wood, the gates are solid, and the work generally resembles the locks on the existing Lachine canal, already described. The depth on the lower sill varies between 6 feet and 7 feet, and the lift is at low water, 3 feet. When I went through it (30th June, 1876,) the lift was about 2 feet, and the time occupied in passing the steamer was, from shutting of lower gates to her getting clear out only 5½ minutes. From the up-stream end of the lock a crib-work "wing dam" extends on the river side for 840 feet to above the head of the rapids, so that the water at the lock is kept at the level of the higher reach of the river. On the land side there is a crib-work pier continues for 160 feet above the lock, and beyond this are 4 detached guide piers.

When constructed and cost. These works were chiefly constructed between 1840 and 1843, since which the channel has been deepened, the whole costing, to 1867, £33,614.

Carillon and Grenville Canals. At 27 miles above the "St. Anne lock" commences the "CARILLON canal" the lowest of the three artificial channels known as the "Carillon and Grenville canals." These were originally military works designed by, and constructed between 1820 and 1828, under the superintendence of the "Royal Staff Corps" in order to enable war stores to be sent to the lakes viâ the Rideau canal, without having to pass along the St. Lawrence where that river skirts United States territory. They remained under the management of the Imperial Government till 1853, when they were handed over to the Provincial Government, and have since been managed by the Canadian Department of Public Works. As there was nothing of particular interest in the works, and they generally resembled those already seen, I passed them without inspecting them. For the sake of completeness, however, I will give short descriptions of them, compiled from official reports.

(*b.*) The CARILLON CANAL commences 27 miles above "St. Anne lock."—

Length of canal, 2½ miles.

Breadth of canal, bottom 30 feet, surface 50 feet;—masonry locks (3,) each 126½ feet, × 32½ feet, two of them lifting (going westwards) 21¾ feet, one dropping again 13 feet, a summit level having been made to save expensive cutting. Least depth of water on sills 6 feet.

The canal is on the north bank of the river and overcomes the Carillon rapids. The cost of construction is not known, as all records connected with the work were burnt in 1852, when the Ordnance office at Montreal was destroyed by fire.

(*c*). THE "CHUTE A BLONDEAU" canal commences 4 miles above the Carillon canal.

Length of canal, ⅛th mile.

Breadth of canal 30 feet, sides vertical, being cut through solid rock.

1 lock, 130 feet × 32½ feet; lift 3¾ feet, the chamber cut out of the rock, but lined with dressed masonry at the quoins and recesses.

The canal is on the north bank of the river and overcomes the "Chûte à Blondeau" rapids.

Records of cost, &c., destroyed, with those of Carillon canal.

(*d.*) The GRENVILLE CANAL commences 1⅜ mile above the last noticed canal.

Length of canal, 5¾ miles.

Breadth of canal at bottom 20 to 30 feet; at surface 25 to 60 feet, part being in earth and part in rock cutting.

Locks—6 "lift" locks (4 of which are combined in two sets of 2 each) and 1 "guard lock."

Length of chambers, from 107 to 130 feet.
Breadth of chambers, from 29 to 32 feet.
Total lift 45¾ feet; least depth on sills 6 feet.

The canal is on the north bank of the river, and overcomes the "Long Sault" rapids. Records of cost, &c., destroyed with those of two previously noticed canals.

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*Group 3—The Rideau Canal.**—This canal was constructed, between 1826 and 1832, by the Imperial Government, in order to provide, together with the Ottawa river and canals, a means of easy transport to the lakes of naval and military stores, at a safe distance from the United States frontier. As by this route it is nearly 70 miles more from Montreal to lake Ontario than by the St. Lawrence, and as there is little or no traffic between the upper Ottawa and the lakes, this canal is commercially almost useless and financially a burden. Its maintenance, however, was stipulated for by the Imperial Government when the Canadas were constituted a Dominion.

* Visited 30th June to 3rd July and 17th July, 1876.

The following description of the general features of this line of navigation is extracted from a report of the "Commissioner of Public Works" for 1867 :—

"The Rideau canal might, perhaps, be more properly called the "Rideau and Cataraqui Navigation" than a canal, in the ordinary acceptation of the term; since it consists in the conversion of the Rideau and Cataraqui rivers (two obstructed and rapid streams spreading occasionally into deep ponds and lagunes) into one continuous navigable channel.

"The Rideau river drains an area of 1,550 square miles, and discharges itself over an abrupt and perpendicular fall of about 45 feet into the Ottawa at Ottawa city, rendering an artificial entrance to its waters by canal absolutely necessary, to connect it with the Ottawa river for navigable purposes.

"The Cataraqui discharges into the St. Lawrence at Kingston, draining a basin of 200 square miles.

"Ascending the long sweeping course of the Rideau river for a distance of 86 miles, we are brought to its head waters, at a point which happens to lie within one mile of an absolute straight line drawn between Ottawa City and Kingston; and from thence, crossing a short portage of one mile, we find ourselves at the head waters of the Cataraqui, and descending the winding course of that river for 40 miles, we are led into the waters of lake Ontario at Kingston."

In the whole 126¼ miles, there are only 16½ miles of artificially excavated canal, in 20 separate portions.

Flight of locks at Ottawa.

The entrance to the canal from the Ottawa river is by a flight of 8 combined lock chambers, situated at the mouth of the rocky ravine running at the foot of the hill, which is crowned with the fine pile of the "Parliament and Departmental Buildings" of the Dominion. The total lift of this flight of locks is 82 feet. The chambers are (as are all the locks on this canal) 134 feet long, from mitre to mitre, and 33 feet wide, with 5 feet depth on the sills. The walls are of ashlar masonry and between them is a stone invert. The gates are ordinary double leaf "framed" ones worked by balance beams which are moved by chains attached to their ends, and winches. Water is let into and out of the locks through a culvert 4 feet × 3 feet running round the back of each gate and the valves closing these are worked by crab winches and chains. I saw no suspension bars or diagonal ties on the gates, and I believe therefore that they run on the rollers and tracks.

At 4½ miles above Ottawa are two more combined locks (visited 3-7-76) like those already described, and just above these is a cut-stone waste weir with an overfall of about 18 feet down a sloping cut-stone apron, at the bottom of which is a timber floor. The crest of the weir is at full water level and has no shutters on it, but in the middle of the breast wall is a gap 3 feet wide to bed level, closed by planks. At a mile or so above this the canal joins the river which is ponded back for 4 miles by an earthen dam 320 feet long and 50 feet high. I was told that 2 or 3 masonry dams at this place had been carried away—the last about 14 years ago. At the end of this dam is a wooden "bulk-head" with 5 openings, each 20 feet wide, their sills about 16 feet below water surface. These openings are closed by stop logs dropped down grooves and lifted by chains and winches. The apron below this bulk-head is 100 feet long; it is a timber floor on crib-work bolted down to the rock, and from its edge there is a pitch of some 15 feet on to rock. Both bulk-head and apron showed much injury from ice and logs. Beyond the bulk-head a bye-wash, 150 feet wide, lets ordinary surplus water escape to bed of the river.

At this place, known as "Hogsback," are two combined locks, the walls of which are much bulged and cracked and look most dangerous.

Canal from Kingston to Kingston Mills

I did not go further along this northern end of the canal but visited (7-7-76) its southern end for 5½ miles from Kingston to "Kingston Mills." At the latter place the Cataraqui river has, at the head of falls, been dammed and set back for about 10 miles by an embankment nearly a mile in length and in parts 20 feet high. I noticed on the lower side of this bank a dry stone retaining wall 15 feet high, 9 feet thick, built of flat limestone slabs on edge, the true beds all vertical, which was standing well. The surplus weir of this pond has 20 feet length of crest on which stop logs are dropped down grooves and lifted by a winch and chains at each end. I may here say that nowhere in America or Canada did I see on any of the weirs so simple and effective an arrangement as the shutters running against angle iron rebates, and lifted by screws, in use on many of the Madras canals. Out of the lake above the embankment one lock drops into a masonry basin, and from that a flight of 3 chambers combined, drops 45 feet into the bed of the stream, the channel of which is used to Kingston harbor.

Number and lift of Locks.

The total number of locks on the whole canal is 47—33 ascending (going from Ottawa to Kingston) 282½ feet, and 14 descending 164 feet. The breadth of the excavated portions of the canal at bottom is in earth 60 feet, and in rock 54 feet. As so much of the line is through broad expanses of water, and steam is the only motive power used on it, there are no tow-paths.

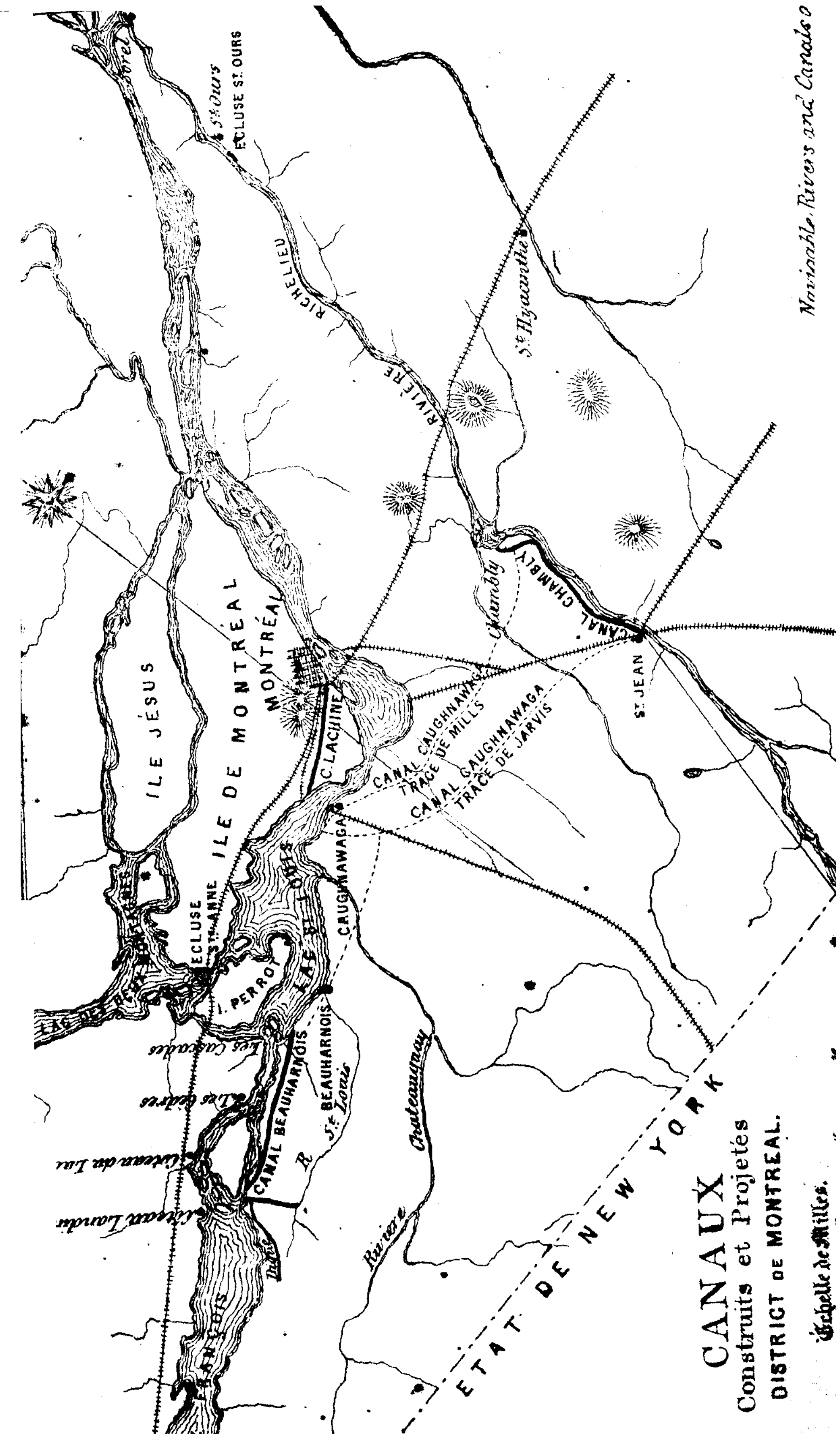
The original estimated cost of all the Rideau canal work was £576,757, that estimate was afterwards increased to £762,679; the actual cost to original completion was £803,774, and this with necessary improvements to 1867 amounted to £1,020,632.

I was informed that there is a full description of this canal and its works in the first volumes of the Royal Engineer's papers, written by Lieutenants Frome and Denison, the latter of whom, subsequently as Sir William Denison, was for some years Governor of Madras.

4. *The Works to improve the navigation of the Richelieu river.*—Lake Champlain, covering 1,130 square miles, discharges its surplus waters by the Richelieu river, which, running nearly due north for 81 miles, delivers them into the St. Lawrence at "Sorel," 46 miles below Montreal. The 4th group of the Canadian canals consists of the works which overcome the natural obstructions in this river and, so admit of navigation passing between the St. Lawrence and the lake, and from it viâ the Champlain and Erie canals to the Hudson river and New York.

(*a*). St. Ours Lock and Dam.—At 14 miles above the mouth of the river it is dammed, ponding it back so as to give a least depth of 7 feet for 32 miles to the entrance to the Chambly canal. The river at the place is divided into 2 channels. Across the main or western one the dam is 600 feet long and is composed of stone-filled crib-work, with an apron 40 feet wide of similar work, well founded in clay. The depth which in freshets goes over this dam is from 8 to 10 feet. Across the eastern channel the dam is

The Dams.



an earthen embankment 300 feet long, 25 feet wide at top, with slopes 2 to 1, the water side pitched. In the middle of the embankment is the lock. It is of cut-stone masonry, 200 feet long between the quoins and 45 feet wide, with 7 feet least water on the sills, and an average lift of 45 feet. Piers of crib-work extend from the lock for 420 feet below and 270 feet above it.

The Lock. **The Piers.**

The works were constructed between 1844 and 1849, and have cost (to 1867) £30,385. **Cost.**

(*b*). THE CHAMBLY CANAL.—At 32 miles above the St. Ours dam is situated the foot of the "Chambly" rapids, which extend up to the town of St. John's and from that place there are no further obstructions to the navigation of the Richelieu river. The canal which turns these rapids is 12 miles long, has a bottom breadth of 30 feet, and a surface breadth of 60 feet. **The Prism.**

There are 8 masonry locks with a total lift of 74 feet, and 1 "guard" lock. Their lengths vary from 118 feet to 125 feet; their breadth is 23½ feet, and they have 7 feet depth on the sills. **Locks.**

The other principal structures are— **Other structures.**

6 timber bye-washes and waste weirs.

3 „ culverts under the canal.

8 „ swing bridges, 56 feet span, 10 feet wide.

1,600 feet of wharfage.

This canal was opened throughout in 1843, but the works had soon after to be extensively strengthened and improved. Their total cost was £158,678. **When constructed and cost.**

From the head of this canal to lake Champlain, at Rouse's Point, is by river about 23 miles, and from there to the head (south end) of the lake and entrance to the Champlain canal is 111 miles. The total distance by this route from Montreal to New York is 449 miles. **From the canal to New York.**

The canal boats are taken across the lake in tows by powerful tugs. I saw (24-6-76) one leave St. John's towing 12 canal barges fully laden with sawn timber which had come from Ottawa.

It is stated that

Extract from Official Report 1876.

* * "The coarse grains of Eastern Canada, a large portion of the sawed timber from the St. Maurice, the Ottawa, and other rivers emptying into the St. Lawrence, as well as a large amount of flat and square timber in rafts find their way each year to the American markets over this route."

Proposed Ship Canal.—It has at various times been proposed to provide a channel from the St. Lawrence to Lake Champlain navigable by vessels as large as will be able to pass through the new St. Lawrence canals, and for this purpose the route just described viâ the Richelieu river has been recommended. It has, however, the serious disadvantage of a great and apparently unnecessary amount of lockage. Lake Champlain is 79 feet higher than the St. Lawrence at the mouth of the Richelieu river, but only 29 feet higher than the St. Lawrence above the Lachine canal, so that the present route from Lake St. Louis has a *drop* of 50* feet and a *rise* of 79 feet, with a lockage of 123¾ feet against 29 feet, which is all that would be necessary in a canal from the St. Lawrence above the Lachine canal to near St. John's. The latter route would also save some 80 miles (see diagram V) to vessels coming from the westward, from which direction nearly all the traffic seeking lake Champlain would come. But a "ship-canal" to lake Champlain would be of little use if the vessels that might navigate it could not go on to New York. Propositions for making the Champlain canal also a "ship-canal," have been numerous, but, as already noticed in the remarks on that canal, there seems little likelihood of any of them being carried out.

* Lachine Canal	44¾
River from canal to Sorel.. ...	5¼
	50

Financial results of Canadian Canals.

I am unable to give in figures the financial results of the Canadian canals, but the Chief Engineer of Public Works, in his report, 9th July, 1874, says—

"It is well known that none of the canals have paid the interest of the money expended in their construction, or indeed very little more than the working expenses connected with them. Still, few who compare the past with the present condition of Canada will doubt but that they have been of far greater benefit to the country than the aggregate amount of their cost."

PLANS ACCOMPANYING NOTES ON CANADIAN CANALS.

	No. in Vol. of Plans.
Map of Part of British America	55
General Plan, with details of suspension gear, &c., of Lock Gate	56
General plan, enlarged Lock Welland Canal ...	57
Plan regulating Weir, Welland Canal	58
Drawing "Osgood and Starbuck" dredge	59

Navigation from the Lakes to the Mississippi.

General Remarks.

To the west of lakes Michigan and Superior the water-parting between the basins of the Mississippi and the lakes, the former 1,200,000 square miles and the later 400,000 square miles, is narrow and of slight elevation. Several of the tributaries of the Mississippi rise within a few miles of the lakes, from which they are separated by a ridge only a few feet in height. In some cases the heads of streams flowing to the two different basins overlap, and upwards of 200 years ago Indian traders made passages for their canoes from one stream to the other, and thus joined the waters which flow into the Atlantic at Newfoundland, with those which flow into the gulf of Mexico at New Orleans. Since then little has been done compared with what might have been expected, in taking advantage of the wonderful facilities which nature has provided for the joining of two of her grandest systems of inland communication. What has been done, and what it is intended to do, I propose now to give some description of.

1st. *The Illinois and Michigan canal and the canalization of the Illinois river.**—The Illinois and Michigan canal commences in the city of Chicago, and runs from the south branch of the Chicago river, at about 3 miles from its mouth on lake Michigan, to the Illinois river at La Salle, a distance of 97 miles. The canal was begun in 1836, but, owing to financial difficulties, was not finished for some 10 years later. The work was a State one, but was carried out with money borrowed chiefly from English capitalists by whom the canal was really controlled till 1872, when the State (Illinois) acquired sole possession of it. In order to save in depth of cutting through the water-parting the canal was originally locked up 8 feet from the Chicago river and down the same height at Lockport from a "summit level" of about 29 miles in length. As, however, the Chicago river which receives the greater part of the drainage of the city seldom had sufficient current to carry it on to the lake and never sufficient to push it far out from shore, and as, therefore, both river and harbor were filling up and becoming extremely offensive, the city of Chicago in 1871 deepened (at a cost of about 3 million dollars), by 8 feet, the summit level of the canal to 6 feet below lake level, and so secured a flow *from* the lake through the portion of the river in the city and through the canal to "Lockport," where the surplus water is used to work mills and discharged into the "Des Plaines" river, down which it passes to the Illinois river, and so to the Mississippi. The depth of cutting in the summit level by which this is accomplished is only 15 feet.

* Visited 25th—27th July, 1876.

From Lockport to the Illinois river at La Salle the canal, in its 68 miles, falls 145 feet by means of 16 locks, 109 feet × 18 feet. Locks.

The prism of the canal is 40 feet wide at bottom, 60 feet at water surface, 6 feet depth. Prism.

The capacity of boats which can pass through the canal is stated to be 160 tons. Boats.

There are no individual works of such importance or interest on this canal as to render separate description of them advisable.

The following table collated from report for 1875, gives the main commercial and financial facts connected with the canal for the last 10 years:—

1	2	3	4	5	6
Year.	Repairs, ordinary and extraordinary.	Salaries and maintenance.	Tolls.	Tons transported.	Number of days open.
	Dollars.	Dollars.	Dollars.		
1866	116,363	Believed to be included in Col. 2.	302,958	746,815	203
1867	162,656		252,231	746,954	209
1868	122,052		215,720	737,827	210
1869	91,765		238,759	817,738	222
1870	108,695		149,635	585,870	184
1871	97,222		159,050	629,975	234
1872	88,876		165,874	783,641	244
1873	65,698	15,400	166,641	849,533	225
1874	58,399	15,399	144,831	712,020	236
1875	59,988	14,523	107,081	676,025	228

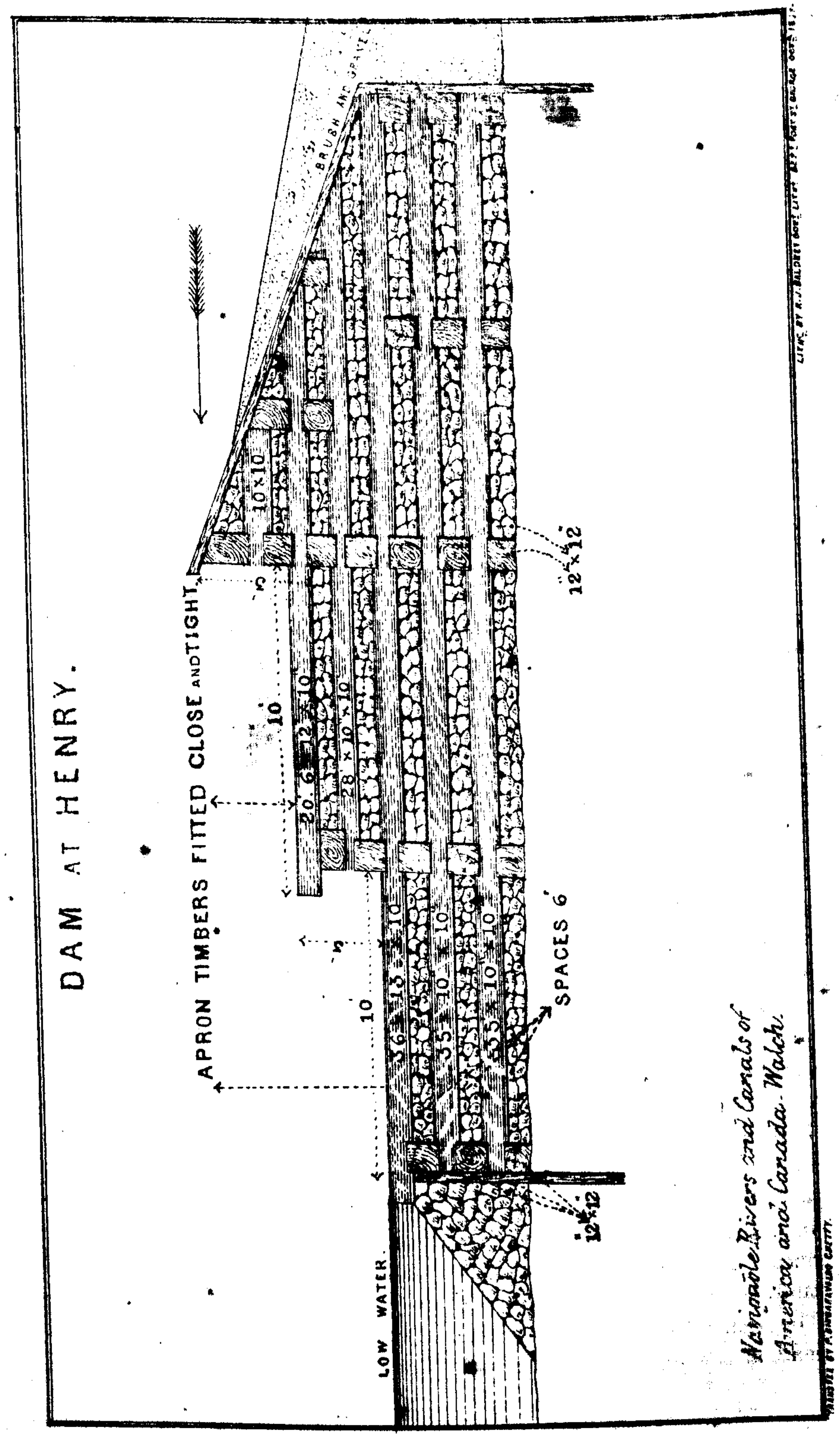
The cost of the canal was 6,557,681 dollars, and from the figures given above it is evident that the canal is not a financial success. The traffic on it is much less than might have been expected on a channel connecting two such important routes of traffic as the Mississippi and the lakes. Doubtless this is chiefly owing to the uncertain state of the navigation in the Illinois river which is obstructed by bars, and in dry seasons is not navigable for boats drawing even 2 feet.

Improvement of the Illinois river. Congress, regarding this line of navigation as of national importance, allotted at different times, between 1865 and 1869, dollars 185,000 for the dredging of the river, but this scarcely sufficed to make any appreciable improvement, and now the "canalization" of the river has been undertaken.

From the end of the canal at La Salle the Illinois river is 228 miles in length to its junction with the Mississippi, at "Grafton," 40 miles above "St. Louis." Its fall in the 228 miles is only 29⅓ feet, and it has been decided to erect 5 dams across the river, converting it into so many pools giving nowhere less depth than 7 feet, with locks 350 feet × 75 feet, from pool to pool. The work is being carried out by the State of Illinois with occasional assistance by the National Government. Its cost is estimated at 2,660,000 dollars, inclusive of 430,000 dollars for some dredging that will be necessary. Only one of the dams with its lock is yet finished; visited by me on 26th and 27th July, 1876.

"Henry" Lock and Dam. The "Henry" lock and dam are situated 30 miles below the mouth of the canal. They were finished in 1872, at a cost of 400,000 dollars. The success of the work is thus spoken of by the Chief Engineer, Mr. D. C. Jenne, in his report for 1875:—

"The lock and dam at Henry has been in use during four navigable seasons, and the results show that everything contemplated by this lock and dam has been accomplished, not only in the perfect navigation from this point to the entrance of the canal at La Salle, but in the practical use of a lock of this large size. It has been demonstrated beyond a question, that if all the locks and dams required on this river were built, it would afford good navigation for at least 8 months in the year to the largest class of steam boats, and for barges 300 feet long and 72 feet wide drawing 6



water, and would become one of the most important navigable ... of the country; it would be the great thoroughfare for heavy freight in either direction, and its influence for cheap transportation would be felt all over this and adjoining States."

The dam is 530 feet in length between its eastern abutment and the lock. It is formed of timber "cribs" filled with loose stone, covered on the top with planking. From crest to low water level below the dam it has two vertical drops of 3 feet each on to timber offsets or platforms 10 feet wide. It raises the low water level of the river immediately above itself by 6 feet, and at La Salle by 4½ feet. When I visited it there were 3 feet 5 inches going over the top with no perceptible overfall. The sketch herewith I took from a lithographed plan, dated 1870, in the Lock Office, but of which I could not procure a copy.

The lock stands in the river, to the right bank of which it is connected by an embankment, the top of which is of course above high water level. The lock is founded on 12 inch diameter piles, of which there are 5 longitudinal rows under each side wall and 7 rows under the chamber, the piles in each row being 3 feet apart. On these piles are longitudinal "foundation" timbers 12 inches square, and on these again are similar timbers across the lock from side to side, 6 inches apart, except under lower sill, where they are laid close together; all spaces between these timbers to 3 inches below the longitudinal ones are filled with concrete. Over all are laid 2½ inch planks jointed closely together and bolted to the cross timbers. A second course of planking, 2 inches thick, is laid as a floor between the side walls and between the wings, and is secured by binding timbers 6 inches × 8 inches running over it crossways at every 10 feet, bolted down to the foundation timbers. Five rows of sheet piling, 6 feet deep, run across the lock under the foundation timbers. The clapping sills, which are laid 6 feet below lowest water on them, are of oak, 20 inches square for lower gates and 20 × 12 inches for upper ones. The lower sill timbers are bolted to the foundation timbers and backed up by a stone arch, 18 inches deep. The upper sill timbers are bolted to a massive stone sill wall, 6 feet high, arched in plan, the top voussoirs being 1 foot thick and clamped and dowelled together. Across the head-bay, clear of the swing of the gates, is a breast wall the same height as the sill. The chamber walls are 5 feet broad at top, have a face batter of $\frac{1}{2}$ inch in a foot and at back are stepped out to about 12 feet thick at bottom; counterforts, 8 feet long and 3 feet deep, are placed $15\frac{1}{2}$ feet apart and come up to 20 feet below the top of the walls. The front wings and head-bay and chamber walls are carried up to 22 feet above upper sill to 90 feet back from the upper gates, that is, to where the dam joins the lock, and there the chamber walls step down 6 feet. The length of the chamber is 350 feet from mitre to mitre and the breadth 75 feet. All the walls are of massive limestone masonry, with "cut-stone" faces.

The gates are of the usual two-leaf style, set at an angle of $21\frac{1}{4}$ degrees, with a line from heel to heel. Both upper and lower are $20\frac{1}{2}$ feet high. They have 10 longitudinal bars or "ribs" each 12 inches thick, the two bottom ones 2 feet 6 inches apart, the two upper ones 20 inches apart, and the others with spaces from 10 inches to 16 inches between them. The two upper and two lower ribs are built solid of 4 longitudinal timbers formed to 28 inches wide at the ends, and 46 inches wide in the centre; the other 6 ribs are similar in external form, but are made of only 3 longitudinal timbers, and instead of being solid have a centre longitudinal space, down which run 5 vertical posts, 12 inches × 12 inches, mortised into the solid ribs. These 6 ribs are each braced by 2 "hog chains" or bars passing across three vertical saddle posts attached to the lower face of the gate. The heel and mitre posts are 28 inches in the square. The planking on the upper side of the gate is 2 inches thick of white pine; all the rest of the woodwork is of white oak. The gates turn on a chilled iron pivot 12 inches in height, 8 inches diameter at the bottom, tapering to 7 inches at top and running up into a chilled iron socket at the bottom of the heel post; the pivot base is $2\frac{1}{6}$ feet diameter, and is let only 2 inches into the floor, but has 3 lugs, $1\frac{1}{2}$ inch square, which keep it from turning. The gate is kept 3 inches clear of the floor and does not run on tracks, but is entirely suspended by wrought iron suspension bars, the land ends of which turn round a steel pin on a cast iron "tower" post, 8 feet high, which stands on the coping and is tied back by 6 iron guy rods radiating from it and attached to anchors built into the masonry. The gate itself is not in any other way tied back to the masonry, has no collar at the top of the heel post. The gates are opened and shut by means of the pole or spar arrangement described in the notes on the Lachine canal. On this lock the spar is $55\frac{1}{2}$ feet long, 9 inches × 9 inches with flat iron bar along its bottom; it is pivoted on the top of the mitre post and travels on iron rollers on the coping. The capstan, which winds the wire rope, is set on the coping 45 feet in front of quoins and 10 feet back from line of chamber wall. This system of swinging and working large lock gates is excellent. I saw, on 26th July 1876, the lower gates fully opened by 2 men to each capstan in $3\frac{1}{2}$ minutes, one leaf of it closed by 2 men in $3\frac{3}{4}$ minutes, the other in $5\frac{1}{2}$ minutes, for 3 minutes of which time, however, there was only *one* man at the capstan. The upper gates with 2 men to each capstan were opened in 6 minutes; with 3 men to each capstan, that is 6 to each gate, full opening or shutting could easily be done in 3 minutes. As will be seen in my notes on the Louisville and Portland canal, the gates of the locks there which are only five feet wider than those of the Henry lock, but run on tracks and rollers and are moved by drag-chains, took 18 men to close them in 8 minutes and 20 men to open them in 10 minutes, and the time, I was informed, was often much longer owing to the clogging of the rollers and tracks by silt. The lithographed plan, herewith, of the gate for the Copperas creek lock, on which I have entered some dimensions and remarks from observation at Henry, is applicable to the gates of this lock except in some minor particulars, such as number of vents in the gate. When I saw the Henry lock worked there was a difference of level above and below it of only 3 inches, so I could not make any observations of interest on the times of filling and emptying. The former is done by 8 horizontal turning valves in a wooden floor above the upper gate which admit water into calverts passing into the chamber through the sill wall; there is also one valve in each leaf of the upper gate. The emptying is done through a culvert, closed by 5 valves in the masonry at the back of each side of the lower gate. There are also 2 valves in each leaf of the lower gate.

Dam and Lock at Copperas Creek.

The next of the series of dams and locks for the improvement of the Illinois river is situated at Copperas creek, 60 miles below Henry, and will probably be finished next year. The works are in general character similar to those at Henry, and are thus described by the Chief Engineer in his report, 1st December 1874:—

"The lock is built entirely out of the river, and is connected at each end by a short canal, with vertical and slope wall protections. It is built similar to the lock at Henry in form and dimensions, with the exception that the lock will be filled and discharged through valves inserted in the lock gates, instead of culverts in the walls as at Henry. There will be seven valves in each gate, or twenty-eight in all, four by two and one-half feet, inserted vertically and operated by levers on top of the gate.

The walls of the lock are to be twenty-six feet high from the head to a point one hundred feet below the upper gates, where the dam connects with the wall, and twenty-one feet high thence to the foot.

The gates are to be twenty-one feet high and forty-three feet wide, to be in similar form to those at Henry, and being on the suspension plan.

The dam will be 650 feet long, 11 feet high and 45 feet wide at base, raising the water 6 feet, and will set back 2 feet on the dam at Henry, a distance of 60 miles. It is to be built of timber cribs filled with loose stone, with only one drop, and have an apron of timber of 25 feet and one of brush and stone of 20 to 30 feet. The lower end is also protected by square piles driven close together, the entire length, at least 10 feet into the bed below the bottom of cribs."

The estimate for these works at contract rates and exclusive of 73,726 dollars spent on the foundations and of 28,446 dollars for "engineering and contingent expenses," is as under:—

Quantities.	Measure.	Items.	Price.	Amount.	Total.
......	......	Grubbing and clearing ...	$100·00	$100·00	
......	......	Baling and draining ...	5,000·00	5,000·00	
50,500	Cubic yards.	Excavation...	·17	8,585·00	
10,500	do.	Embankment	·16	1,680·00	
80,000	do.	Do. in guard bank ...	·15	12,000·00	
12,000	do.	Lining	·60	7,200·00	
1,500	do.	Puddling	·20	300·00	
18,000	do.	Loose stone...	2·55	45,900·00	
6,000	do.	Brush and gravel	·20	1,200·00	
1,200	do.	Do. stone	4·00	4,800·00	
1,700	do.	Slope and pavement wall...	2·95	5,015·00	
2,700	do.	Vertical wall in cement ...	8·00	21,600·00	
1,400	do.	Do. laid dry ...	5·00	7,000·00	
840	do.	Concrete masonry ...	5·00	4,200·00	
8,800	do.	Cut stone do. in lock walls.	13·00	114,400·00	
925	do.	Uncut stone. do do.	11·00	10,175·00	
100,000	Feet B. M.	White oak timber in lock gates	65·00	6,500·00	
40,000	do.	Timber of all kinds in foundation	18·00	720·00	
700,000	do.	Do. ... dam ...	22·00	15,400·00	
120,000	do.	Plank and boards of all kinds	20·00	2,400·00	
13,000	Feet lineal.	Delivering round bearing piles.	·15	1,950·00	
10,000	do.	Do. square... ...	·16	1,600·00	
22,000	do.	Driving round and square..	·04	880·00	
400	do.	Snubbing posts	·25	100·00	
120,000	Pounds.	Wrought iron	·13	15,600·00	
24,000	do.	Cast iron	·07	1,680·00	
14,000	do.	Spikes and nails	·09	1,260·00	
1,000	do.	Lead and antimony ...	·50	500·00	
600	Feet.	Steel wire rope	·25	150·00	
28	Number.	Composite valves	18·00	504·00	
1	do.	Sulphur and sand cement..	100·00	100·00	
1	do.	Painting lock gates ...	50·00	50·00	
		Total ...	......	......	$298,549

The following lithographed plans from the report of the Canal Commissioners for 1874 are sent herewith.

Plan of lock at Copperas creek....No. in Vol. of Plans... 60

Do. do. lock gate.... ... do. do. ... 61

The proposed sites for the other 3 dams and locks are,—50, 90, and 130 miles, respectively, below Copperas creek. It will be some years before all these works are carried out; when they are finished the enlargement of the Illinois and Michigan canal, to fit it for the same scale of navigation, must follow.

2nd. *The "Hennepin Canal."*—It has been proposed to construct a canal from the Illinois river at 19 miles below the end of the Illinois and Michigan canal to the Mississippi at 8 miles above Rock island, that is, at 200 miles above the mouth of the Illinois river. The length would be only 65⅓ miles; the lockage 207 feet ascending from the Illinois river to the Hennepin river, and thence 92 feet descending to the Mississippi. A "feeder" 38 miles long, would be required to supply the canal. Such a canal, with prism 132 feet at bottom, 160 feet at water surface and 7 feet depth and with locks 350 feet × 75 feet, has been estimated to cost about 12½ millions of dollars. It would save "about 300 miles of transportation for two-thirds of Iowa, all of Minnesota, half of Western Illinois, and all of Western Wisconsin which desires to reach Chicago."

This canal would undoubtedly be of great importance, but there is not much probability of its early execution.

3rd. *The "Fox" and "Wisconsin" river improvements.*—I did not see these works, but to make the subject of the connection of the Mississippi and the lakes complete, I give the following extracts from official documents:—

Extracts from Report of Committee on Transportation Routes, 1874.

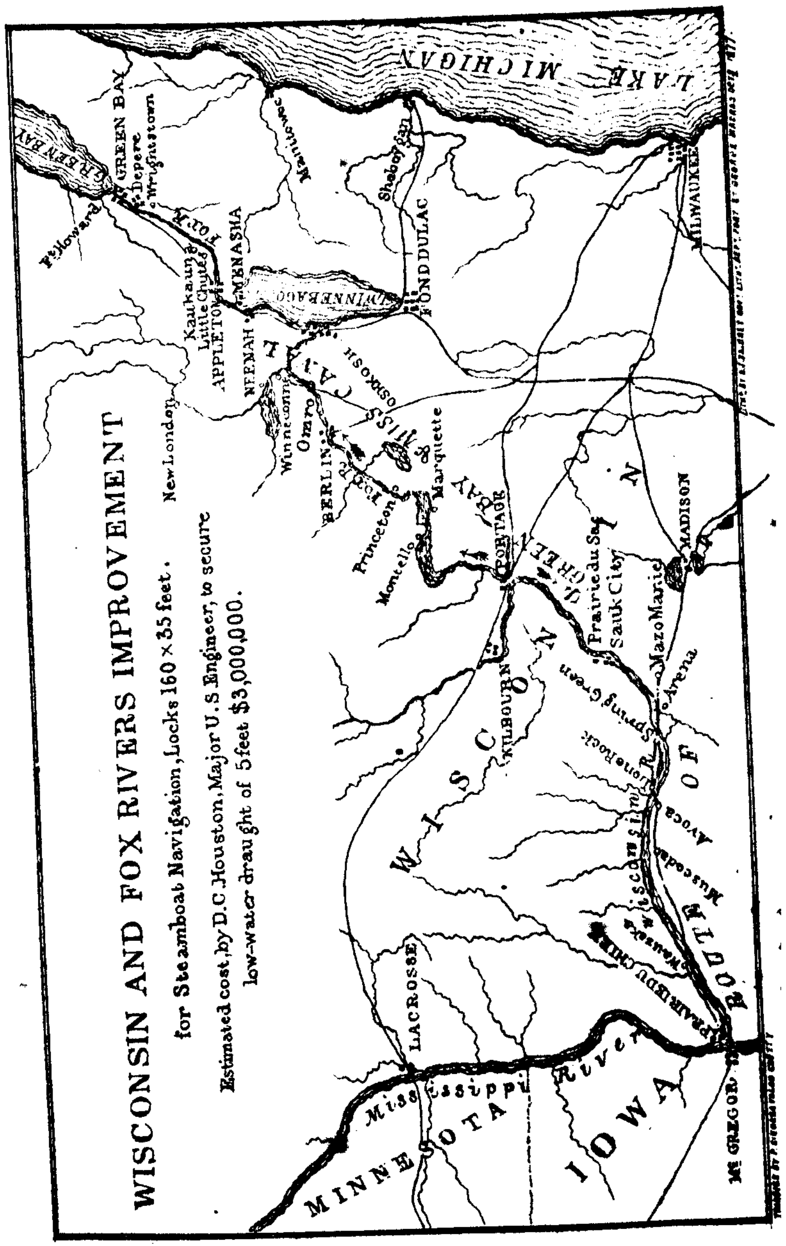
"The Wisconsin river, having its rise in the northern part of the State of Wisconsin, runs southerly until it approaches the Fox river, turns abruptly south-westerly, and, running in that course one hundred and eighteen miles, empties into the Mississippi at Prairie du Chien.

The Fox river, having its rise in the southern part of Wisconsin, runs north-westerly until it approaches the Wisconsin river, turns abruptly north-easterly, and, running in that course one hundred and sixty miles, (to be reduced to one hundred and fifty-three miles) empties into Lake Michigan at Green Bay.

The course of the two rivers below the portage, the point of nearest approach, is surprisingly straight, and nearly upon a due line passing through Prairie du Chien and the Straits of Mackinaw.

The divide, or portage, separating the Wisconsin river waters, leading into the gulf of Mexico, from the Fox river waters leading into the Saint Lawrence, is a level sand prairie, without rock, and in width one and one half miles. The Wisconsin at the portage is at the summit level. It is about 7 feet higher than the Fox at the portage, about 200 feet higher than lake Michigan at the mouth of the Fox, and 169 feet higher than the Mississippi at the mouth of the Wisconsin.

Already a canal at the portage connects the Wisconsin and the Fox (This canal is 2 miles long, nominally 4 feet, really only 2 feet deep, wit



'guard' lock on the Wisconsin and a 'drop' lock into the Fox.) A lack-water communication extends from the portage to Green Bay, a istance of one hundred and sixty miles, overcomes by locks (of dry stone rotected by wood) and dams, the fall of 200 feet, and connects the Wis-onsin river with lake Michigan.

The Fox river from its mouth to Oshkosh, on lake Winnebago, has a low water channel of about 4 feet, and from lake Winnebago to the port-age of about 3 feet. At stages of high water, boats of 3, 4 and even 5 feet draught have passed from lake Michigan up the Fox river, and down the Wisconsin into the Mississippi river. As late in the season as June boats of 300 tons burden have made the passage. In stages of low water the Wisconsin cannot be navigated on account of the drifting sand." *

The Wisconsin and Fox rivers improvements to have five feet draught, to be 271 miles in length, of which 118 are to be unobstructed river and 153 slack-water navigation, with 27 locks, 160 feet by 35 feet and 6 feet on sills, and a total lockage of 195 feet: and not to exceed six miles of canal in all, including the short canals around the dams, and to pass boat of over 500 tons. * * * *

The special advantage, presented by this route are these:—

1. It runs on a direct line to the centre of the great surplus wheat area of the country, which supplies the bulk of the grain shipments east and to or near the centres of the surplus areas of other grains.

2. It has less canal, less lockage, and costs less than any other proposed route.

3. Its point of connection with the lake at Green Bay is nearly 200 miles nearer to the eastern markets than the southern end of lake Michigan. * * *

4. Congress has already directed the Secretary of War to improve the Wisconsin, and has prescribed the plan of improvement; no further action of Congress being necessary excepting to make additional appropriations * * "Colonel Houston, United States Engineer in charge of this work, estimates its entire cost at 3,000,000 dollars, a sum totally insignificant in comparison with the results to be obtained. Owing to the inadequacy of the sums heretofore appropriated, the improvement has progressed very slowly, and at much greater expense than was necessary. In view of the great benefits to be obtained, the Committee are of opinion that liberal appropriations should be made to complete the improvement at the earliest practicable moment."

A sketch map of the Wisconsin and Fox rivers is appended.

IMPROVEMENTS OF THE UPPER MISSISSIPPI.

(Visited 27th July—2nd August 1876.)

——:o:——

The Upper Mississippi from its sources in lakes "Leech" and "Winnebagoshish" to its junction with the Missouri river is 1,330 miles in length, and drains a basin of 169,000 square miles in area. At 675 miles from lake Leech the river falls over a sandstone and limestone cliff about 50 feet high, known as the Falls of St. Anthony.

Extracts from Report of Committee on Transportation Routes, 1874.

Above this "the river has for several years been successfully navigated by steam-boats from the Falls of Saint Anthony to Sunk Rapids, a distance of 78 miles. During navigable seasons small steam-boats are also run or the various reaches of the river from Minneapolis to Leech lake, th entire distance being about 675 miles."

It is proposed, but not decided on, to improve the navi gation of this portion of the river by means of locks, of total lift of 62 feet, at "Sunk Rapids," "Little Falls," an "Pokegama" Falls.

Below the Falls of St. Anthony the river has no pe pendicular drops, but has two rapid slopes—one, the "Roc Island Rapids," above and along Rock Island; the other, t "Des Moines Rapids" between Montrose and Keoku Both of these have rendered the navigation of the riv above Keokuk difficult at most times, and impossible for t ordinary river steamers during low stages of the riv The works dealing with these two obstructions constitu with the exception of some dredging and construction o few loose stone dykes, the whole of the improvements of t Upper Mississippi.

Rock Island Rapids.

The work on the Rock Island Rapids, 348 miles bel the Falls of St. Anthony, consists of the enlargement a straightening of the tortuous natural deepest channel t wound its way through the bars and reefs of magnes limestone which, in the 14 miles between St. Claire Devenport, separate the river into 7 or 8 pools. The e mate for the whole work was 57,141 cubic yards to cost 813,602 dollars, but both the quantity of work done and total cost have been greater than anticipated. When I visited Rock Island (28th and 29th July 1876), there remained but a few hundred cubic yards of rock excavation to finish the work to the prescribed breadth of 200 feet and depth of 4 feet at lowest water. Where the rock to be removed lay in continuous sheets it was got out by means of coffer-dams. The appended excerpt from the official report of the work done in 1874, with accompanying sketch, will give a fair general idea of the nature of the coffer-dam work which in this case cost 12 dollars a cubic yard, and has over the whole work cost from that to 10 dollars a cubic yard :—

Operations of 1874.

"As soon as the contract was awarded, Mr. Williams commenced with his usual energy the work of coffer-dam at Lower Chain. The peculiar position of the coffer-dam at the Iowa side of the channel demanded a strong breakwater, as the current at this place is a very swift one. Six stone cribs, of the dimensions 16 feet by 16 feet, were sunk in intervals and connected by strong timbers, upon which an apron rested to create still water, in which the head and corners of the coffer-dam could be placed.

The work was commenced August 8, 1874, and on the 4th of October, 1874, 2,649.6 cubic yards of rock had been removed from the inside of the coffer-dam, which represented a length of 1,505 feet in its circumference. The average cutting of the rock was one foot and seventeen hundredths of a foot over the whole surface of bottom enclosed by the limits of excavation, and the rock itself was a hard limestone intermixed with silicate. The rock excavated in the pit was given by your permission to the city of Davenport for improving streets. The contractors delivered the flat-boats loaded with rock at the levee, about one mile distant from the head of coffer-dam, and the city unloaded them with her own forces. In this way the work was carried on rapidly, and the Government and city were both benefited. During the progress of the work of excavation the water in the river raised considerably, and the coffer-dam was overflooded for a period of thirty hours; but, owing to the unceasing energy of the superintendent of the contractor's forces, the crown of the dam was raised, the water baled out, and after the lapse of the above-stated time work of excavation was resumed and without interruption brought to an end. The work was inspected by a thorough level, and showed that the plane of grade 4 feet below low water of 1864 had been kept very finely.

Pains were taken to make the bottom of the pit like a floor, and of the last levels no difference exceeding 0.20 below grade were found. The dredge was afterward set to work to remove the coffer-dam cribs, stones, and puddling, and on the 19th day of October this work was reported finished.

The sounding-machine was towed over the ground where the coffer-dam stood. A thorough inspection with it, and besides an investigation with a kind of a rake attached to the machine, proved undoubtedly the work to be done very well, in consequence of which the whole work was recommended to you for acceptance, and as the season was near at an end, a final estimate closed the improving of Lower Chain."

Where the rock to be removed was in patches too small to make it worth while to construct coffer-dams it was broken up by enormous steel-edged jumpers worked by a ringing machine, and then dredged out. Such work varied in cost from 12 to 16 dollars a cubic yard. Boulders were removed by drilling holes in them from a tripod platform and then blasting them, the fragments being either dredged out or dragged by chains into some deep pool where they were not in the way.

Sounding Machine.

When at Rock Island I had the opportunity of seeing the ingenious and most useful sounding machine invented by Mr. Hoffman, and am indebted to that gentleman for the enclosed description of it (see at end of note); the courtesy shown me by him and by Colonel Macomb, Corps of Engineers, U. S. A., who is in charge of the Improvements of the Upper Mississippi and Illinois rivers, deserves my grateful acknowledgments.

Rock Island Arsenal.

To Colonel Flagler, of the Ordnance Department, who has charge of the Rock Island Arsenal works, I am also indebted, for his kindness in showing me thoroughly over his interesting works. The power for all the Arsenal workshops is to be obtained from 40 turbines, worked by a head of water, of from 7 to 8 feet, gained by running a "wing dam" from the entrance to a branch of the river at the upper end of the island, to above one of the sharp slopes of the rapids, and then putting a masonry dam with the turbines on its down-stream side, across the branch about a mile below its head. The turbines being some $\frac{1}{4}$ mile from the workshops, the question of how best to transmit the power occupied much attention. It was originally intended to do this, by compressed air as in tunnel driving, but that system, after elaborate investigations, Colonel Flagler has shown not to be applicable in this case, and wire rope is to be used as the transmitter. The Ordnance Department, under which the work is, do not, it appears, publish reports, but I trust Colonel Flagler will before long make public his investigations.

THE DES MOINES RAPIDS are situated 145 miles below Rock Island. They extend from Montrose Island opposite Nauvoo (the first home of the Mormons) to Keokuk, a distance of about 8 miles, in which the total fall, when the river is low, is $18\frac{3}{4}$ feet. At such times the water flows over the limestone rock, which here paves the bed of the river, with a depth of only a few inches, except where it has worn for itself a narrow tortuous trough of about 3 feet deep. For a great part of the year these rapids are quite impassable by ordinary river-steamers, and cargoes have to be unloaded and sent over the rapids in smaller boats, or sent past them by rail and re-shipped, at considerable cost. The United States Government having decided to turn these rapids by a canal, which shall at all times be able to pass the largest boats which navigate the river above them, the work was commenced in 1868, and when I visited it (1st and 2nd August, 1876,) was nearly completed, but was at a temporary stand-still for want of appropriation of funds—a state of affairs which has happened more than once in the history of the works and has, of course, added considerably to their cost.

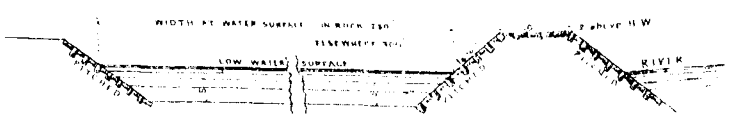
The cost of the whole work will very much exceed the original estimate, and will be between 4 and 5 million dollars. Major Stickney, Corps of Engineers, who is in charge of the works and whose courteous kindness to me I desire to acknowledge, has lately found that he can do the works much cheaper and better "departmentally" than by contract, as the following table, compiled from his report, 3rd July, 1875, will show:—

Classes of work.	Cost. By labor hired by U. S.		Cost. By contract.		Remarks.
	Dolls.	Cts.	Dolls.	Cts.	
Cut-stone masonry, per cubic yard ...	5	65	8	00	
Concrete foundns. do ...	2	85	5	55	
Rock excavation per do ...		84	2	40	
Do in river deepening channel per cubic yard...	*5	60	*8	00	*Not in report but given me by Major Stickney.
Earth excavation ...		33		45	
Slope wall ...	1	33	1	00	
Wrought iron work, per lb.		†08		10	†Sic.

The canal proper is 7·6 miles long and skirts the right (west) bank of the river. At the lower entrance to the canal is a lock with lift of 11 feet; at 2 miles above this is another one with a lift of 8 feet, and at the upper entrance to the canal, at Nashville, is a "guard lock" with gates and head-bay walls above the highest floods which, at that place, rise 11 feet above low water. Above the canal a channel through a chain of rocks has been excavated nearly 4 miles long, 200 feet wide and 5 feet deep at low water. Most of this excavation was got out with the use of coffer-dams, one of which last year enclosed 95 acres. The canal proper is at water surface 250 feet wide when wholly in rock cutting, and 300 feet wide in other parts; the bed is 5 feet below lowest water surface. The bank between the channel and the river is 10 feet wide at top, 2 feet above highest water, and is protected by pitching on both sides.

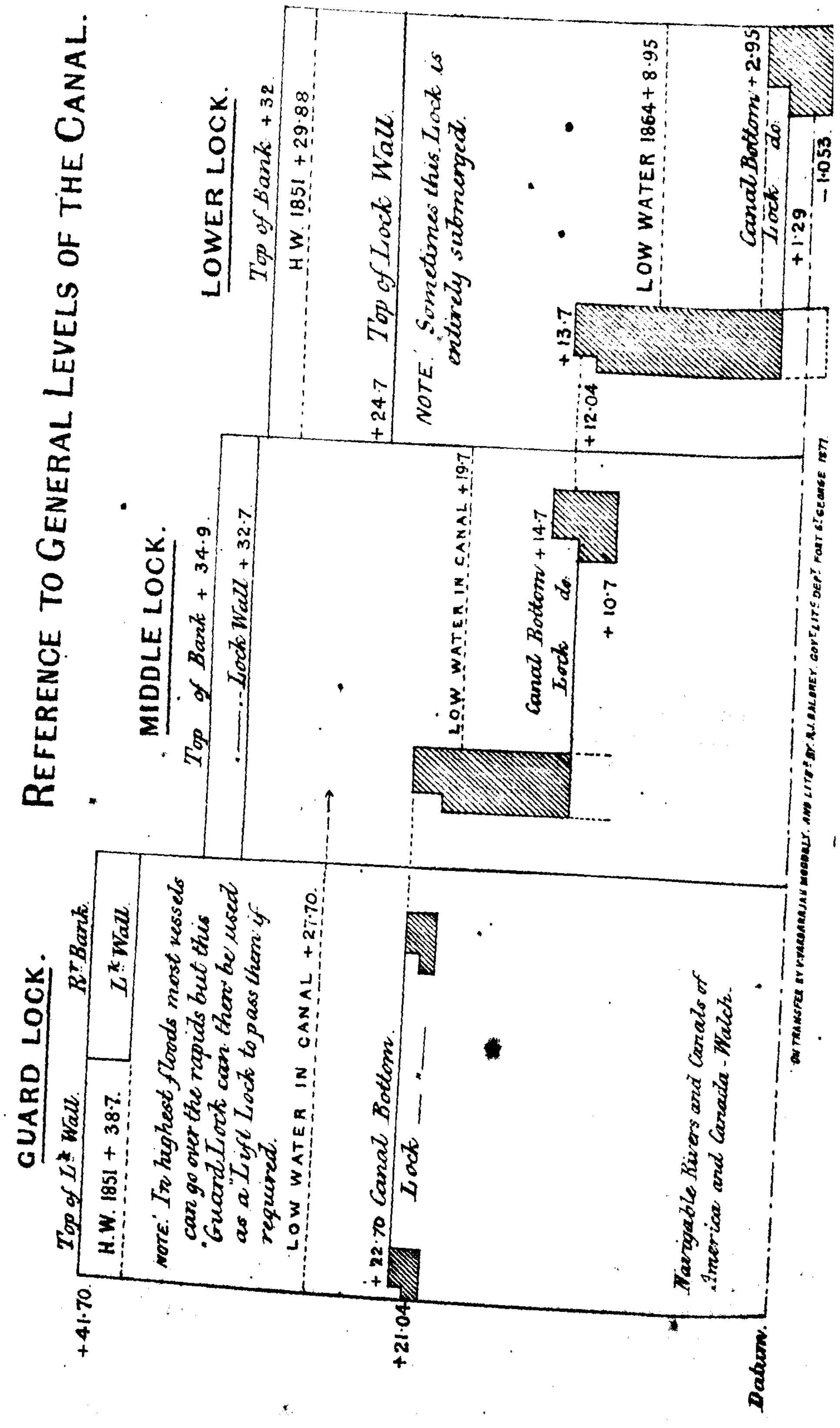
Prism.

Sketch of prism of canal.



Locks.

The locks are 334 feet long from mitre of lower, to back of upper sill and 78½ feet wide at floor. They are built of large blocks of magnesian limestone set in hydraulic cement and are founded on the solid rock. The side walls are 6 feet wide at coping, with a face batter of ½ inch in a foot and stepped out at back 7½ inches at every 5 feet down. The masonry sills of the guard and middle lock are 5 feet, and those of the lower lock 6 feet, below lowest water. The floor of upper bay of each lock is at the same level as that of the chamber, and has across it a breast wall of the same height as the upper sill and 33 feet in front of it. From each side of this bay 4 vents, 3 feet wide × 6 feet high, lead into a culvert, 8 feet wide × 9 feet high, which runs with these dimensions to 58½ feet beyond the upper sill wall, and from there continues, gradually tapering, for 183 feet, at 10 feet back from the face of the side wall; in this



183 feet, eight vents, 3 feet wide × 6 feet high, open from the culvert into the chamber. For emptying the locks the arrangement is similar. In each lower gate recess are 4 vents of the size given above, which lead into a culvert out of which 5 vents open into the tail bay. *Each* of the vents in the head bay and in the lower gate recesses is closed by a shutter; it would have been simpler and less expensive in cost and maintenance to have merely closed the side culverts by one, or two shutters.

The gates are built of white oak. The leaves are each 46 feet 2 inches long from heel to mitre, and are formed to 2 feet wide at the ends and 4 feet wide in the middle by the front ribs being built of four 3 inch planks bent to the required camber, the space between them and the rear straight timbers being kept by 3 vertical posts, through which run the bolts fastening the front and rear ribs together. The planking in front of the gate is 3 inches thick. The ribs which are 1 foot apart, are each braced by a tension bar passing over a cast iron saddle on a vertical post on the rear side of the gate at the middle of its length. The heel posts are cast iron casings into which the ends of the ribs are bolted and the quoins in which they turn are of cast iron built into the masonry. The gates are kept 11 inches clear of the floor and are entirely suspended by wrought iron suspension bars, 2 to each leaf, which turn on a 3 inch diameter steel pin on a cast iron tower post, which is held in position by 4 iron guy rods attached to anchors built in the masonry. The general arrangements of the gates and suspension gear are given on the 2 sheets of sketches (Nos. 62 and 63 in Vol. of Plans) sent herewith, which, together with the general plan and cross-section of lower lock, were, by the kind permission of Major Stickney, copied from plans in the office of the works at Keokuk.

The lock gates and side vent shutters and those of the surplus channel sluice are all to be opened and shut by chains and gearing actuated by hydraulic power, which is to be so arranged that only one man on each side of the lock will be required to work it. Of these arrangements I am unable at present to give details, but I am in hopes that when

Major Stickney has perfected and patented them, he will send me a description of them; if so, it shall be forwarded as an appendix to these notes.

The feed and surplus water is carried past the locks along a channel, 16½ feet wide at bottom, the entrance to which is through a sluice with six openings, 3 feet wide and 6 high, with shutters, which will be lifted and lowered by the hydraulic apparatus above mentioned.

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APPENDIX.

Description of Model of Sounding Machine.

"An apparatus for obtaining and recording soundings with greater rapidity and accuracy and at less expense than by other methods has been used for some years in the improvement of Rock Island and Des Moines rapids of the Mississippi river.

In general surveys of portions of river by the use of the machine, large numbers of soundings are made at *regular* intervals, with no wide gaps as are customary in skiff-sounding, so that superior hydrographic maps are obtained which accurately define the channel and give a perfect representation of the river bottom. In rock excavation coffer-dams may be properly located, or where chisel and dredge or the various methods of submarine blasting are employed for removing smaller patches of rock than it is customary to coffer-dam, the quantities of rock removed can be accurately determined.

This machine was designed and constructed by Major E. F. Hoffmann, Assistant Engineer, under supervision of Col. J. N. Macomb, Corps of Engineers, U. S. Army.

BODY OF MACHINE.

The body of the machine consists of five small flat-boats, one of which is somewhat larger than the others, combined as shown in the model into a system one hundred feet in length. This system is attached to the bow of a light draught steamer, at right angles to her centre line, by means of two diagonal spars, so as to place the apparatus completely under her control, and insure a steady uniform motion at any rate of speed desired. Upon this system of boats is erected a frame-work of masts stiffened by guy-rods, which carries the sounding boxes and poles, ten in number, at intervals of 11.1 feet.

APPLICATION OF POWER AND OPERATION OF POLES.

The power for working the apparatus is transmitted from the steamer by means of a steam capstan. This runs a line of shafting, passing through the lower ends of the sounding boxes, on which shafting are the wheels which carry the chains which draw down the sounding poles. The poles on striking the bottom displace a lever arm, thus bringing a counter-weight running in the sounding boxes nto play, which draws the pole back to its original position. Should the water be deeper than the length of the pole, on reaching full length the lever is struck by a fixed arm on the sounding boxes and the pole returns as before.

PERPENDICULAR MOTION.

To insure a perpendicular motion of the poles in their descent, cords are attached to their feet, which cords pass around wheels on a line of shafting laid along the bows of the flat-boats. This shaft is run by a pair of screw wheels on the main shaft, the perimeters of which wheels are so adjusted as to give just sufficient line to each pole to insure perpendicularity at whatever depth it may descend.

RECORDING APPARATUS.

On the axes of the wheels at the tops of the sounding boxes are screws, the dimensions of which are such that the periphery described by a point in the thread of the screw in one revolution is in proportion to the periphery of the wheel itself as to 2 to 15; so that for each 15 inches of descent made by the pole, the line passing around the screw will be wound up 2 inches. (In the machine small pulleys are used instead of screws and the proportion is as 1 to 15.)

The lines passing around these screws are conducted by small pulleys and made fast to the upper end of small steel rods, ten in number, each rod corresponding to one of the poles. These rods run on small sharp-edged wheels pressed firmly against white paper, on which paper as the poles descend marks are made proportional in length to the distance of descent of the corresponding pole. This series of marks constitutes the record and may subsequently be reproduced in figures by means of a scale prepared for the purpose.

METHOD OF LOCATION.

The mode of locating the soundings made by the machine is as follows:

On the shore at both ends of a measured base line are two men with theodolites. At the instant of sounding, the signal (in the model represented by a brass ball) is run up, this being accomplished by a line passing over a wheel run by the main shaft, this signal, the centre of which is in a line with the sounding poles, is covered at the same instant of time by the cross-hairs of the theodolites on shore. Thus, then one end of the system of boats is located. Another man with theodolite is stationed on the same end of the apparatus, who at the instant of sounding takes the angle representing the difference of direction of the centre line of the system of boats

and a line from his instrument to one of the instrumental stations on shore. The relative positions of the poles, the signal and the theodolite on the boats being known, the location is complete.

CAPABILITIES OF MACHINE.

Although the machine is capable of making 6 dips a minute, or 60 soundings, yet as the theodolite observers cannot, without great labor, make more than 3 observations per minute for any protracted length of time, the operation of the machine is restricted to 3 dips or 30 soundings per minute. This would give, making allowances for the usual delays, about 10,000 soundings per day. By means of a skiff about 1,000 per day can be made. The advantage then in *point of time* of the machine over skiff-sounding is as 10 to 1. In preliminary surveys or where great accuracy of location is not required, the full quota of 6 dips per minute may be made by interpolation, and 20,000 soundings per day can thus be obtained.

The following table shows the advantage per day of the machine *in point of expense*:—

SKIFF.

2 Theodolite observers	@ $4-00,	$8-00
2 Boatmen	@ 2-00,	4-00
1 Sounder	@ 2-00,	2-00
1 Flagman	@ 2-00,	2-00
3 Recorders	@ 1-33⅓	4-00
Total per day		$20-00

By skiff 1,000 soundings per day, at $20.00 would give 2 cents per sounding.

MACHINE.

Hire of steamer (including men and coal)..................................		$36-00
1 Pilot......		5-00
3 Theodolite observers......	@ $4-00,	12-00
1 Machinist		3-00
1 Assistant Machinist..........		2-00
4 Recorders	@ 1-33⅓,	5-33
Total per day		$63-33

By machine 10,000 soundings per day, at $63.33 would give about 63-100 of a cent per sounding.

Or the advantage of the machine is about 3⅕ to 1 in point of expense."

P.S. by Major Hoffmann.—"For using the machine to a greater depth, in rivers or harbors the sounding boxes and rods must be increased in length to the respective depth required say 30 feet, and in such a case a corresponding lengthening of the small flat-boats would be advisable, the original width being maintained. The great advantage of the machine is, that it covers a width of 100 feet of river; that the poles descend simultaneously and with a perpendicular motion (a thing never possible in hand-sounding), further; that the depth of the water is measured from the surface of the water to the bottom of the river, and not as done in sounding by hand from the bottom of the river to the surface of the water. The feet of the poles on the machine are accurately adjusted to the surface of the water. The machine itself always moves up stream very slowly and steadily, and thus sounds from an unchangeable plane to the bottom of the river. All incorrect readings in the system of sounding by hand occasioned by ripples or waves on the water are avoided and the automatic recording sets aside all errors so frequently observed when sounding and recording is done by men. The machine in throwing out the records of the sounding saves besides considerable labor in the office in compiling figures and reducing them to low water from the sounding books.

The reduction for low water is effected mechanically by the machine, and human errors are thereby avoided.

A sum of from $2,500 to $3,000 would construct a fine machine sounding to 30 feet.

Acknowledgment.

I wish to specially acknowledge the courtesy extended to me by the American Society of Civil Engineers, and in order to show English Engineers how neatly and thoroughly such things are done in America, I give the letter which I received from the Secretary of the Society soon after my arrival in the country.

AMERICAN SOCIETY OF CIVIL ENGINEERS,
4, East Twenty-third Street, New York.
June 2nd, 1876.

In Philadelphia:
West Gallery, Main Exposition Building,
And with American Institute of Mining Engineers,
1123, *Girard Street.*

Dear Sir,

On behalf of this Society, I am instructed to extend to you its courtesies, during your visit to the United States.

Its rooms and library with means for writing, are placed at your disposal; upon request, your correspondence will be received and forwarded as advised by you.

The Centennial Commission of the Society, (Mr. John Bogart, Resident Secretary), has rooms in West Gallery, Main Exposition Building, Philadelphia, where similar facilities will be furnished, and information given, not only regarding the various Engineering Exhibits of the International Exhibition, but location and means of inspecting the more interesting manufacturing and public works of the country.

The American Institute of Mining Engineers kindly permits this association to join with it in welcoming you to its rooms 1100 Girard Street, Philadelphia, which are open in the evening (the Exposition then is closed,) and are the resort of engineers, and those interested in engineering.

You are also invited to attend the Eighth Annual Convention of the Society, to be held in Judge's Hall, Centennial Grounds, June 13th and 15th next, from $10\frac{1}{2}$ A.M. to $1\frac{1}{2}$ P.M., and to take part in the proceedings.

Permit me herewith to hand you a card of introduction to members of this association, with a list giving their names, location, and engagements, whereby in your travels about the United States you may at once refer to those who are in charge of principal engineering operations.

Your obedient Servant,
G. LEVERICH,
Secretary.

To GEORGE T. WALCH, Esq.

INDEX.

LIST OF PLANS
In separate volume.

MORRIS CANAL.

INCLINED PLANE, CHESAPEAKE AND OHIO CANAL.

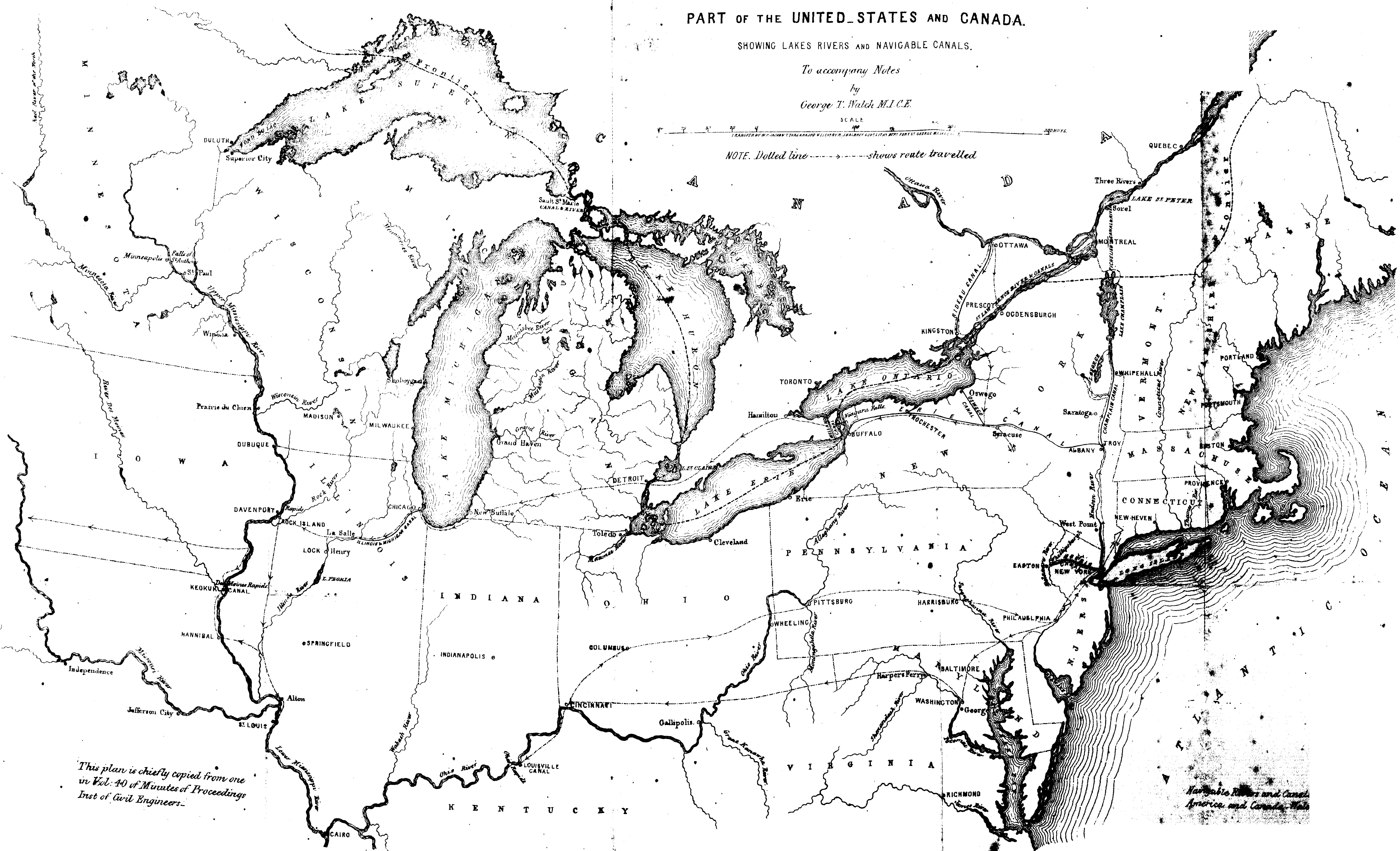
NAVIGATION OF THE OHIO RIVER AND ITS TRIBUTARIES.

THE ERIE CANAL AND ITS BRANCHES.

THE CANALS OF CANADA.

CANALIZATION OF ILLINOIS RIVER.

MISSISSIPPI RIVER—DesMOINES RAPIDS CANAL.


PART OF THE UNITED_STATES AND CANADA.
SHOWING LAKES RIVERS AND NAVIGABLE CANALS.
To accompany Notes
by
George T. Walch M.I.C.E.
SCALE
NOTE. Dotted line ————→———— shows route travelled
This plan is chiefly copied from one in Vol: 40 of Minutes of Proceedings Inst of Civil Engineers.
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
LAKE ERIE
CANADA
MINNESOTA
WISCONSIN
MICHIGAN
IOWA
ILLINOIS
INDIANA
OHIO
PENNSYLVANIA
NEW YORK
VERMONT
MASSACHUSETTS
CONNECTICUT
MAINE
KENTUCKY
VIRGINIA
MARYLAND
ATLANTIC OCEAN
DULUTH
Superior City
Sault St Marie CANAL & RIVER
St Paul
Minneapolis
Winona
Prairie du Chien
MADISON
MILWAUKEE
Sheboygan
DUBUQUE
DAVENPORT
ROCK ISLAND
La Salle
CHICAGO
New Buffalo
Grand Haven
DETROIT
Toledo
Cleveland
Erie
BUFFALO
ROCHESTER
Syracuse
ALBANY
TROY
Oswego
KINGSTON
PRESCOTT
OGDENSBURGH
OTTAWA
MONTREAL
Sorel
Three Rivers
QUEBEC
LAKE ST PETER
TORONTO
Hamilton
Niagara Falls
ERIE CANAL
RIDEAU CANAL
Saratoga
WHITEHALL
CHAMPLAIN CANAL
PORTLAND
PORTSMOUTH
BOSTON
PROVIDENCE
NEW HEVEN
West Point
NEW YORK
EASTON
PITTSBURG
HARRISBURG
PHILADELPHIA
WHEELING
COLUMBUS
BALTIMORE
Harpers Ferry
WASHINGTON
Georgetown
RICHMOND
CINCINNATI
Gallipolis
LOUISVILLE CANAL
INDIANAPOLIS
SPRINGFIELD
Alton
ST LOUIS
Jefferson City
Independence
HANNIBAL
KEOKUK CANAL
Des Moines Rapids
LOCK Henry
L. PEORIA
CAIRO
ILLINOIS & MICHIGAN CANAL
Ottawa River
Ohio River
Wabash River
Missouri River
Upper Mississippi River
Lower Mississippi River
Wisconsin River
Rock River
Illinois River
Grand River
Hudson River
Allegheny River
Navigable Rivers and Canals America and Canada