

SECT. II.—OTHER SELECTED PAPERS.

(Paper No. 3322.)

“Some Bucket-Ladder Dredgers.”

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THE progress which has been made in the design of bucket-ladder dredgers since the construction of the first dredgers recorded as having been used in this country, has been identified with the general industrial development of last century. Steam-power has been substituted for horse- and hand-power, and iron and steel have been substituted for wood.

The application of horse-power to bucket-ladder dredgers is described by Mr. Timperley in the first Paper¹ printed in the “Transactions” of the Institution. The dredger there referred to, which was visited by Mr. Walter Hunter, the founder of the Author’s firm, in the year 1802, had a bucket-chain driven by two horses working a horse-grind on the deck; the main course trodden by the horses was 20 feet in diameter, and the horse-grind made about 4 revolutions a minute. The first pair of wheels between the horse-grind and the top roll were of a type which may be seen on some old mechanical drawings, consisting of wheels with open spokes engaging one another. The second pair seem, from their description, to have been a pair of skew bevel-wheels, and must have been properly geared. The buckets were constructed of $\frac{3}{8}$ -inch bars of iron spaced $\frac{1}{8}$ inch apart, the bucket being 4 feet in length, 13 inches in depth, 12 inches in width at the mouth, and about 6 inches in width at the bottom. The dredger, according to Mr. Timperley, raised about 30 tons an hour. The cost of working was $2\frac{1}{2}$ d. per ton, which covered the wages of three men working the dredger and eight men working the lighters, and the keep of three horses. The lighters had to be towed out into the Humber, and were provided with drop-hatches for dumping the spoil. According to Mr. Webster, the first dredger to which steam was applied was a spoon-dredger for

¹ “An account of the Harbour and Docks at Kingston-upon-Hull.” By J. Timperley. “Transactions” Inst. C.E., vol. 1. p. 1.

Sunderland Harbour, engined by Messrs. Boulton and Watt, and was set to work in 1796. From these early dredging-machines to the large and powerful hopper-dredgers now constructed on the Clyde and in Holland, is a great advance. The Author proposes to confine himself in the following Paper to the work of his own firm, which provides a consecutive record of smaller bucket-ladder dredgers from the year 1826 to the present time, and affords indications of the general progress in the mechanical arts during that period. The successive improvements in the steam-engine are illustrated by the disappearance of the heavy, slow-running engines of the low-pressure type in the "fifties" of last century. Oscillating cylinders were used in one or two vessels in the "sixties," and in the "seventies" compound marine-type engines appeared, with inverted cylinders and higher piston-speeds. The gain in lightness of the engines and gear, due to increased steam-pressures and higher piston-speeds, and the diminution in the weight of the hull caused by the substitution of iron, and subsequently of steel, for wood in its construction, are illustrated by a comparison of the dredger made by Messrs. Hunter and English, in 1826, for the Port of Yarmouth, and that made by them for the mouth of the Ebro in Spain in 1835, each capable of lifting about 100 tons per hour. The displacement of the Yarmouth dredger was about 135 tons, and of the Spanish dredger about 95 tons, whilst the latter had to carry, in addition to her ordinary dredging machinery, about half the weight of a shore ladder 120 feet in length. The hull for the Yarmouth dredger was 9 feet in depth, that for Spain being 2 feet 6 inches in depth, whilst the draught of the former was 5 feet, and of the latter 1 foot 6 inches. The very special requirement of a hull of 1 foot 6 inches draught to carry machinery of this power was fulfilled by bracing the hull by girders, in a similar manner to that employed in shallow-draught steamers, and a reduction of 30 per cent. in the weight of the hull affords satisfactory evidence of economy of material and correctness of design. Another advantage derived from the use of high-speed engines is the possibility of substituting a belt-drive for gearing. This has been more extensively adopted on the Continent than in this country for large dredgers, and seems to the Author to be a good system, providing as it does in a simple manner for the necessity of having a frictional drive between the engine and the top-roll shaft. The Author's firm has adopted belt-drives in smaller dredgers since 1892 with success.

Considerable improvement has been made in the means provided for handling a dredger as a floating surfacing-tool. The earliest

appliance for this purpose was in the form of surging-drums, attached to a shaft in the vicinity of the main gear and framing, one on each side of the vessel. These drums were always in gear, and were available as long as the engine was at work. As, however, six chains are necessary to work a dredger properly, and only two could be worked at a time by these drums, the other chains had to be made fast to the bitts. When the direction of the vessel's work had to be altered, the chains had to be shifted from the bitts to the surging-drums, and *vice versa*, necessitating more deck hands than are now required. At first the surging-drums were supplemented by hand-crabs for the quarter-chains. Then the surging-drums were done away with, and six power-crabs were substituted, three crabs for each end of the vessel, friction-gear being found most convenient and safest for driving them. The fore-and-aft chains are sometimes worked by crabs with independent engines, as the cables for these are heavier than those for the kedge- or quarter-chains.

The method of delivering the spoil varies with the local requirements; but, where circumstances permit, shore deliveries constitute a great saving in cost of working. The first dated design of this type found by the Author is dated 1869. This dredger was capable of delivering at a height of 15 feet vertically over a bank, from just above the deck of the dredger, and to a distance of 50 feet from it, the creeper being made of shallow dished plates. In 1888, difficulty was experienced in using a band for this purpose, *i.e.*, to elevate as well as to carry ashore. In 1892, therefore, the couloir-shoot, with water lubricant, was adopted, with good results. An important detail in the construction of dredger-buckets, namely, the use of a false back actuated by the top roll, for forcibly ejecting the spoil inside the bucket, should it have any tendency to stick to the front plate, appears to date from 1856.

The foregoing are, in the Author's opinion, the most significant features of the development of this class of machine. Amongst features of less general significance may be mentioned bucket-ladder dredgers worked by hand, and those having framings capable of being folded down to pass under low bridges, and dredgers which may be used upon land as excavators, the earliest design found by the Author for an excavator of the last-mentioned class being dated 1845.

The following description of some dredgers built under the Author's supervision is intended to illustrate:—

1. The economy to be obtained by delivering along long shoots to the shore without the interposition of manual labour or lighterage.

2. The usefulness of forcible-delivery buckets.
3. The saving in weight obtained by the modern steam-engine, with increased steam-pressures and higher piston-speeds.
4. The compactness and handiness of the new type of friction-driven crabs.
5. The care which is now taken in preserving the life of boilers by all means likely to insure the purity of the feed-water, especially in salt or brackish estuaries.
6. The use of oil fuel.

In 1899 the Author's firm completed a dredger for use in connection with irrigation works in Egypt. It was required to excavate 75 cubic yards per hour from a depth of 13 feet of water, and to deliver the material, by means of a long couloir or shoot, at a distance of 65 feet from the centre of the hull, Figs. 1, Plate 3. The draught of the vessel was not to exceed 2 feet 6 inches. The bucket-well opens to the sea at the aft end of the vessel, to enable the dredger to cut its own flotation, and to dredge up to the edge of any channel it may be working in. The ends of the pontoon and the hull are rounded off for this purpose. Owing to special difficulties of transport and launching, the main hull had to be made in three sections, in addition to the separate pontoon for carrying the derrick supporting the shoot. The hull was divided into these three parts longitudinally, and specially constructed keelsons were provided to enable the three portions to be bolted together when afloat. To enable this to be done, each keelson consisted of two plates, each riveted to the section to which it belonged, separated by two strips, each attached to its respective keelson-plate; the bolt-holes for the bolts which were to tie the vessel together were plugged with screws, the screws being larger than the bolt to enable the latter to pass the tapped hole freely. A water-tight joint between these compartments was made by means of india-rubber held between the angles at the top of the keelson-plates, and a flat cover-plate extending the whole length of the keelson. The bucket capacity of this dredger being 3,300 cubic feet per hour, it was capable of giving a total delivery of 120 cubic yards per hour with full buckets. A dredger of very similar design, which the Author's firm constructed for Peru, has delivered as much as 82 cubic yards per hour, doing continuous work, thus showing an efficiency of 68 per cent. The efficiency is greater when the shoot delivers the material directly ashore, and then, also, the cost of removing the spoil in barges is avoided. The buckets were helmet-shaped, with cast-steel backs and forcible delivery, it being anticipated that the alluvial soil in which they were to work would be much matted with weeds. The forcible

delivery is obtained by having a hinged plate forming a false back to the bucket, which is raised by a pusher on the top roll as the bucket travels over it, thus releasing the clay from the front plate, where it is liable to stick. Special care was taken in designing the bucket that the curves should give free delivery once the material had been started. The arrangement of the gear in this vessel is adopted chiefly with a view to an equal distribution of the weights on each side of the centre of flotation. Wire rope was used for the hoisting-gear and for lifting the ladders. The engines were of the usual marine type with inverted compound cylinders, the air-pump being worked by a rocking-beam from the low-pressure cross-head. A surface-condenser was fixed to the side of the ship, away from the engine, and was supplied with circulating water by means of a centrifugal pump capable of delivering 400 gallons per minute through the tubes of the condenser to the shoot. This pump could be driven either by its own independent engine or by means of a belt from the fly-wheel of the main shaft. The boiler was of the multitubular return-tube type, and was easily capable of supplying steam for 50 I.H.P. In the gear for driving the bucket-chain, the crown-wheel at the bottom of the vertical shaft was fitted with friction-plates to prevent breakage in the machinery, should any unexpected obstacle come in the path of the bucket-chain. Both the top and bottom tumblers, which are of cast iron, are fitted with steel wearing-pieces which can be easily renewed when worn out. The buckets were constructed with cast-steel backs and mild-steel fronts, the latter being strengthened with hard-steel cutting-lips. The cast-steel back is pierced with a hole to enable the pushers on the top roll to raise the false back, and so eject any material that is inclined to stick. The winch for raising the ladder is operated by means of friction-gear, and can be thrown in and out of gear at a moment's notice without altering the speed of the engine. The winches for manœuvring the vessel are fixed amidships upon the deck, and consist of two sets of three barrels working independently. They also are provided with friction-gear, and can be easily controlled by one of the deck hands, the tension upon the chains when at rest being maintained by powerful brakes. The pocket-shoot which receives the material direct from the buckets, and the pontoon which carries the legs for supporting the couloir-shoot, were made so that the couloir-shoot for shore delivery could be fixed on either side of the vessel. The couloir-shoot was long enough to deliver the material at 65 feet from the centre of the hull and was of semi-circular section, with a fall of about 1 in 10,

which is sufficient, with the aid of the tail-water from the circulating-pump, to deliver the material without choking. Stages were provided on the main framing from which the man in charge of the ladder could control the dredging operations by signal to the engine-room, and also attend to the lubrication of the working parts of the machinery at the top of the framing.

In the year 1847 the Author's firm supplied the Honourable Corporation of Trinity House with a 25-HP. (nominal) side-lever engine, by Messrs. Boulton and Watt, to drive the dredging machinery of a vessel 90 feet in length by 23 feet beam and 10 feet 6 inches depth, having double ladders working outside the hull. In the autumn of 1898 it was found that, owing to the ladders having been lengthened to meet the necessity in recent times of going deeper for ballast, the engine was practically worn out, and in 1899 the old side-lever engine was replaced by a 20-HP. (nominal) marine-type compound engine with inverted cylinders and separate condenser. The old engine was capable of working only one of the ladders at a time, and could barely lift 100 tons of ballast in an hour. With the new engine both ladders can be worked at one time, and the dredger has raised as much as 300 tons in an hour. The change has resulted in a saving of 57 per cent. in fuel, reckoned on the tonnage of spoil delivered alongside. The engine is capable, when in good order, of raising 1 ton of spoil by 2 lbs. of coal, or an expenditure on coal of 0.2*d.* per ton of spoil raised. The weight of the new boiler and engines was considerably less than that of the old ones, and a gain of about 4 inches in draught on the vertical centre-line of the top roll was thus effected. In addition to this the top-roll shaft was raised 12 inches, so that the ends of the shoots were raised altogether about 16 inches higher above the water-line than they had been formerly, enabling barges with a higher free-board to come under the shoots. The speed of the bucket-chain on this dredger was somewhat faster than that usually adopted by the Author's firm for buckets of $3\frac{1}{2}$ cubic feet capacity, being between 21 buckets and 22 buckets per minute, but no evil effects were experienced from keeping up to the same speed with the new engine.

At the commencement of the year 1900, Messrs. Samuel Williams and Sons, Limited, of Dagenham, required a dredger to duplicate the work of the "Diver" dredger,¹ built for them by the Author's firm in 1885. Mr. Arthur Williams, the Engineer to the Company,

¹ This dredger is referred to by Mr. Walter Hunter in the discussion on Mr. Webster's Paper on Dredger Appliances published in the Minutes of Proceedings of the Institution, vol. lxxxix. p. 54.

in conjunction with the Author, designed, and Messrs. Hunter and English constructed, the new dredger, the "Gleaner," capable of lifting 300 tons of spoil from a depth of 56 feet and delivering into barges alongside, Figs. 2, Plate 3. The hull is 143 feet in length, 25 feet in beam and 9 feet 6 inches in depth. A special feature of the hull is the stiffening produced by running the well-plating throughout the whole length of the vessel, thus forming two continuous longitudinal bulkheads. The hull is also protected by double plating wherever it is exposed to attrition by the spoil, the exposed plate being in each case made removable. Thus the shoots are lined throughout, and the sides of the hull are lined for about 6 feet in width below the shoots. Each shoot is made in three divisions, so that the two portions projecting beyond the sides of the vessel can be raised in succession, in order to trim the barge into which they are delivering, and the hinges are so constructed that when the outer section has been raised through a sufficient angle to give a clear opening at the next shoot it will proceed to lift that shoot if the hoisting-winch is kept in motion. The engines are 30-HP. (nominal) compound surface-condensing marine-type engines, the condenser forming part of the back supports of the engine. The air-pump is of the Edwards pattern, and this as well as the circulating-, feed- and bilge-pumps are worked by sway-beams from the cross-heads of the engines. The suction for the circulating water for the condenser is taken from the forward swim of the vessel by siphon-pipes, so as to be quite clear of any of the dredgings. The hull is divided into seven watertight compartments, and special pumps are provided, one on each side of the well, for sucking from all the compartments in the event of a collision, the spindles on the cocks of the suction being carried up to the deck for use in cases of emergency. Each of these pumps has a suction from the sea and a delivery service into the shoots. Owing to the great length of the ladder, and consequently of the well, and also to the necessity for fairly distributing the weights of the heavier parts of the machinery, it was found necessary to place the engine on one side of the well and the boiler on the other; the steam connections were taken over the top of the gantry, and were covered in by non-conducting composition and a wrought-iron casing. Steam separators and traps were fitted in the engine-room to prevent condensed water from gathering in the pipes. An alternative exhaust-pipe was taken from the low-pressure cylinder to the atmosphere. The boiler feed-pump is placed in the engine-room to be under the control of the engine-driver, and the stoker has

means of communication by a speaking-tube between the boiler-room and the engine-room. In connection with the boiler feed-pump, an oil-filter for cleansing the feed, and an evaporator for making up loss of feed, are fitted. The boiler is of the multi-tubular return-tube type. An auxiliary engine with separate steam-connection is fitted on the starboard side of the well, somewhat aft, for raising the ladder, which can also be raised by the main engines. The gear for driving the bucket-chain is fitted with the usual friction appliances. A noticeable feature of the dredger is the gantry over the well running nearly the whole length of the vessel. By means of this and a monkey-carriage which runs upon it, the bottom roll or any of the buckets can be lifted off the ladder and transported along the gantry to the aft end of the vessel into a barge. Two overside cranes are fixed to the gantry to lift buckets from barges alongside, and also for ordinary cargo purposes; they may be swung back so as to command the centre of the well. The ladder is hoisted by means of two steel ropes passing over the drum of a powerful winch fixed at the aft end of the stern and driven by the auxiliary engine already referred to. The winches for manœuvring the vessel are fitted with friction-gear, and there are three independent barrels on each set of winches, one set being placed forward and one aft. A vertical capstan is arranged at each end of the vessel, with a small rope-barrel for working rope through fairleads placed on a level with the top of the bulwarks, for use in shifting barges alongside. The shoots are raised by a friction-driven hoist fixed in the fore-part of the vessel.

In 1878, the Author's firm made a small hand-dredger for the War Office, to clean out a canal at Enfield. This dredger has lifted 5 tons an hour when worked by eight men. A small machine being required for cleaning out irrigation canals on some sugar estates in the Straits Settlements, the Author's firm submitted a copy of this design for the purpose. It was adopted with the substitution of an oil-engine of $3\frac{1}{2}$ brake-H.P. in place of the men, Figs. 3, Plate 3. The hull was 40 feet in length by 9 feet beam and 2 feet 6 inches in depth, drawing about 21 inches of water when ballasted. A tank was framed at the forward end of the boat under the engine to supply the cooling-water to the jacket of the cylinder, and at the same time to form the necessary ballast for bringing the hull on to an even keel. With the power at its command this dredger will raise 10 tons to 15 tons per hour.¹

¹ Since this Paper was written the Author has been informed that this dredger is capable of raising 20 tons per hour.

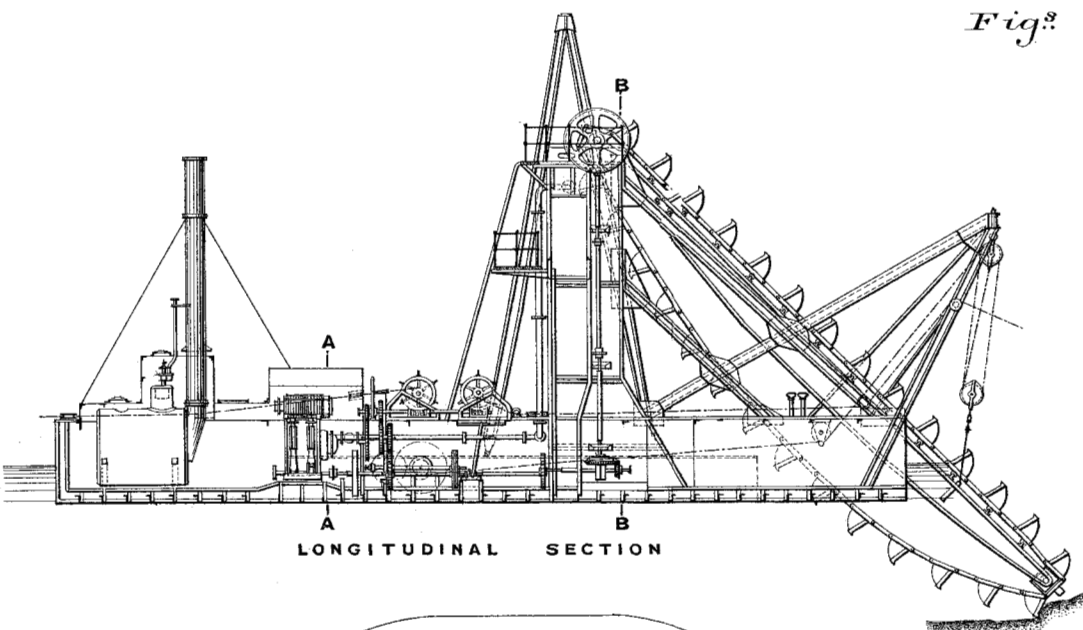
The ends of the hull are cut away for the purpose of enabling the dredger to work in very narrow channels. It will sweep the bottom and trim the banks of a channel not exceeding 16 feet in width at the water-line, and will make the channel 7 feet 6 inches deep in the centre. The crabs for raising the ladder and drawing forward the dredger are worked by hand. The engine is of the Hornsby "Akroyd" type, made by Messrs. Richard Hornsby and Son, Limited, of Grantham.

There is not much scope, perhaps, for radical alterations in the general design of so simple a machine as a bucket-ladder dredger, but the stresses which come upon the hull and machinery in such rough-and-tumble work as dredging are difficult to forecast, and the guidance of precedent in what has been known to stand them before is of great use to the engineer in turning out a successful tool.

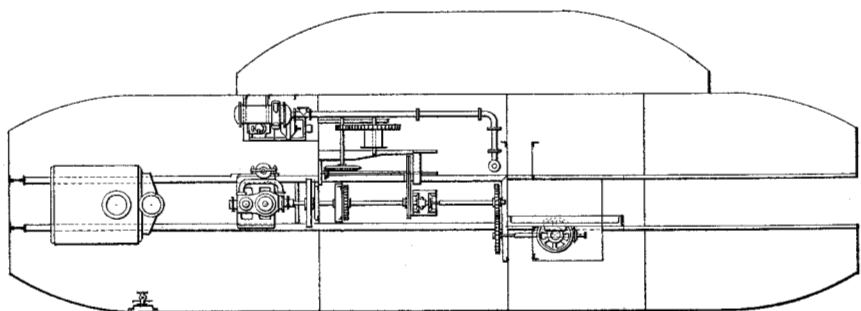
The Paper is accompanied by six sunprints, from which Plate 3 has been prepared.

SOME BUCKET-LADDER DREDGERS.

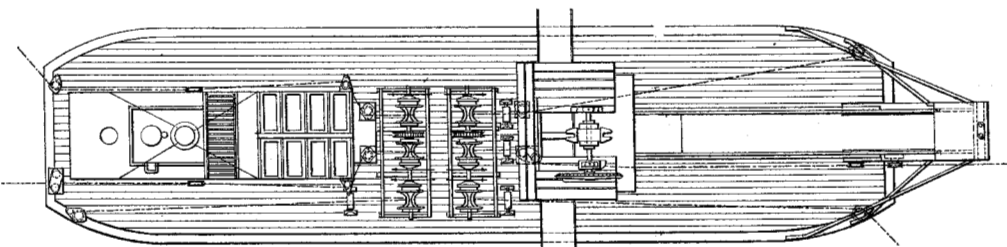
Fig^s 1.



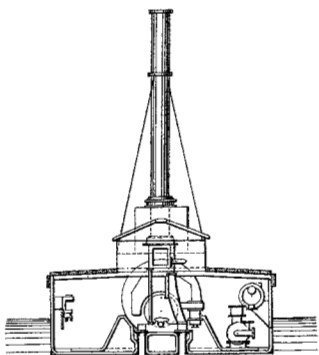
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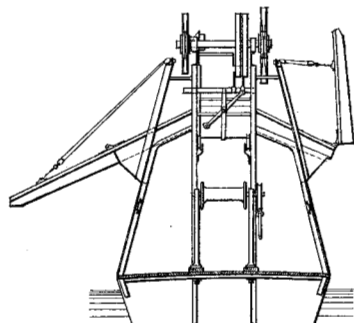
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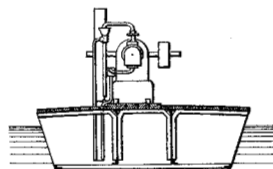
PLAN.



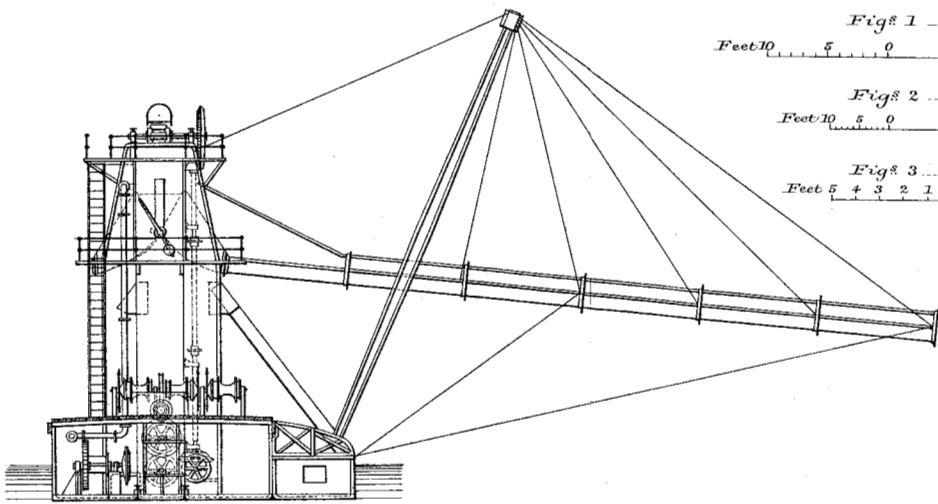
SECTION A A.



SECTION F F.

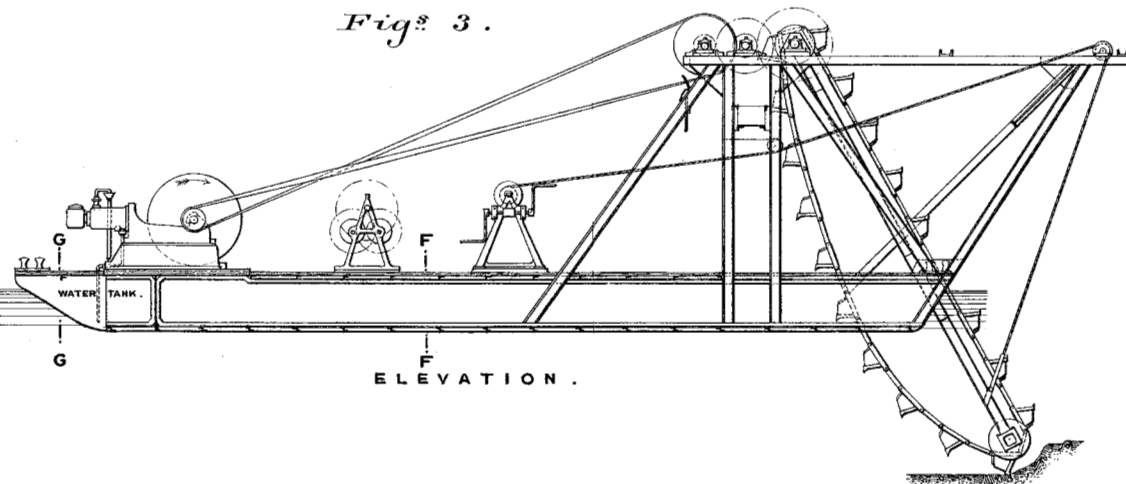


SECTION G G.

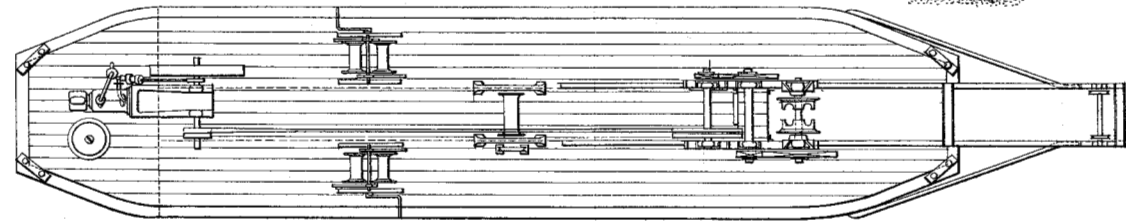


SECTION B B.

Fig^s 3.



ELEVATION.



PLAN.

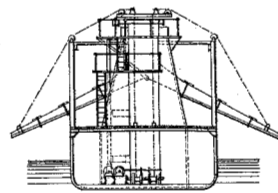
SCALES.

Fig^s 1 1 Inch = 16 Feet.
Feet 10 5 0 10 20 30 Feet.

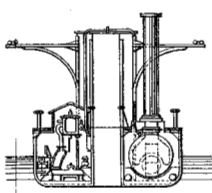
Fig^s 2 1 Inch = 32 Feet.
Feet 10 5 0 10 20 30 40 50 Feet.

Fig^s 3 1 Inch = 8 Feet.
Feet 5 4 3 2 1 0 5 10 Feet.

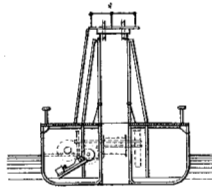
Fig^s 2.



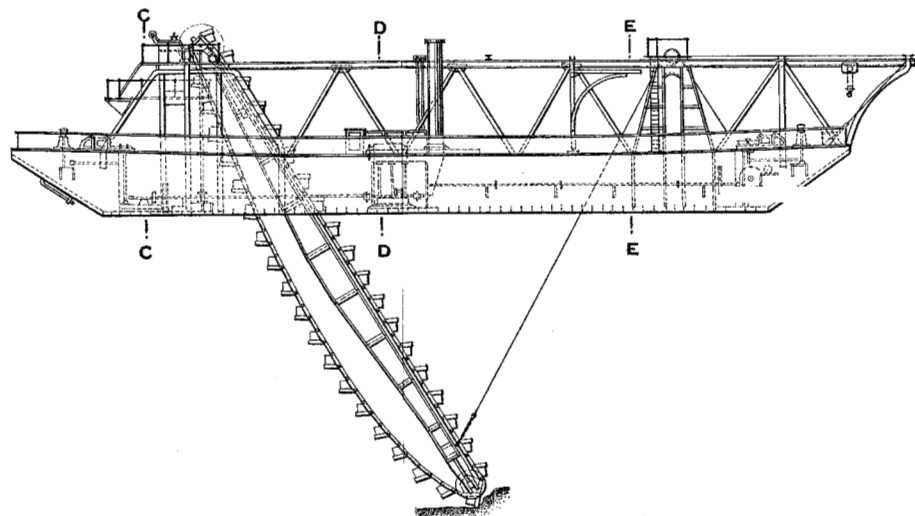
SECTION C C.



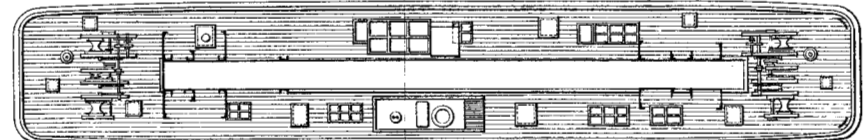
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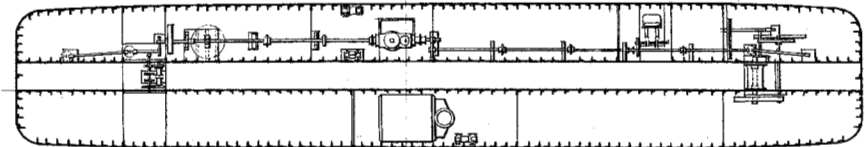
SECTION E E.



ELEVATION.



PLAN.



SECTIONAL PLAN.