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THE 20-INCH HYDRAULIC DREDGE "KING EDWARD."

By A. W. Robinson, M. Can. Soc. C.E.

This dredge is one the more recent acquisitions of the Department of Public Works of Canada to its fleet of dredges, and is intended for work on the Pacific Coast. The plant of the department in that district up to the present has been small, comprising the dipper dredge "Mud Lark," clam-shell dredge "Muskrat," snag-boat "Samson," and some other small plant, the whole under the jurisdiction of G. A. Keefer, M. Can. Soc. C. E., resident engineer. The works in contemplation include principally the rectification of the Fraser River in its lower part, and also such incidental dredging at various points as may be required. It was decided to adopt a hydraulic dredge as being best suited to the conditions.

This type of dredge is sometimes termed a suction dredge, but the writer has adopted the term hydraulic dredge as being more suitable, for the reason that the suction principle is not employed at all for purposes of dredging. The dredge consists essentially of a mechanical excavator, by means of which the material is dug up or loosened and fed into the mouth of the suction pipe and the remainder of the process is simply one of transportation. A centrifugal pump is employed to create a rapid flow through the pipe from the point of excavation to the point of discharge and the solid matter is carried along with the water. In view of the fact that the percentage of solid matter is small and the volume of the water transported is large, it might be supposed that this method of dredging would be a very wasteful one, but there are several other incidental advantages gained at the same time and in the light of practical results the process is not so wasteful as it seems. In the first place, the essential feature of this type of dredge is the disposition of the material, and, therefore, in comparing the results of its work with any other type, the cost of disposing of the material as well as dredging it must be included. It is also especially adapted for filling up and reclaiming low lands, and, in work of this kind, the presence of a large volume of water with the discharged material is a great advantage as it serves to distribute it over a large area while the water is flowing off.

The velocity of flow in the discharge pipe of dredges of this type varies from eight to sixteen feet per second, and different kinds of material require different velocities of flow for the most efficient work. Material like clay or soft mud can be transported at a slower velocity than sand or gravel material, which tends to quickly precipitate. A high velocity of flow means a greater friction in the pipe and pump, and, consequently, greater expenditure of power. It must always be borne in mind that a fluid mixture of sand or mud and water is heavier than water alone and, therefore, takes more power to pump it against a given head, and, also, the friction in the pipe is greater.

In the earlier hydraulic dredges great trouble was experienced with the abrasion and wear of the interior of the pump. As the first pumps used were similar to centrifugal pumps for water only, it was not an infrequent occurrence for the pump to be renewed after three or four weeks' work. By successful improvements, however, we have been enabled to increase the durability of the pump so that, under ordinary conditions of service, they can be made to last two or three years and, in fact, the principal parts of them are now so designed as to last indefinitely with the parts subject to special wear arranged to be renewable. The interior of dredging pumps are now made of cast steel instead of cast iron as formerly. This is not, however, on account of the greater resistance to abrasion of cast steel as compared with cast iron, because practically, there is very little difference, but it is due to the fact that the cast steel piece can be worn very thin before breaking. Sometimes centrifugal pumps for dredging purposes are lined throughout with renewable steel plates. This is an advantage in some cases, but, as a rule, the delay and expense of renewing the linings amounts to more than the occasional renewal of an entire pump shell as the latter can be put in in less time than linings. Also the bolts or fastenings of the linings tend to produce abrasion and wear at that particular point. Wherever there is a crack or joint in the interior of the pump, it is liable to produce an eddy or change of direction in the flow, and a stream of gritty material acting in this way will soon cut out the fastenings and joints of the linings. A great deal can also be done to reduce the interior wear of the pump by careful design. It is better to allow ample clearance for the flow at all points, especially the periphery of the pump, and this can be so proportioned that the abrasion is comparatively slight and evenly distributed. If experience shows that there is undue wear at one point, it means that there is a stream of gritty material flowing or impinging against the surfaces at that point and at a high velocity. This can be remedied by removing those surfaces further away, thus giving the stream more room at that point. Many pump designers are of opinion that the throat or cut-off of the interior of the pump should be as close as possible to the periphery of the pump-runner, in order to prevent any flow past this point. Careful experiments have shown that this makes very little difference, and that for dredging pumps especially it is better to allow great clearance at this point, otherwise it will cause great wear.

Hydraulic dredges may be divided into four leading types: First. The sea-going hopper type; second, the lateral feeding or ship-channel type, with floating discharge pipe; third, the forward feeding or Mississippi type, with floating discharge pipe; fourth, the radial feeding with spud anchorage and floating discharge pipe.

The dredge "King Edward VII.," which forms the subject of this paper, belongs to the fourth class,—that is to say, it is anchored by spuds and has a radial feed, the cutter describing an arc of a circle about the spud as a centre, and the material is principally deposited on shore or to a distance through the floating discharge pipe.

It will aid in understanding the construction of the dredge and the reasons for adopting this particular construction, if we first give some consideration to a statement of the conditions to be fulfilled by this dredge. After an examination of the ground and a consideration of the subject these conditions were defined as follows :—

First. The dredge must be capable of dealing with sand and soft material at an ordinary rate of 500 cubic yards per hour.

Second. It must also be able to dig and discharge hard clay, gravel, shell or difficult material and to pass occasional stones up to 10 ins. diam. without difficulty, and also to encounter snags, roots or logs, and cut them up if necessary.

Third. It must be capable of working at any depth down to 40 feet and making a cut of any width up to 120 feet.

Fourth. It must be capable of cutting its own flotation through a solid bank.

Fifth. It must be able to work in a current of five miles per hour, in either direction and in ebb or flow of tides.

Sixth. It must be able to discharge its material in three different ways, viz. :—

1. Into scows alongside.
2. On shore or over an embankment by means of a suspended side-pipe.
3. To distant points through a pipe up to 3,000 feet.

Seventh. It must be self-propelling at a speed of not less than eight miles per hour, and be seaworthy enough to cross the Gulf of Georgia, or go up or down the coast.

Eighth. It must contain quarters for captain and crew with all supplies, and coal for at least ten days.

To fulfill the above conditions the dredge herein described and illustrated, was designed by the writer and built by the Polson Iron Works of Toronto, Ont., and was completed and went into commission in November, 1901.

Referring to the illustrations, Fig. 1 is a deck plan and longitudinal section of the dredge by which the general arrangement of the machinery, crew's quarters, etc., may be seen. Fig. 2 shows front end view and cross-section.

The hull of the dredge is 32′ wide, 125′ long and 7′ 6″ deep. It is built square ended at bow and stern, with corners well rounded, and a rake on the under body fore and aft in order to make it fairly easy to propel. By referring to the cross section it will be seen that the bilges are rounded and that the frame of the vessel is built of steel, while the plank and sheathing are of wood. By this construction great strength is obtained, the steel frames being practically indestructible, while the planking can be renewed at any time when necessary, from injury or decay. This form of construction was also especially suitable for erection on the Pacific coast as the entire frame of the hull could be fitted and erected at the works, where built, leaving only the planking to be purchased and put on at place of erection. The hull is stiffened by two additional steel trusses extending the entire length. These trusses are fifteen feet deep, and serve to strengthen and carry the weight of the upper deckhouses. They also sustain the weight and thrust of the front A frame and furnish the necessary support for the wheel beams, at the after end. The hull is further stiffened by four transverse water-tight steel bulkheads.

The main engine and dredging pump are illustrated on plate 14.

The engines are of the triple expansion marine type, of five hundred horse power. The engines and pump as they appear in the engine room are illustrated in figure 1. There are no special features about this engine which call for detailed description. It is simply a first class marine engine without the link motion. The work of driving a centrifugal pump is somewhat analagous to that of driving a screw propeller, and, therefore, the type of marine engine is well adapted to the purpose. There are, of course, many little practical details concerning the manner of attachment of the pump, and providing for the special wear and thrust that occur in the pump that are different from marine practice.

The dredging pump itself is of the centrifugal type, of a pattern which has been arrived at through the correction of defects of earlier designs. The pump has a cast iron shell with cast steel runner and blades. The suction and discharge pipes are both 20" diam. The blades of the pump runner are faced with renewable steel blades at points of greatest wear and the pump is so designed that it can be readily taken apart and the pump runner removed without taking down the pump shell or discharge pipe connections. The internal passageways of the pump are of large area so as to freely pass any stones or solid bodies that may enter through the openings of the suction head without injury or liability to choke it. It will readily be seen that if the passages of the pump were of smaller size than the openings through the cutter head that stones or other obstructions might lodge in the pump, but by the foregoing precaution this liability is obviated.

By referring to the plan it will be seen that the entire suction pipe projects in front of the dredge and swings thereupon, its lateral movement being accomplished by means of a block and tackle on each side, the hauling parts of which are carried to the drums of the auxiliary engines. The suction pipe has a universal movement on the hull so that it can raise and lower as well as swing. This movement is provided for by a section of rubber suction hose where it passes over the deck, the suction pipe being attached by hinges to a revolving base plate on the bow of the dredge.

The material is excavated by means of a rotary cutter head, which is formed of a cast steel hollow shell and removable cast steel blades. These blades are arranged on a spiral and so as to give the maximum effect with the least liability of choking. The action of the cutter is such that the blades slice off or excavate the material and feed it into the interior of the shell through the openings, from whence it is removed by the pump suction. The cutter head with its shaft, gearing and all connections are of ample strength to stall the engines which drive them. Thus, in case of an immovable resistance being encountered, nothing worse can happen than the stoppage of the engines, and by slacking off the feed of the cutter a little, they are enabled to proceed and try again. It is worthy of note that since this dredge has been in commission she has worked in all kinds of material, including roots, stumps, hard-pan and stones, and that no breakage or injury has occurred to the cutter head or its driving gear.

It will be observed that the suction pipe when swinging on the hull will make a cut about equal to the width of the hull, while the latter is anchored by its two spuds. When it is desired to make a wide cut the suction pipe is secured in its mid-position and the swinging lines are carried out on each side to a shore anchorage, and the entire dredge swings on its stern spud, thus making a cut from 150 to 175 feet wide at one time. The spuds are oscillating so as to permit the dredge to move up without drifting out of position, and when the move is made, they are lifted and dropped again in vertical position and the work proceeds. The moving up is accomplished by giving a turn or two to the stern wheel by the propelling engines.

In figure 2 is shown the auxiliary engines on the forward deck. These are for the purpose of working the swinging lines and also hoisting the forward spud. The operator of the dredge controls all the movements of feeding and moving up through the medium of these engines and by bell signals to the engineer. The entire dredge is, therefore, under the control of one man.

The boilers, as shown on the plan, are of the Heine water tube type. This type of boiler is not, strictly speaking, a marine boiler, although it has answered very well for this class of work. They are of the usual land type, cased in steel, lined with fire-brick. The boilers are designed for a working pressure of two hundred pounds per square inch, and have an excess of capacity to provide steam for all machinery, and in case of necessity the dredge can work at fair capacity with only one boiler in commission, while the other is under repairs.

In the engine room the usual auxiliaries are found, such as surface condenser, air pump, centrifugal circulating pump and independent feed and fire pumps. These are all of ample size and conveniently arranged for ease of access and repairs.

The propelling engines are of the stern wheel type, so often seen on the western rivers. They are of the direct acting long stroke horizontal type and have cylinders 16″ dia. x 6 feet stroke. They are mounted on a steel frame and have answered the purpose very well.

It will be seen that the hull of the main deck is occupied with machinery and the whole of the upper deck is given up to quarters for the officers and crew.

The performance of the dredge has been quite satisfactory, although no very large or continuous outputs have been made, owing to the fact that the work to be done has been principally small jobs at different points, and in various kinds of material, some of which has been of a very difficult nature. The capacity of five hundred cubic yards per hour has frequently been obtained, and, under favorable conditions, the output, for short periods of time, has approached one thousand cubic yards, but the average, owing to the reasons already stated, has been much less than this.

The illustration, figure 3, shows the character of the work done by the dredge when pumping material ashore. The dredge is seen in the distance with a floating pipe line extending to the shore, after which plain lengths of sheet steel pipe are used laid on the ground and blocked up where necessary. These pipes are simply slipped into one another like stovepipes, and no special arrangements for keeping them tight. The gravel and clay in the interior soon block up any small openings, and absolute tightness is not required. It will be seen that the material distributes itself over a large area of ground. Thus for land reclamation the value of this type of dredge is evident. The manner of working the dredge and disposing of the material must of course be determined by the local conditions, and while the hydraulic type of dredge has its limitations, its sphere of usefulness as exemplified in the "King Edward" is considerably widened.

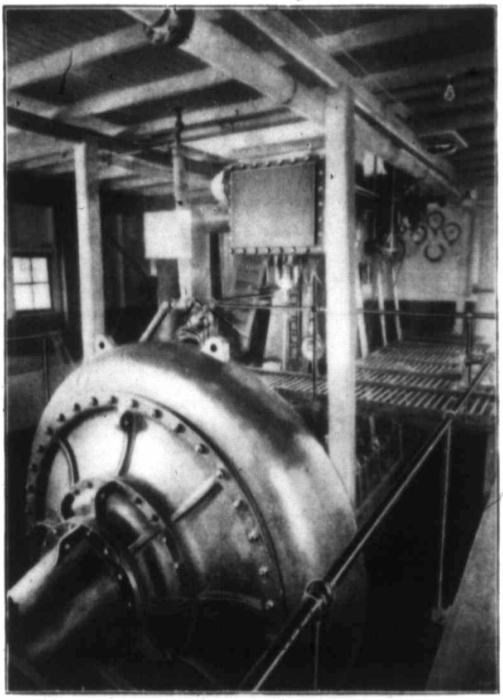


Fig. 1.

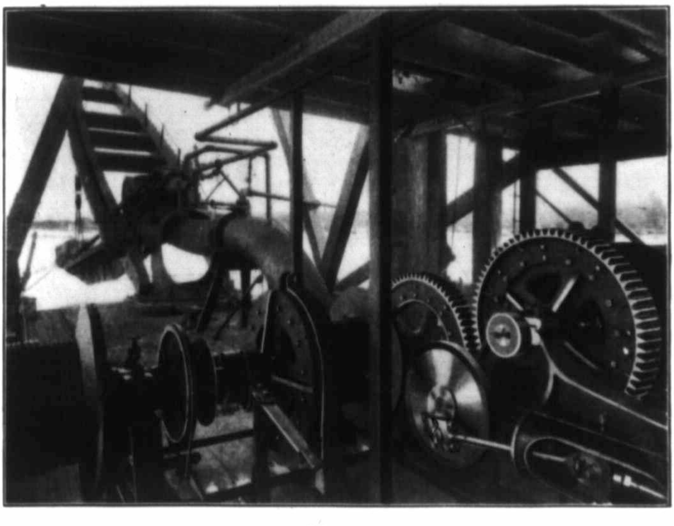


Fig. 2.

Fig. 3.

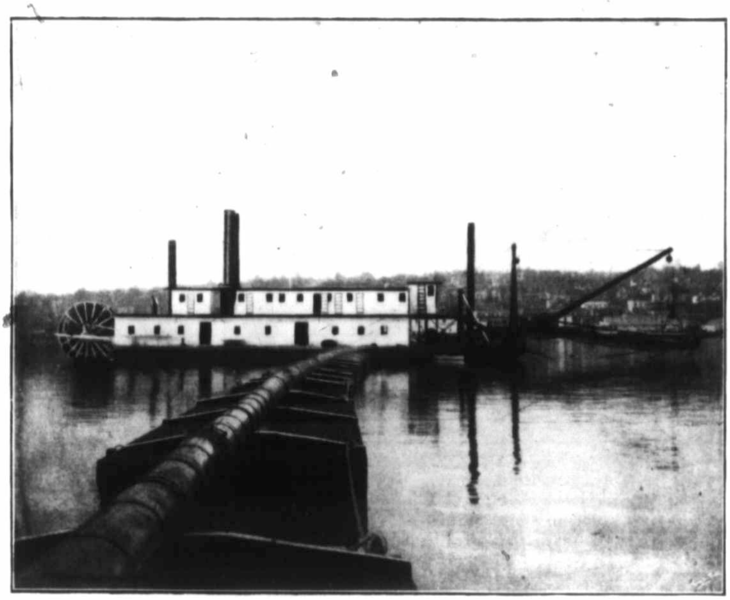
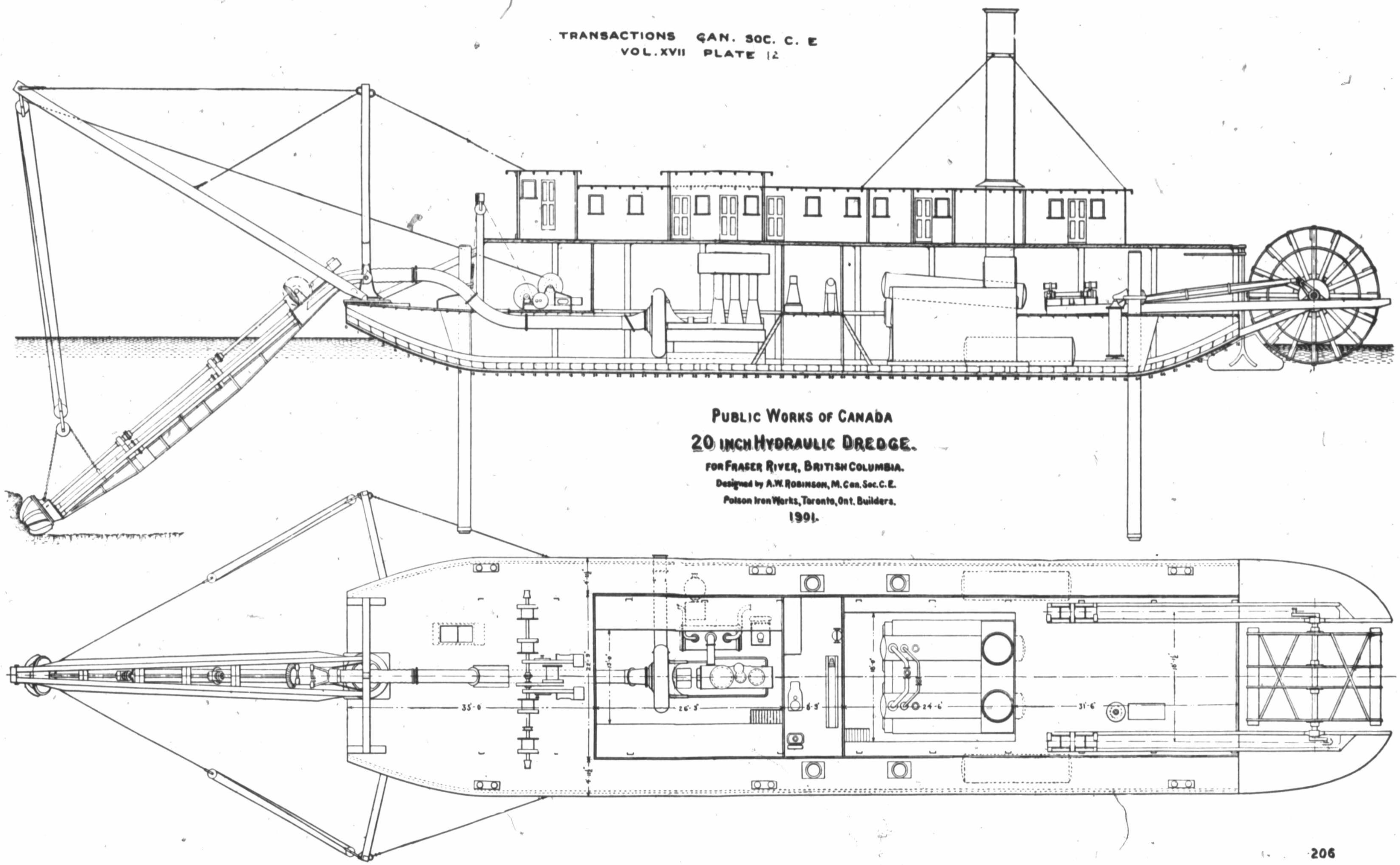


Fig. 4.

Fig. 5.



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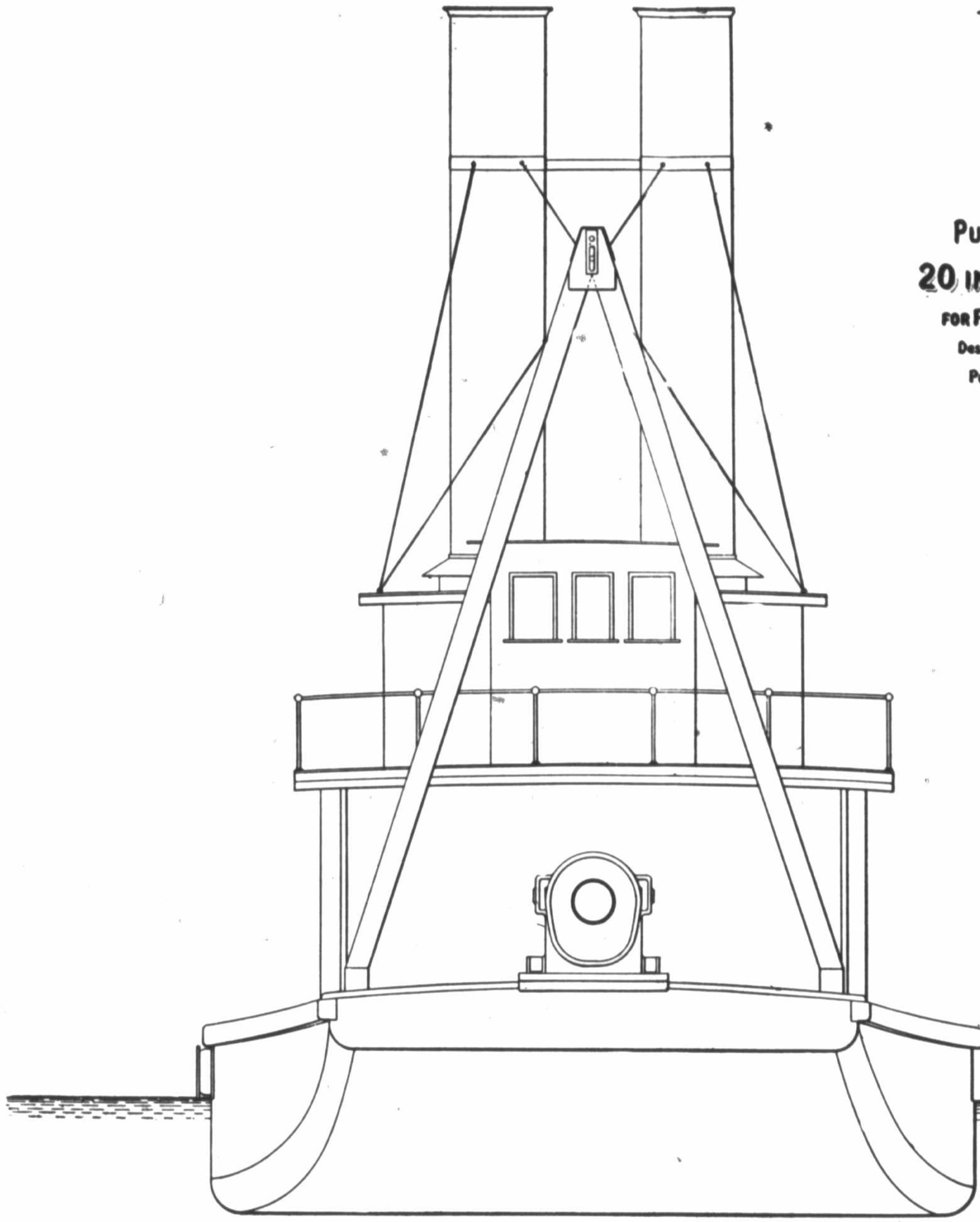
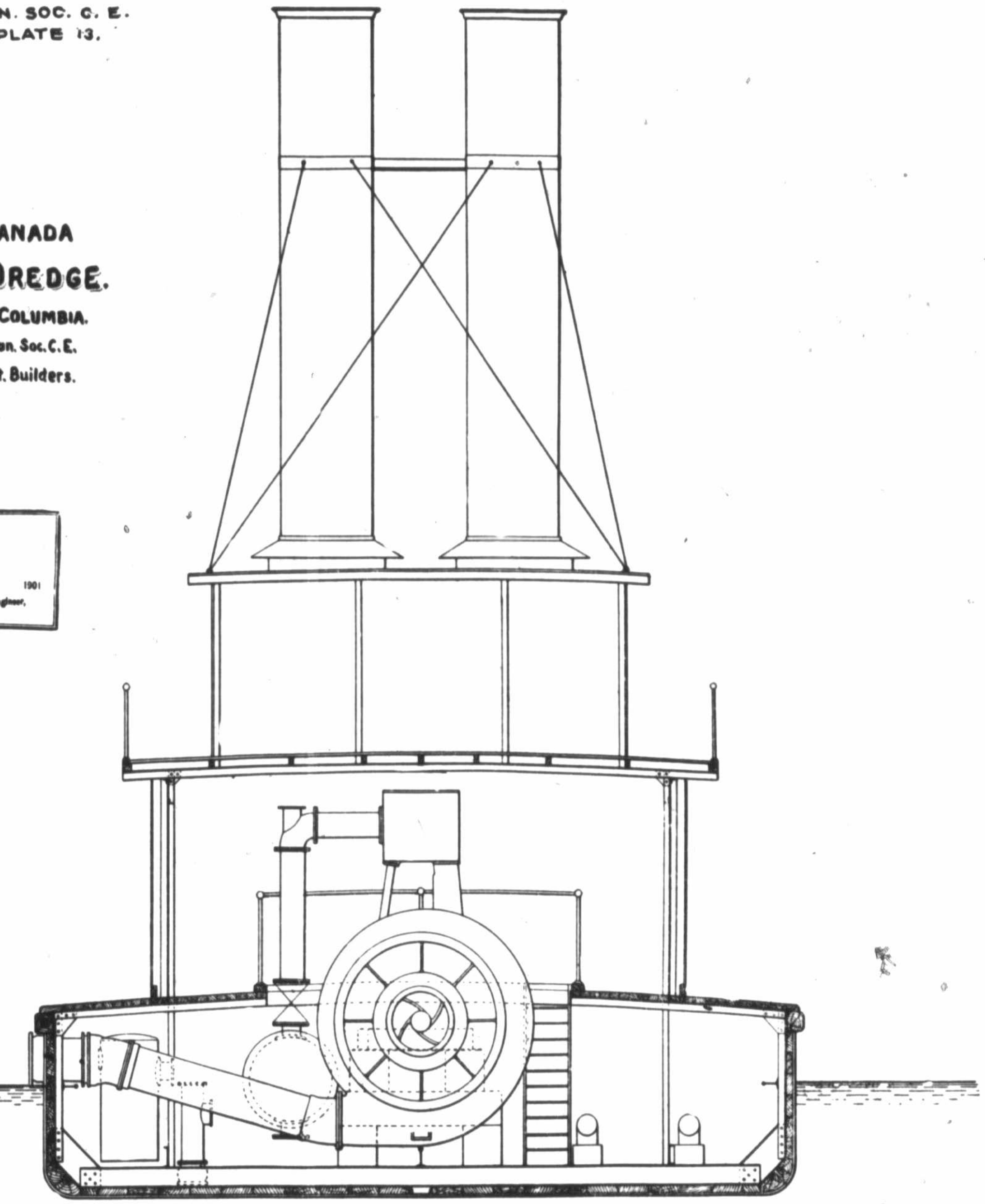
Scale, $\frac{3}{8}$ in. = 1 ft. July 1901

A. W. ROBINSON, Mechanical Engineer,
MONTREAL.



Front End View



Cross-Section at Pump.

TRANSACTIONS CAN. SOC. C. E.
VOL. XVII PLATE 14.