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Construction, Capacity and Cost of Operating Dredging Machines of Several Types in Recent Excavations of Large Magnitude.

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by

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The excavations for a large canal have been in progress under the direction of the writer during the years 1897, 1898, 1899, 1900 and 1901. In this period there have been moved 5 868 000 cubic yards (4 486 287 cubic mètres). Of this material 1 436 000 cubic yards (1 097 871 cubic mètres) were excavated under water by dredges of several different types and 4 432 000 cubic yards (3 386 416 cubic mètres) were excavated above ground by Steam Shovels and certain special forms of graders and excavators and conveyors, this latter amount including 88 700 cubic yards (67 814 cubic mètres) of rock requiring blasting*).

The canal is in St. Lawrence County, State of New York, United States of America and connects the St. Lawrence River with the Grasse River. Its length is 16 200 feet (4 937,7 m) (3,068 miles). It carries water from the St. Lawrence River above the Long Sault Rapids to the Grasse River, the water of which is at this point about

*) In this paper the types, descriptions and results of working of these subaqueous excavators or dredges is given in special detail and only such information is included as to excavations above water and as to other constructions as seems necessary for a clear presentation of the facts. The official summary of subjets for discussion at the International Congress of Navigation seems to suggest such limitation, although other information of a practical character as to the facts and economic results obtained during the progress of a canal work of this magnitude might be of interest to those who may have to direct similar undertakings in the future.

44 feet (13,41 m) below that of the St. Lawrence. Here there has been built a power house for the development of water power and electricity. The design for the completed works includes a lock to transfer vessels from the Canal to the Grasse River and through that River to the St. Lawrence below the Rapids. The lift of this lock will vary with the elevation of the water in the two Rivers, never exceeding 45 feet (13,72 m).

The alignment of the canal is very direct. It has but three curves each of 5730 feet (1746,49 m) radius. There are two deep excavations each about 3000 feet (914,42 m) long in which the natural surface has a maximum elevation of about 72 feet (21,95 m) above water surface in the canal. Throughout the remainder of its length the natural surface averages from 12 to 14 feet (3,66 to 4,26 m) above water surface. The whole canal is in excavation. One bridge of 412 feet (125,58 m) clear span crosses the canal at one of the ridges; another bridge is made a part of the power house construction.

The St. Lawrence River at the entrance to the canal fluctuates in height about $2^1/_2$ feet (0,76 m) as a maximum. The fluctuations in the Grasse river are generally $4^1/_2$ feet (1,37 m) the River being near its low stage during the greater part of the year. Occasionally the River has attained a height of 14 feet (4,27 m) above low water for a few hours. This occurs only under certain conditions of ice in winter which sets the water back.

When the water of the St. Lawrence is introduced through the canal to the Grasse, the large volume used for power will raise the water in the Grasse and will also modify the conditions as to ice which now set the water back. The water of the Grasse River may be raised some seven feet above its low stage should the canal in the future be excavated to its proposed dimensions so as to deliver sufficient water to develop 150 000 Horse powers. The elevation will not be so great above high water in the Grasse River because the topographical conditions then afford comparatively greater area of outflow and variations of elevation will be much diminished. The head upon the turbine wheels at the Power House will never be less than 30 feet (9,14 m) except possibly for a few hours under special conditions of ice formation. Dredging certain parts of the Grasse River will afford a flow under all conditions sufficient to secure a minimum head of at least 32 feet (9,75 m).

The area of the water section of the canal when finally completed will be (5870 square feet) (545,33 square mètres). The dimensions below water surface will be $187^1/_2$ feet (57,15 m) wide at bottom; 265,3 feet (80,86 m) wide at water surface; 25,93 feet (7,92 m) depth of water. The total excavation requisite to secure

this water section will amount to 7 760 000 cubic yards (5 932 785 cubic mètres).

After some progress had been made it was decided to excavate at first a canal with a water section of 2574 square feet (239,13 square mètres) the reduction being made so as to permit the development of a large amount of power sooner than could be done if the whole excavation were completed before transmission of water through the canal. The canal with this reduced section has been completed. The present dimensions below water surface are: 155,8 feet (47,49 m) wide at bottom; 199,3 feet (60,75 m) wide at water surface; 14,5 feet (4,42 m) depth of water.

The material excavated was largely alluvial deposit. A soft gray clay with some sand, some gravel, some boulders and with loam at the surface was found everywhere except at the two high ridges. At these the material was an indurated clay with gravel and large boulders. This indurated material was very difficult to excavate. Power and dynamite were used freely in all excavations made above water. Very powerful steam shovels could not work advantageously until the indurated material was blasted, the conditions of the locality, difficulty in obtaining suitable dredges and the unexpected failure of the two very large vacuum dredges hereafter described led to the excavation by steam shovels and other methods of dry removal for about three quarters of the total amount moved and only about one quarter by dredging under water.

The dredges used have been of the following described types

Centrifugal Pump Dredges; the excavation made by a rotary cutter; the excavated material forced to its place of deposit through long steel pipes. In one of these dredges the pipe was 12 inches in diameter; in another it was 18 inches in diameter.

Dipper Dredges. The excavation made in the usual way by the scoop dipper with movable back; deposited in scows and these towed by tugs to the place of deposit in water.

Vacuum Pump Dredges. The excavation made by an Orange Peel bucket, deposited in a hopper and transmitted by use of vacuum chambers through long steel pipes to place of deposit. This pipe was for these dredges 18 inches diameter.

The Centrifugal Pump Dredge with suction and discharge pipes of one foot (0,30 m) diameter was built on the ground where some excavation had been made, water was pumped to this excavation after the dredge was built so as to float it and a sufficient supply of water was continued by pumping to allow the dredge to work without interruption.

The hull is southern pine 65 feet (19,81 m) long; 30 feet (9,14 m) wide; 6 feet (1.83 m) deep. The longitudinal timbers on

bottom are 8 inches by 12 inches and 3 feet center to center. The timbers on each side of the center are double 16 inches by 12 inches. The side uprights are 6 inches by 8 inches and 3 feet center to center. The whole is covered by plank 3 inches thick. At the front of the hull is an „A" frame of timber 12 inches by 12 inches, reinforced by two steel $1^3/_4$ inch rods to each timber. The top of this frame is 45 feet high above the deck. It is anchored by two other timbers 12 inches by 12 inches running from its top, back to each side of the hull 24 feet from the front and also by two 2 inch rods from its top to each side of the deck at the middle of the hull. Six feet above the deck is a cross piece on the A frame, the center of which supports the foot of a timber boom or frame, the other end of which is supported by a wire cable from the top of the A frame. At the end of the boom are three sheaves each carrying wire cable, two of these swing the dredge from side to side, the other raises and lowers the timber frame which supports the suction pipe, the cutting instrument and the shaft operating this cutter. At the stern of the hull are two anchoring spuds of timber 9 inches by 16 inches, 40 feet long. These are raised or lowered by cables running through sheaves on a square timber frame and by means of these spuds the dredge is held in position and is moved forward or backward by raising one spud, swinging the hull, dropping that spud, raising the other and swinging in the other direction.

The movable frame is 45 feet (13,72 m) long, made of two timbers each 12 inches by 12 inches, with space between them for the suction pipe, 12 inches in diameter. A shaft of steel 4 inches diameter is above the suction pipe. The frame and its appurtenances is raised, lowered and held in position by the cable from the A frame passing through the sheave at end of boom and running to the engine. The suction pipe and the cutter shaft are jointed so as to allow free vertical movement of their supporting frame. The cutter is composed of blades which radiate from the end of the shaft and are curved backward and connected at their outer ends by a ring of metal thus forming a skeleton basket shaped frame of $3^1/_2$ feet diameter at base and 2 feet 10 inches deep. The shaft passes through the center of this cage and the blades are forged together and attached to the end of the revolving shaft.

The number of blades varies with the character of the material excavated; adhesive material and clay requiring greater space between the blades than free friable earth or sand. In the soft clay excavated by this machine a space of about $2^1/_2$ inches between the blades was found advisable.

The end of the suction pipe is fixed at the rear or base of this cutter. When the shaft and cutter revolve the blades loosen

and cut into the material against which the cutter is held. This disintegrated material passes between the blades into the interior of the basket and thence directly into the suction pipe with a volume of water ranging with the character of material excavated. This pipe goes directly to the centrifugal pump. This pump is connected to a separate compound condensing engine of 125 horse powers. It is capable of operating against a head of 60 feet (18,28 m). It delivers the water and excavated material directly into the pipe which passes out from the stern of the dredge. This pipe is of wrought iron, spiral rivetted. Its lengths are connected by flanges bolted together and at convenient intervals there are placed sections of heavy rubber pipe 6 feet in length, thus permitting all requisite changes of alignment. The length of the discharge pipe actually used for this work was generally 1200 feet (365,75 m). The pump forced the water and material through this and greater lengths of pipe without difficulty. The lift above the surface of the water in which the dredge floated averaged 30 feet (9,14 m).

The Lidgerwood Engine which does all the work except actuating the pump is in the forward part of the boat and has a cylinder $6^1/_4$ inches by 10 inches, link motion, with six drums. One drum raises and lowers the cutter and suction pipe; two drums swing the boat from side to side and two raise and lower the anchoring spuds. The same engine turns the shaft of the cutter,

The boiler is of 125 horse powers and supplies steam at a pressure of 125 pounds.

Every movement of the machinery is controlled by one man operating levers placed in a house on the upper forward deck of the dredge.

As the cutter revolves, the frame carrying it and the outer end of the suction pipe is slowly moved sideways, the whole boat swinging upon one of the anchored spuds as a pivot, until the edge of the required excavation is reached. The frame is then lowered enough to cut another slice of material and then moved in the other direction. This operation is repeated until the proper depth is attained. When the dredge is moved backward for another cutting.

The water with the excavated material is delivered at the outer end of the discharge pipe. The amount of material carried with the water varied from seven per cent to thirty per cent. The usual running average of excavated material was about 25 per cent. The semi-fluid mass was so directed that it spread over a considerable area of land, depositing the solids gradually, the water running to one of the rivers or at certain points back into the canal. When sufficient area was provided so that there was time for precipitation, the water became quite clear. When it ran to the river within a

short time it carried with it about $2^1/_4$ per cent of suspended material.

This dredge was not able to excavate the indurated material above described. It did excavate successfully the soft clay and loam and sand, separately or as they occurred in combination. It worked continuously throughout each season, except when ice prevented. Rain and bad weather did not interfere with it. It was run 22 hours during each 24 hours, except on Sundays. It was served by two sets of men each working eleven hours. It excavated and delivered during three seasons 459 800 cubic yards (351 533 cubic mètres). The cutting was made to a maximum depth of 22 feet below the surface of water in which the dredge floated and the material was raised an average of 30 feet above that water and deposited an average of 1200 feet from the dredge.

This dredge requires for its operation one Captain, one Engineman, one oiler, one fireman, one foreman of deck hands and three men. The compensation of the force at the average rates paid during the progress of this work amounted for each shift of 11 hours to . . . . . dollars 17,95

For each day of 22 hours	dollars 35,90
Oil, waste, etc., for 22 hours . .	5,00
Coal 9 tons at dollars 3, for 22 hours	27,00
Total each 22 hours	dollars 67,90

This amount includes the labor required in placing and taking care of the discharge pipe as well as in operating the dredge.

The pay of the deck hands, the lowest priced labor employed on this dredge was dollars 1,65 for the 11 hours or 15 cents per hour. The above cost of dollars 67,90 thus equals 41,18 days pay of this class of labor. These laborers were selected as partially skilled men, the pay of common unskilled labor being $12^1/_2$ cents per hour or dollars 1,375 per day of 11 hours. The price of coal is more than it would be in many parts of the United States.

The cost of this dredge was dollars 40 000. Interest at four per cent. is dollars 1 600,00 per annum. The life of the dredge would not exceed about ten years, that is to say, it would require an expenditure equal to the original cost of the dredge to keep it in constantly good condition and to have it in that condition at the end of ten years. There must therefore be charged against the work done dollar 4000 per annum for repairs and renewals and dollars 1600 per annum for interest.

In the locality of this canal and generally in the Northern parts of the United States dredging can only be done during about eight months of the year. The annual cost for repairs, renewals and

interest must in this particular case be distributed over the actual working days, say dollars 26,80 per working day. The dredge must be cared for during the winter season at a cost which distributed over the actual working days may be charged at dollar 1,00 per working day.

The total cost per actual working day of 22 hours is thus:

Labor and supervision	dollars 35,90
Coal at dollars 3, per ton . . .	27,00
Supplies	5,00
Interests, repairs, renewals . . .	26,80
Care during winter	1,00
Total	dollars 95,70

As stated above this dredge excavated during three seasons 459 800 cubic yards. Very careful observations were made of actual working days occupied in the excavation of 218 250 cubic yards (166 859,6 cubic mètres). This amount was excavated and discharged in 194 working days, thus giving for this, large volume an average of 1125 cubic yards (860,1 cubic mètres) per day of 22 hours.

The average cost was thus, with allowance for repairs, renewals, care in winter, coal, supplies and labor 8,507 cents per cubic yard (11,127 cents per cubic mètre).

It will be observed that if the cost of labor, coal and supplies alone was taken into consideration the resulting average cost would be 6,035 cents per cubic yard (7,894 cents per cubic mètre). This compares with statements of cost of dredging which have been made with reference to other works. The cost of capital invested and of repairs and renewals is certainly an actual element of cost of work done.

The Centrifugal Pump dredge with suction and discharge pipe of 18 inches (0,457 m) diameter was substantially of the same construction as the one with 12 inch suction and discharge pipe already described quite fully. All parts were correspondingly larger. The hull of this dredge was that of one of the vacuum dredges hereinafter referred to, which was incapable of economically working in this material. The hull is 103 feet long, 34 feet wide and 10 feet deep. The vacuum machinery and the excavating bucket and all attachments were removed. A centrifugal pump 18 inch suction and discharge and an engine, drums, cutter, cutter shaft, suction pipe and other machinery put in.

The mode of operating this dredge is exactly the same as the 12 inch one already described. It excavated similar material. It worked through two seasons except when ice prevented. It was run

22 hours each day, except Sundays and was managed by two sets of men each working eleven hours. It excavated and delivered during two seasons 290 780 cubic yards (222 311 cubic mètres). The cutting was made to a depth of 22 feet below surface of water in which the dredge floated and the material was raised an average of 30 feet above that water and deposited an average of 1200 feet from the dredge.

This dredge requires for its operation one Captain, on Engineman, one oiler, one fireman, one Spud tender, one foreman of deck hands and three men. The compensation of this force at the average rates paid during the progress of this work amounted for each shift of 11 hours to dollars 20,95

Or for each day of 22 hours	dollars 41,90
Oil, waste, etc., for 22 hours	8,00
Coal 18 tons at dollars 3, for 22 hours . .	54,00
Total each 22 hours	dollars 103,90

This included placing and taking care of the discharge pipe.

The cost of a new dredge similar to this one would be dollars 60 000. Interest at 4 percent is dollars 2400 per annum. Repairs and renewals as explained for the similar dredge would be for this dredge dollars 6000 per annum. These distributed over actual working days would be dollars 40,19 per working day. The care during winter distributed over the actual working days dollar 1,00 per day.

The total cost per actual working day of 22 hours is thus:

Labor and supervision	dollars 41,90
Coal at dollars 3. per ton	54,00
Supplies	8,00
Interest, Repairs, Renewals	40,19
Care during winter	1,00
Total	dollars 145,09

Careful observations show that this dredge excavated and discharged 246 983 cubic yards (188 827 cubic mètres) in 160 working days, thus giving an average of 1543,6 cubic yards (1180,13 cubic metres) per day of 22 hours.

The average cost was thus with allowance for repairs, renewals, care in winter, coal, supplies and labor 9,399 cents per cubic yard (12,294 cents per cubic mètre).

The excavations made by dipper dredges and delivered into scows at side of dredges amounts to 525 306 cubic yards (401 614 cubic mètres). One of these dredges has a dipper with a capacity

of 2 1/2 cubic yards. The dipper has three steel teeth about six inches by 5 inches. The hull is 85 feet long; 28 feet wide and 10 feet deep. There are three anchoring and supporting spuds, each 20 inches square.

The dipper arm is 28 feet long, of wood sheathed with steel. The material was delivered into scows each having a dropping pocket with a capacity of 140 cubic yards. A tug boat took these scows in turn into the St. Lawrence River, dropping the excavated material in a bay near the mouth of the canal. The distance to which the scows were towed averaged about 5500 feet (1676,38 m).

The dipper dredge worked ten hours per day. The tug and scows could not be operated at night. This dredge excavated to a depth of 20 feet below water surfaee.

The cost of operating this dredge including the crew of dredge, tug and scows, coal, supplies, etc., was for each day of 10 hours dollars 30,56.

The cost of dredge, tug and two scows is dollars 43 000. Interest at 4 per cent is dollars 1720 per annum. One tenth cost for repairs and renewals is dollars 4300 per annum. These distributed over actual working days would be dollars 28,80 per working day. Care during winter months distributed over working days dollar 1,00 per day. The total cost per actual working day of 10 hours is thus:

Labor, supervision, Coal and Supplies .	dollars	30,56
Interest, repairs and renewals	„	28,80
Care during winter	„	1,00
Total	dollars	60,36

This dredge excavated, delivered into scows and deposited in the River 138 001 cubic yards (105 506,5 cubic mètres) in 183 days of 10 hours thus giving an average of 754,1 cubic yards (576,54 cubic mètres) per day of 10 hours.

The average cost was thus with allowance for repairs, renewals, care in winter, coal, supplies and labor, both for dredge, scows and towing tug 8,004 cents per cubic yard (10,469 cents per a cubic mètre).

This excavation was indurated material as described above. Neither the Centrifugal pump dredges or the orange peel bucket dredges referred to below could excavate this material.

Another larger and heavier dipper dredge worked during one season. This has a dipper with a capacity of 6 cubic yards with which it excavated the indurated material depositing it into scows in the same manner as the dredge last above described. The location of its working was such as to make it impracticable to keep an

account of the amount of material moved by it during sufficiently prolonged periods to warrant an exact statement and comparison with the figures of cost of the other dredges above given. While the amount per day excavated by this large dredge was greater the cost per cubic yard was about the same as that shown by the smaller dipper dredge as given directly above.

Another dipper dredge with a scoop of $1^1/_2$ cubic yards capacity worked during one season. It was quite similar to the one with the dipper of 2 cubic yards capacity and the cost of excavating and depositing material by it was the same as stated above.

Vacuum Pump Dredge: Soon after the beginning of the work on this canal two large dredging machines were built at Buffalo and brought by water to the canal.

The designers of these machines expected that they would give effective and economical results, both in the indurated and in the softer material. The two machines were of exactly the same design and construction.

The hull is 103 feet long, 34 feet wide and 10 feet deep. There are two decks, the upper one having sleeping and living rooms for the captain and all hands. All parts of the hull and upper works are strongly braced with heavy timbers and steel rods. The dredge is provided with large water tanks and coal hoppers. There are three anchoring spuds, two forward and one near stern. These are operated by an independent double drum engine. There are two Marine boilers each 150 horse powers, supplied with water by two Blake pumps. Two Steel Vacuum Chambers are near the center of the boat, each cylindrical, 5 feet diameter, 19 feet high. There is a hopper attached to bow of dredge, 40 feet long, 12 feet wide, built of I beams covered with $^3/_8$ inch steel.

The bottom of hopper slopes to center of boat. A suction pipe 18 inches diameter runs from center of hopper into and close to bottom of hull, backward 35 feet where it connects by a Y to two pipes also 18 inches diameter, going to the two vacuum chambers. From each of these an 18 inch pipe leads aft to a Y whence an 18 inch discharge pipe passes out the stern of the boat. There are four 18 inch valves one in each branch of each Y. These valves are separately operated by steam pistons controlled at the pilot house. In the hopper at entrance to suction pipe is a cutter with four $2^1/_2$ inch blades. This cutter is run by a separate double cylinder engine. A high pressure Blake pump, 10 inches suction and 8 inches discharge supplies water to the hopper.

A heavy A frame 26 feet from the bow carries a cable passing from engine drum to outer end of a boom 40 feet long. This frame also carries the cables for operating the dredge bucket. This bucked

is suspended from two sheaves 30 inches in diameter near the end of the boom, The bucket has a capacity of 4 cubic yards. It is of the form known as the Hayward Orange Peel so called from its resemblance to the peel of an orange when cut into quarter pieces. It has four triangular curved blades which when closed form a tight semi-spherical bowl. When open the blades resemble sharp spades and are so adjusted to steel arms, connecting rods and cables that the maximum downward digging effect is produced with but slight tendency to lift the bucket until closed. The dredging is done by the main engine placed back of the pilot house. This has cylinders 14 inches by 18 inches and two drums 30 inches in diameter carrying the hoisting cables.

A 4 inch high pressure Blake pump supplies water to the vacuum chambers and is regulated by pressure valves so that it will stop acting when the chambers have the requisite pressure. A direct current generator supplies electric light.

All the machinery is controlled by levers placed in the pilot house, at the bow of the boat.

The dredging is done by the orange peel bucket in the ordinary manner. This lifts the material from the bottom or sides of the excavation and drops it into the hopper which is supplied with water by the large pump. The cutter is revolving in order to disintegrate the mass of excavated material. Steam is turned into one of the vacuum chambers and then cold water is pumped in through a spray, condensing the steam and forming a vacuum. The forward valve is then opened and the water and excavated material drawn from the hopper into the chamber. The valve is then closed, the rear valve opened, steam turned into the chamber forcing the water and excavated material into and through the discharge pipe. While one vacuum chamber is discharging, the other should be filling, their work alternating and the discharge made practically continuous.

An orange peel bucket with capacity of one cubic yard had been successfully operated in excavating the soft clay from the canal near the Grasse River. This was supported on a movable platform on land. The clay was wet but not under water. It was expected that this large floating dredge would be more advantageous. It was found however that this large bucket was quite incapable of excavating the indurated material. It could not move sufficient to pay for its maintenance. It could excavate the softer material but the hopper, the cutter, and the vacuum method of transmission failed to transport the material with economy. It formed into balls and lumps in the hopper and did not flow with the water as suspended material but rather as small separate masses carried through the pipes. The steam capacity though, large was not sufficient to operate the vacuums

alternately with continuity and thus instead of a steady flow through the discharge pipe there was an intermittent series of impulses. The attempt to use these vacuum orange peel dredges for this excavation was abandoned and one of them was rebuilt as the centrifugal pump dredge with 18 inch discharge pipe described above. The other vacuum dredge was sent to the vicinity of New York and is working in material quite different from any encountered in the canal above described.

No ladder or continuous scoop dredges were used on this work. Experience on the St. Lawrence River not very far from this locality had shown good results from such dredges and it is regretted by the writer that the contractors did not place at least one such in operation.

Summarizing the statements above made: The total amount excavated by dredges in this canal was 1 436 000 cubic yards (1 097 871 cubic mètres). There were in addition excavated by other means 4 432 000 cubic yards (3 388 416 cubic mètres).

The vacuum pump dredges with orange peel buckets and pipe transmission lines were not serviceable in excavation and transmission either of the indurated or the softer material.

The Centrifugal pump dredge excavating by revolving cutter to depths under water not exceeding 22 feet (6,71 m) lifting the material to a height of 30 feet (9,14 m) above water and depositing it through a pipe of 12 inches diameter 1200 feet (365,76 m) distant from the canal could not excavate the indurated material but worked with success in the softer material. It excavated and deposited in three seasons 459 800 cubic yards (351 533 cubic mètres) of this material at an average cost of 8,507 cents per cubic yard (11,127 cents per cubic mètre) this cost including labor, supplies, coal, repairs, renewals and care during the winter seasons.

The Centrifugal pump dredge generally similar to the one last above mentioned but with a discharge pipe of 18 inches diameter, working in the softer material, excavated and deposited in two seasons 290 780 cubic yards (222 311 cubic mètres) at an average cost of 9,399 cents per cubic yard (12,294 cents per cubic mètre).

The Centrifugal pump dredges worked 22 hours of each 24 hours.

The dipper dredges excavated during three seasons 525 306 cubic yards (401 614 cubic mètres). This was the indurated material. It was deposited in scows and towed by tugs and deposited in water about 5 500 feet (1 676,38 m) from the dredges. One of these dredges with a dipper of 2,5 cubic yards capacity, working 10 hours each day and excavating to a depth of 20 feet below water surface lifted and delivered 138 001 cubic yards (105 506 cubic mètres) in 183 working days of 10 hours at an average cost of 8,004 cents per

cubic yard (10,469 cents per cubic mètre) this cost including labor, supplies, coal, repairs, renewals and care in winter, all for both dredge, scows and tug for towing.

Coal is included in these statements at a cost of Dollars 3,00 per ton. The modification for a different price of coal can be readily found.

In latitudes where dredging can be done during all seasons of the year the modification required can be easily made from the data above given. The cost per unit will be reduced provided also there is continuous work for the dredge throughout the year.
