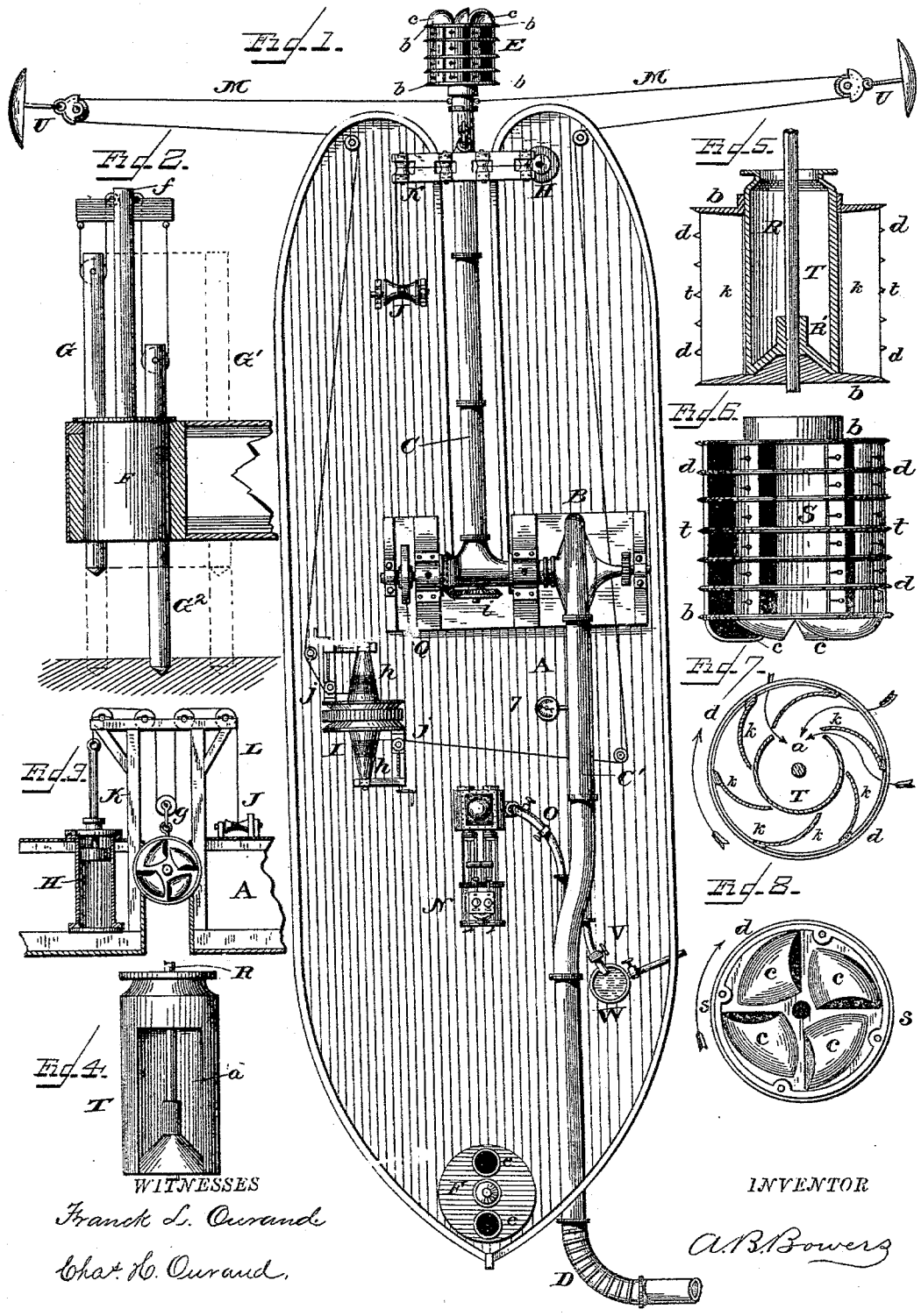
2 Sheets—Sheet 1.

A. B. BOWERS.

DREDGING MACHINE.

No. 318,859. Patented May 26, 1885.



WITNESSES

Franck L. Durand

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A. B. Bowers

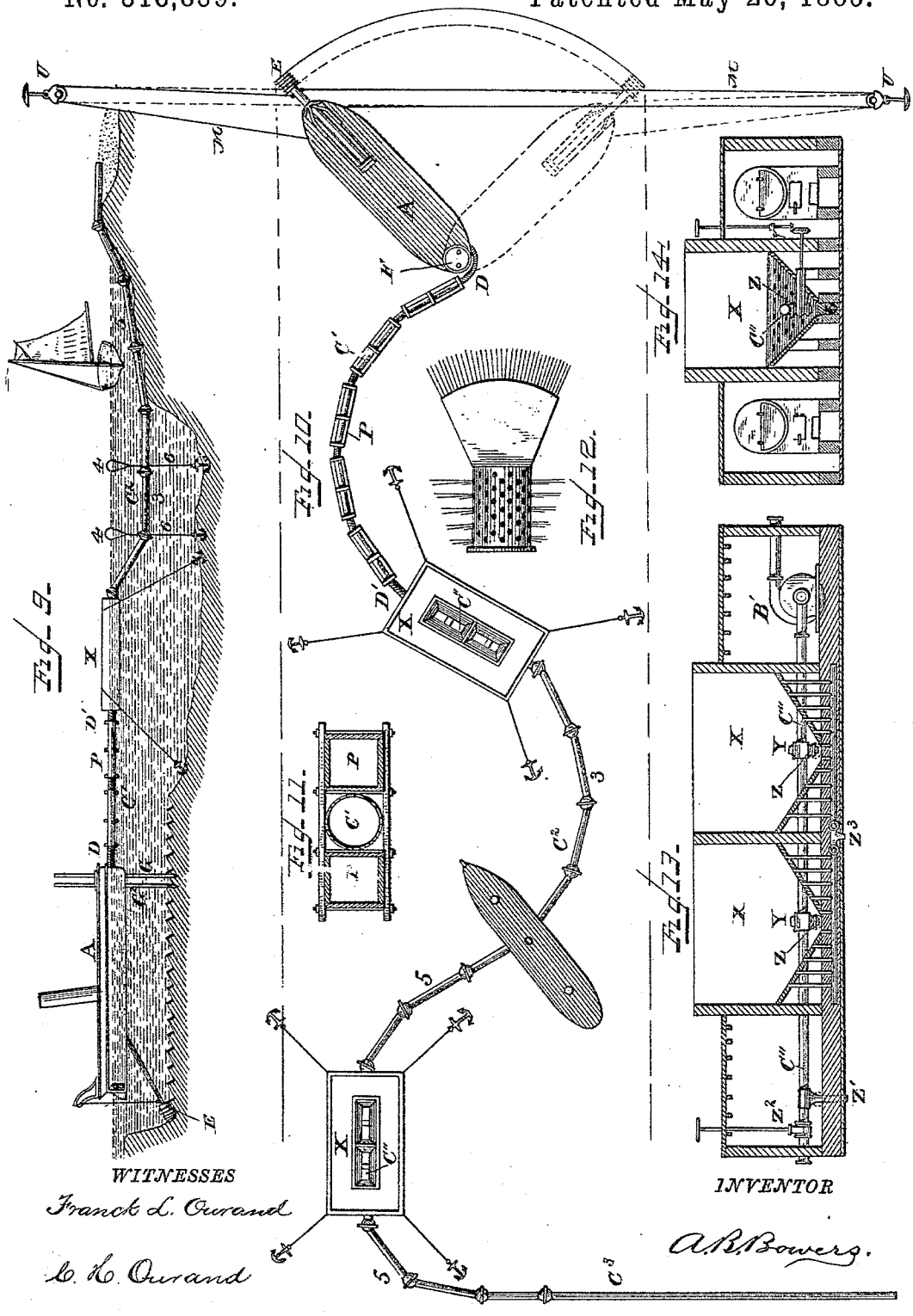
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UNITED STATES PATENT OFFICE.

ALPHONZO B. BOWERS, OF SAN FRANCISCO, CALIFORNIA.

DREDGING-MACHINE.

SPECIFICATION forming part of Letters Patent No. 318,859, dated May 26, 1885.

Application filed December 9, 1876. Renewed April 16, 1879.

To all whom it may concern:

Be it known that I, ALPHONZO B. BOWERS, of San Francisco, California, engineer, have invented a Novel Construction for Dredging and Transporting Spoils, of which this, with the accompanying drawings, is a specification.

It consists of a rotary bottomless-bucket excavator-wheel of moderate size, novel construction, and great capacity, combined with a hydraulic transporting device of equal capacity, by means of which the spoils may be cheaply carried to a distance of several miles over land or water and across navigable channels without interruption of navigation, together with novel feeding devices, through which the percentages of earth excavated by the cutting-wheel and of the water therewith delivered are adjustable to the precise amount of each necessary for most economical working, and by means of which clean work is done, the excavator going twice over no ground and missing no ground, thus saving much time, and effecting a material reduction in the cost of apparatus, repairs, and cost of dredging and of disposing of the spoils, these being the chief objects of the invention.

Figure 1 is a plan of a portion of my dredging apparatus. Fig. 2 is a vertical "fore-and-aft" section of a portion of the hull through the well in which rotates the turn-table, with a side view of the turn-table, vertical anchors, and hoisting apparatus. Fig. 3 is a vertical cross-section of a portion of the hull through the counterbalance-cylinder and longitudinal well, showing also an end view of the bucket-wheel and the arrangement of the counter-balance and hoisting apparatus. Fig. 4 is a view of the inner chamber or shield around which the bucket-wheel usually revolves. Fig. 5 is a longitudinal section through the discal ends of the bucket-wheel in the line *s s*, Fig. 8, showing also where the shaft R is secured to the hub of the cutting-wheel and the outlines of two of the buckets *k k* connecting the discal ends *b b*. Between these buckets is shown a longitudinal section of the inner chamber, T, and shaft R and bearing of this shaft, R′. Fig. 6 is a side view of the bucket-wheel excavator. Fig. 7 is a cross-section of the bucket-wheel, inner chamber, and driving-shaft through the line *t t*, Fig. 6. Fig. 8 is a view of the outer discal end of the bucket-wheel, showing the detachable ring-knife *d* and cutting-lips *c*. Fig. 9 is a reduced side view of the dredge-boat A, vertical anchors G G², flexible connection D, floating and oscillating discharge-pipe C′, supported by hollow floats P, flexible connection D′ between the oscillating and non-oscillating sections of the discharge-pipe, mud-receiver X, (the details of which are shown in Figs. 13 and 14,) suspended discharge-pipe 3 with its buoys 4 4, submerged discharge-pipe 5, resting upon the bottom, over which a vessel is represented as passing, and guys 6 6, for holding the discharge-pipe in proper position. Fig. 10 is a plan of the dredging and transporting apparatus, showing also a vessel passing over the discharge-pipe and the cut made by the dredger as it swings from side to side. Fig. 11 is an enlarged cross-section of the discharge-pipe C′ and hollow floats P. Fig. 12 is a view of the under part of a section of the discharge pipe, showing numerous openings therein for the escape of the heavier and coarser material, while the water and lighter material are propelled onward to a farther point of discharge. Fig. 13 is an enlarged side and part sectional view of the mud-receiver, with its pipes, valves, and relay-pump, showing how the charging and discharging of a large receiver may be facilitated by the duplication of the branches and valves Y Y. Fig. 14 is an enlarged cross-section of the mud-receiver X.

In all these figures like letters indicate like parts.

A is a floating vessel that carries the engines, boilers, and dredging machinery. It is shown in this instance with an elongated longitudinal well for the reception of the swinging portion of the suction-pipe.

B is a large pump that draws the spoils from the buckets of the excavator up the suction-pipe and forces them through the discharge-pipe to a place of deposit.

B′, Figs. 9, 13, is a relay-pump or other auxiliary discharging apparatus, sometimes used in connection with a primary transporting apparatus to carry the spoils to a greater distance than could conveniently be done by the original agent, power, or pump, or than would be practicable without subjecting the

apparatus to a pressure that might endanger some of the parts, or without the use of heavier or more expensive apparatus than would be desirable for ordinary purposes. It may also be used for discharging the receiver X, and for exhausting water from pipe C', (when said pipe is submerged,) for the purpose of raising it preparatory to floating it into a new position. As many of these pumps may be used as are necessary to transport the spoil to the required distance.

C is a suction-pipe connecting the excavator with the pump B. The swinging portion of this pipe is mounted at the inner end of the well upon strong trunnions, one of which forms an elbow of the pipe and passes through a stuffing-box or other suitable connection into the suction-pipe of the pump B. Through the other trunnion passes a shaft that actuates the gears *i*, that drive the shaft R and bucket-wheel E; and upon these trunnions the shaft R, suction-pipe, and excavator swing as the cutter is raised or lowered to suit the depth at which the work is progressing.

C' is a discharge-pipe. It is provided with a strong flexible section, D, or other suitable joint or mounting, at or near the turn-table F, and other pivot or center of oscillation of the dredging-machine or excavating apparatus, and is constructed and arranged to permit said apparatus or machine to swing horizontally upon said pivot or pivots without materially changing the position of said discharge-pipe beyond said mounting, flexible connection, pivot or pivots. When this pipe is several hundred feet in length, I usually support the inner portion by long, narrow, hollow floats, in which case it consists of two parts—an inner oscillating or swinging section (generally composed of several short sections flexibly joined together and to the dredge-boat,) and an outer stationary or non-oscillating section, flexibly joined to said inner section. This permits the boat to feed forward and the oscillating section to swing with the advancing boat (as the work progresses) on the joint connecting the oscillating and non-oscillating sections. The discharge-pipe is provided with a pressure-gage, 7, Fig. 1, to give notice of overpressure and danger of choking of pipe from any sudden change in character of spoil. When pipe C' is above deck and extends but a short distance from the mounting D for discharging alongside, it requires supporting, and is usually suspended from a mast, the claim for which is reserved for another application now on file.

C'' is a pipe passing through the receiver X to the exhausting apparatus of said receiver. When used in connection with the pipe C', it may be regarded as the prolongation of said pipe.

C² is an auxiliary discharge-pipe, used in connection with any suitable auxiliary transporting apparatus, and extends from said auxiliary to another auxiliary transporting agent or apparatus, or to the place of deposit.

C³, Fig. 10, is a discharge-pipe extending from a second relay discharging apparatus to a place of deposit. When a floating discharge-pipe would impede navigation, the greater portion may lie upon the bottom 4, Fig. 9, and when the water is too deep for this it may be suspended from the buoys 5 5, Fig. 9, and guys and anchors 6 may, if necessary, be used to prevent it from being disturbed by winds, waves, or currents. When the pipe is to be submerged, it may be advisable to construct it of thin metallic plates, uniting the several sections with ball-and-socket or other strong flexible connections. In other cases it may be made of wood or metal, according to the preferences of the user.

E is a rotary bucket-wheel excavator, having radiating bottomless buckets *k*, Figs. 4, 5, 6, 7, firmly secured at each end to the discal ends *b b* of said excavator. These buckets may be stiffened, strengthened, and protected by rings or screens *d*, passing around, secured to, and preferably projecting beyond the edges of said buckets, Figs. 1. 5, 6, 7, 8. These rings may be sharp to cut like the revolving disk-colters of plows, and serve to subdivide the material entering the buckets, and to exclude substances too hard to be cut and too coarse to pass through the pipe and pump. They serve also as fenders to enable the cutter to ride over obstructions without catching and breaking. The edges of the bucket are sharp, and may be provided with detachable steel knives or cutters S, Fig. 6, for working in hard material. The outer discal end, Figs. 1, 3, 6, 8, may be provided with cutting edges, lips, or scoops *c*, to obviate the danger of breakage from jamming against a hard bank as the dredger heaves in the swell of the sea. In making the necessary openings in the discal end to admit the silt from said scoops, said end plate becomes changed to the form of a spider or series of arms, which may be strengthened by the lower ring *d*, which in turn may be regarded as forming a series of braces extending between the said arms at or near their outer parts. The several parts of this excavator may be made separate and detachable, or it may be cast in a single piece.

I do not confine myself to the precise mode described of mounting this wheel or of freeing it of its contents. It may be of any desired size and proportion of parts, and may discharge its contents inward through itself into any suitable conduit or receiver. The rings *d* may be omitted in soft mud free from substances too coarse to pass through the pipes and pump, though always at the risk of the projecting buckets catching upon obstructions and getting broken.

F, Figs. 1, 2, 10, is a small cylindrical turn-table rotating in a circular well or frame. It is provided with a strong flange or other suitable bearing, and is rotated in any convenient manner. Two or more vertical apertures, *e e*, pass through the turn-table from top to bottom on opposite sides, as shown.

G G² are vertical anchors passing loosely through the apertures *e e* in the turn-table into the mud below. They are raised by blocks and tackle attached to the mast *f*, or in any other usual manner.

H is a counterbalance-cylinder connected with the suction-pipe, excavator, and hoisting apparatus, to obviate the danger of breakage from pounding upon the bottom in a heavy swell. It is provided with a piston, piston-rod, and gland, like a steam-engine. Steam or compressed air is admitted to the upper side of the piston, the area of which is sufficient very nearly to balance under the given pressure the weight of the suction-pipe and excavator. To the upper end of the piston is attached the hawser L, passing over suitable sheaves in the frame K, thence through the block *g*, Fig. 3, whence it passes over other sheaves in said frame to the windlass J, by which means the excavator can be raised or lowered by said windlass without interrupting the action of the counter-balance. When the dredger rises on a swell, the excavator rises also, and as the dredger sinks in the trough of the sea the excavator falls upon the bottom, not with the full weight of the excavator and suction-pipe, but with the unbalanced weight only, striking so lightly as not to endanger the safety of the wheel. This device is necessary only when dredging a hard bottom in a heavy swell. When not required for this purpose, the cylinder H may be utilized as a steam or hydraulic hoist, or be dispensed with altogether.

I is a variable winding device, of which there are many suitable forms. I prefer ordinary winding-drums driven by a separate engine, though for simplicity of illustration I have shown tapering drums *h h*, loosely mounted on a shaft and driven (through V-shaped friction-couplings and suitable connections) by the main engine. The disengaged drum gives out one warping-line as the engaged drum takes in the other. The office of this device is to vary the speed of the side feed, for the purpose of regulating the percentages of earth and water delivered to the pump without affecting the speed of other parts of the machinery. This speed with the device shown is dependent upon the diameter upon which the warping-lines wind, and is varied by shifting the sliding guide-sheaves *j j* toward or from the larger ends of the drums by means of the hand-wheels and screws, as shown.

J is a windlass for raising and lowering the excavator.

K is a frame from which the suction-pipe and excavator are suspended.

L is a line or chain for raising, lowering, and counterbalancing the excavator.

M M are warping-lines passing from the hold to the winding-drums *h h*, around which they make a sufficient number of turns to prevent slipping, whence they pass around suitable guide-sheaves, to and through the anchored blocks U U, to the outer end of the suction-pipe, to which they are secured, so that the working side strain falls mostly upon the outer end of the suction-pipe, (or of the ladder supporting said suction-pipe, if such be used,) and but lightly upon the joints or trunnions supporting the inner ends of said pipe or ladder. As the outer ends of these lines wind upon the drums in the device shown, the inner ends unwind and descend to the hold. The office of these lines is to swing the excavating apparatus or the dredger from side to side in the process of dredging, and firmly to anchor the excavator end of the dredger when it is not at work, which latter is accomplished by simply engaging both drums *h h* in their friction-couplings.

N is a force and suction pump. It is used to exhaust the water from the discharge-pipe for the purpose of raising the submerged portion, to dilute the spoils, so that they will spread over a large area of land, or to enable them to be transported through long pipes without the aid of a relay-pump, to clear the pipes when accidentally choked, should this ever occur, and to prime the pump B, the latter or its suction-pipe being provided with the usual valve or valves for that purpose. Like most steam-pumps, it is provided with two suction-orifices on opposite sides of the water-chamber and a discharge directly over each suction. To the suction and discharge on one side is connected the branch pipe O, leading into the pipe C′. Each branch is provided with valves in the usual manner of arranging a branch pipe to serve for suction and discharge. The discharge branch only is shown, the suction being directly under it. To the suction on the other side of the water-chamber is secured a valve and pipe communicating with any suitable supply of water, (usually that in which the dredger floats,) and sometimes by a branch pipe and valve with the hold of the vessel for discharging leakage, and by another branch and valve with pump B for priming said pump by suction. To the discharge above this suction is connected a pipe or hose, that may also be used for priming the pump B by discharging into it, and for all the various purposes of an ordinary ship-pump. When O is used as a suction-pipe to draw from pipe C′, the valve on the discharge branch is closed, the suction-branch valve is opened, and the discharge is through the pipe or hose on the opposite side. When O is used as a discharge-pipe to force into pipe C′, the suction-branch valve is closed, the discharge-branch valve is opened, and the suction is through the opposite suction-pipe. When the suction is through the pipe opposite the suction branch of pipe O, the discharge may be through the pipe or hose above it or through the discharge branch of O into pipe C′, as regulated by the valves to suit the purposes of the user.

O is a pipe with branches and valves connecting both suction and discharge on one side

of the pump N with pipe C', and is either a suction or discharge pipe, as regulated by its valves.

P P are long, narrow, hollow floats, preferably extending longitudinally along each side of the short sections of the discharge-pipe, for supporting them on the water. They may be made of wood or metal, and be secured together and to the discharge-pipe by pieces of scantling passing crosswise over and under the pipe and floats and fastened with rods passing each side of the pipe and floats, as shown in Fig. 11, though I do not confine myself to this form of construction.

Q is a pulley or gear for actuating the gears *i* and excavator E. It may be connected with its shaft by a friction-coupling.

R is the driving-shaft of the bucket-wheel. It is keyed or otherwise secured to the hub of the wheel, whence it passes through suitable bearings in the inner chamber, up the suction-pipe, and through a stuffing-box to the gears *i*, by which it is actuated.

S is a strong detachable steel knife, sometimes used on the edges of the buckets when working in hard material. It may be serrated, chisel-toothed, or straight-edged, according to the character of the materials to be cut, a straight edge being preferable for ordinary work.

T is an inner chamber or shield, around which the bucket-wheel revolves, and into which it discharges. This chamber is provided with a strong flange, by which it is secured to a similar flange on the end of the suction-pipe. It is also provided with a large opening, *a*, Figs. 4, 7, through which the spoils enter from the buckets, and through this opening, Fig. 4, is seen a portion of the driving-shaft R, and the bearing of said shaft in the end of said chamber. This chamber or shield forms a bottom for the buckets *k* until they reach the opening *a*, as shown in the cross-section of the wheel and chamber, Fig. 7. As the buckets pass this opening, they discharge mud and water into the chamber, as indicated by the inner arrows, the outer arrow showing the direction of rotation. The office, in part, of this chamber or shield is to prevent too large a percentage of water from entering with the mud; but when the spoils are of a character to require a large percentage of water to carry them up the suction-pipe, or to send them through the discharge-pipe, as may sometimes be the case, the chamber may be cut away until only enough remains to support the excavator and shaft R.

U U are blocks anchored at suitable points on each side of the dredger, through which pass the warping-lines M M, for the purpose of swinging the dredger or the excavating apparatus from side to side. They are usually placed from three hundred to six hundred feet apart, and a little in advance of the ends of the first cuts made by the excavator, to allow a wide swing and avoid the necessity for too frequent change of place as the work progresses.

V is a branch pipe and valve, through which samples of the spoils are drawn from the discharge-pipe, to enable the operator properly to regulate the speed of the side feed. It is preferably placed about one-third the diameter of the discharge-pipe from the lower side of said pipe in order to secure a fair average sample.

W is a small tank resting upon scales. It is provided with a discharge-pipe and valve. It is filled with spoils drawn from the discharge-pipe through the branch and valve V, and the speed of the side feed is increased or diminished according to the weight of the spoils.

X is a floating mud-receiver carrying the relay-pump or other auxiliary discharging apparatus B' and its actuating apparatus. The main purpose of this receiver is to permit the excavator to run continuously, although the relay-pump be stopped for a little while, the receiver affording a receptacle for the spoils in the meantime. Longitudinally through this receiver passes the pipe C'' to the auxiliary discharging apparatus B', whence the pipe C^2 extends to another auxiliary discharging apparatus or to the place of deposit.

Y is a valve on the pipe C'' within the receiver X. This valve is adjusted to open automatically outward with slight pressure, and serves as a relief-valve in case of stoppage of the pump B' while the pump B is running. It serves also as a guide to regulate the speed of pump B', which should be increased beyond that necessary for preventing the opening of this valve in order to aid by suction as well as forcing. This valve may be set wide open for the purpose of filling the receiver, and may be securely closed when the pump B is used to force the material into the pump B' for the purpose of increasing the efficiency of the latter. It is also opened to admit air into the discharge-pipe when the water is to be withdrawn therefrom by pump N.

Z is a branch and valve, through which mud is drawn from the receiver to be discharged through the pipe C^2.

Z' is a branch and valve for admitting water to wash out the pipe C^2 after the mud has been discharged from the receiver.

Z^2 is a valve for closing the pipe C'' while the mud-receiver is being discharged, or when said receiver is disconnected from the pipe C', and takes the mud directly from the dumping or dredging apparatus.

Z^3 is a pipe and valve used for admitting water through the bottom of the receiver for the purpose of diluting the mud when it is too stiff to pass freely up the branch Z. It may have branch pipes with numerous small openings for the more thorough dilution of the spoils. This receiver may be used in connection with any dredging apparatus for continuous transportation of the spoils through pipes

as the work progresses; or it may be filled, towed to the place of deposit, and there be connected with a discharge-pipe for putting the spoils on shore.

The operation of dredging is as follows: The vertical anchors and excavator being raised to allow freedom of motion, the dredger is placed in position with the turn-table in line with the longitudinal axis of the proposed cut. The turn-table is then rotated until the vertical anchors are also in line with said axis, and both anchors are then dropped into the mud. The discharge-pipe is placed in position, the blocks U U anchored at suitable points for swinging the machine, and the dredger swung round until the excavator reaches the side of the proposed cut, as shown in Fig. 10. The lines M M are drawn taut and the excavator lowered below the surface of the water. The pump B is then primed, started, and the excavator set in motion and lowered its entire diameter into the mud. The proper winding-drum is then engaged, and the dredger, swinging on the turn-table as a pivot or center of oscillation, rapidly cuts its way to the opposite side. To secure a steady side feed, the friction-coupling of the unwinding-drum may be adjusted to keep the unwinding line sufficiently taut to prevent the veering of the dredger with wind or tide. Upon reaching the opposite side the winding-drum is disengaged, the excavator again lowered its full diameter, the side feed reversed, and the dredger cuts back again. This process is repeated until the proper depth is obtained. The excavator is then raised above the bank in front, the anchor G raised, as shown in Fig. 2, and the turn-table rotated upon the anchor G^2 until G is squarely in front of G^2, in line with the longitudinal axis of the proposed excavation, as indicated by the broken-lined outline G', Fig. 2. G is then dropped into the mud, and the work proceeds as before, the dredger having been fed forward the distance between the centers of the vertical anchors, which is fixed to correspond with the cut capable of being made by the excavator. This arrangement for feeding forward keeps the center of oscillation of the dredger coincident with that from which the arc to be cut by the excavator should be described. A less perfect forward feed is secured by placing the dredger so that the excavator is at the side, and the turn-table in line with the longitudinal axis of the proposed excavation. The turn-table is then rotated until the vertical anchors are in a line parallel with the transverse axis of the dredger, where it is made stationary. This leaves one anchor diagonally in advance of the other, the dredger lying diagonally across one half of the line of the proposed excavation. The forward anchor is now dropped into the mud to form a pivot, upon which the dredger swings as it cuts to the opposite side. The dredger then lies diagonally across the other half of the line of the proposed excavation, the swing having brought the rear anchor to the front. This anchor in its turn is dropped to form a new pivot, and the other anchor is then raised. The dredger swings first upon one and then upon the other anchor, these anchors being alternately raised and lowered for this purpose. As this mode of feeding by swinging alternately upon two different pivots gives a wedge-shaped cut, requiring two full swings to make one full cut, it is equivalent to a loss of one-half of the time, and is used only to prevent stoppage of work when the apparatus for rotating the turn-table is stopped for repairs or other cause, in which case it becomes valuable.

I do not herein claim the method of oscillating the boat, nor of raising, conveying, and diluting the spoils, the same being claimed in a division of this application filed April 24, 1885, to which division the Patent Office has given the Serial No. 163,262; nor do I claim, broadly, the combination of a rotary excavator having inward delivery with a suction-pipe, nor the methods of relieving pressure in the pipe and of raising the pipe, the same being claimed in still another division of the original application filed April 29, 1885, to which division the Patent Office has given the Serial No. 163,888.

I claim—

1. In a dredging-machine having devices for swinging and working with a side feed, vertical anchors arranged to give a forward feed by serving as alternate pivots, upon which the dredger swings as it cuts from side to side.

2. A dredge-boat having a self-contained pivot or center of oscillation, upon which said boat swings when at work, and a device for swinging and working said boat upon said pivot, in combination with a spud arranged to prevent said boat from drifting from its proper position while said self-contained pivot and boat are being moved into place preparatory to a new swing of the dredger in its successive stages of work.

3. A dredge-boat having a self-contained pivot or center of oscillation, with devices for swinging and working said boat on said pivot, in combination with a spud arranged to measure, regulate, and fix the amount of forward feed in each successive advance in the successive stages of work, and to hold the boat in proper position while said advance is being made.

4. In dredging-machines, the combination of the turn-table F and vertical anchors G G^2, as a means of moving the machine forward or otherwise, substantially as described.

5. In a dredging-machine, the turn-table F, arranged upon the floating hull out of contact with the mud bottom, and provided with means for anchoring it in a fixed relation to said bottom, for the purposes specified.

6. In a dredging-machine, the combination, with the hull of a turn-table, F, (arranged upon the hull out of contact with the mud bottom and provided with means for anchoring it in a fixed relation to said bottom,) of warping-lines, substantially as specified.

7. The combination, in a dredging apparatus, of a self-contained pivot or center of oscillation and a variable side feed.

8. The combination, in a dredging apparatus, of a self-contained pivot or center of oscillation and a variable winding device for swinging said apparatus upon said pivot.

9. A dredge-boat having a self-contained pivot forming a center of oscillation, with devices for swinging and working said boat upon said pivot, in combination with a suction-pipe and exhausting apparatus.

10. A dredge-boat having a self-contained pivot forming a center of horizontal oscillation, with devices for swinging and working said boat upon said pivot, in combination with a suction-pipe, exhausting apparatus, and rotary excavator.

11. A dredge-boat having a self-contained pivot or center of oscillation, with devices for swinging and working said boat upon said pivot, in combination with a pipe for discharging the spoils.

12. In a dredging apparatus having a side feed and self-contained pivot or center of oscillation, a discharge-pipe flexibly mounted at or near said pivot, to allow said apparatus to swing without material alteration of the position of said discharge-pipe.

13. In a dredging-machine having a device for excavating from side to side of the cut, a discharge-pipe extending from a discharging apparatus to or near a center of oscillation, where it is provided with a hollow flexible joint or other suitable connection, and is prolonged thence to a place of discharge.

14. An excavating device having an oscillating or swinging movement, and having a conduit-discharge flexibly joined thereto at or near the center of horizontal oscillation of said device.

15. A mud-transporting apparatus having an oscillating or swinging movement, and having a conduit-discharge flexibly joined thereto at or near the center of horizontal oscillation of said apparatus.

16. A dredge-boat and oscillating section of a conduit-discharge flexibly joined to a non-oscillating section, to allow said boat to feed forward and said oscillating section to swing upon the flexible joint connecting said oscillating and non-oscillating sections.

17. A conduit-discharge for transporting spoils to a place of deposit, said discharge being flexibly joined to an excavating device (having a horizontal swinging or oscillating movement) at or near the self-contained pivot forming the center of horizontal oscillation of said device, and provided with floats for supporting said conduit.

18. A conduit for transporting earthy and similar substances, flexibly joined to a discharging apparatus (having a horizontal swinging or oscillating movement) at or near the center of horizontal oscillation of said apparatus, and provided with floats for supporting said conduit.

19. A conduit for transporting mud, flexibly joined to an excavating and forcing apparatus (having a horizontal swinging or oscillating movement) at or near the center of horizontal oscillation of said apparatus, and provided with floats for supporting said conduit.

20. A discharge-pipe consisting of a series of sections flexibly joined together and supported by long, narrow, hollow floats, in combination with a dredge-boat and rotary excavator.

21. A discharge-pipe consisting of a series of sections flexibly joined together and supported by long, narrow, hollow floats, in combination with a dredge-boat and rotary excavator with inward delivery.

22. A discharge-pipe consisting of a series of sections flexibly joined together, in combination with a dredge-boat having a self-contained pivot or center of horizontal oscillation, with devices for swinging and working said boat on said pivot.

23. A discharge-pipe consisting of a series of sections flexibly joined together, in combination with a dredge-boat and rotary excavator.

24. A discharge-pipe consisting of a series of sections flexibly joined together and supported by long, narrow, hollow floats.

25. A discharge-pipe consisting of a series of sections flexibly joined together and supported by floats, in combination with a dredger having a rotary excavator.

26. A conduit for transporting earthy and semi-liquid substances, said conduit consisting of an outer rigid non-oscillating section flexibly joined to an inner oscillating section, the inner end of said oscillating section being flexibly joined to a discharging device.

27. A conduit for transporting earthy and semi-liquid substances, said conduit consisting of an outer rigid non-oscillating section flexibly joined to an inner oscillating section, the inner end of said oscillating section being arranged to receive said substances, said conduit being provided with a motor.

28. Hollow floats, in connection with and secured to the flexibly-connected pipe C'.

29. Hollow floats, in combination with a conduit for discharging mud and semi-liquid material.

30. In combination with a dredge-boat and pump for transporting spoil, a conduit-discharge provided with a pressure-gage, substantially as and for the purpose specified.

31. In combination with an apparatus for transporting earthy and semi-liquid material, the submerged conduit 3, suspended from buoys.

32. In combination with excavating devices to cut or scoop up mud, a submerged discharge-pipe resting upon the bottom.

33. A submerged discharge-pipe, in combination with excavating devices adapted to cut up the mud and with mud-forcing apparatus.

34. A relay-pump for renewed propulsion, in combination with and flexibly joined to the

discharge-pipe of a mud transporting apparatus, to permit said pipe and transporting apparatus to oscillate while the relay-pump remains stationary.

35. A relay-pump for renewed propulsion, in combination with and flexibly joined to the discharge-pipe of an excavating apparatus, to permit the oscillation of said apparatus while the relay-pump remains stationary.

36. A relay-pump for renewed propulsion, in combination with an earth-transporting apparatus and discharge-pipe.

37. A relay-pump for renewed and continuous propulsion of semi-liquids and of earthy material, in combination with a conveying-conduit.

38. An apparatus for transporting earthy and similar material through a long conduit by means of a carrying stream of water, in combination with a device having openings to allow the escape of the heavier portions of said transported material, while the larger portion of the water and lighter material pass over and are discharged farther on.

39. A mud-forcing apparatus having a closed conveying-pipe leading therefrom and a sampling pipe and valve connected to the closed pipe.

40. In combination with a mud excavating and discharging apparatus and discharge-pipe, the weighing-tank W, substantially as and for the purpose described.

41. In combination with pipe C', the pump N and its connections, substantially as and for the purpose specified.

42. A force and suction pump, in combination with pipe C', and arranged to force into or draw from said pipe as regulated by the valves.

43. A force-pump and injection-pipe, in combination with pipe C', and arranged to force into said pipe, for the purposes specified.

44. A suction-pump, in combination with pipe C', and arranged to exhaust from said pipe, for the purpose specified.

45. In combination with a mud-forcing apparatus having a submerged discharge-pipe, a pump arranged to raise said pipe by substituting air for the contents of said pipe.

46. In combination with an excavating device to draw, cut, or scoop up mud, a flexibly-jointed discharge-pipe resting upon the bottom, substantially as described.

47. A flexibly-jointed submerged discharge-pipe, in combination with a rotary excavator and with mud-forcing apparatus.

48. In combination with discharge-pipe C' and a dredging and transporting device, a pump, B', for exhausting from said pipe.

49. A dredge-boat having a self-contained pivot forming a center of horizontal oscillation, with devices for swinging and working said boat upon said pivot, in combination with a rotary excavator.

50. The combination, with a dredge-boat and non-rotative suction-pipe, of a rotary excavator having an inward delivery, and arranged to force the loosened material through said excavator toward the mouth of the suction-pipe. 7C

51. A dredge-boat having a self-contained pivot, with devices for swinging and working said boat on said pivot, in combination with a suction-pipe and a rotary excavator with inward delivery. 75

52. A dredge-boat having a self-contained pivot or center of oscillation, with devices for swinging and working said boat on said pivot, in combination with an exhausting and discharging device, suction-pipe, and rotary excavator having an inward delivery. 80

53. The combination, with a non rotative suction-pipe, of a rotary excavator having an inward delivery through said excavator.

54. The combination, with a dredge-boat and non-rotative suction-pipe, of a rotary excavator having an inward delivery through said excavator. 85

55. The combination, with a suction-pipe, of a rotary excavator delivering inwardly through itself and rotating independently of said pipe. 90

56. A rotary bottomless-bucket excavator-wheel having an internal bearing and a hub constructed and arranged to hold and support the wheel and allow a free discharge. 95

57. A rotary bottomless-bucket excavator-wheel with driving-shaft and suitable bearings, in combination with pipe C and an exhausting apparatus. 100

58. A hollow rotary excavator with inward delivery, in combination with a suction-pipe provided with an elbow and suitable bearings in the axis of vertical oscillation of said pipe, said elbow being connected by means of a stuffing-box or other suitable connection with a stationary continuation of a suction-pipe leading to an exhausting apparatus, the whole being constructed and arranged to allow said excavator to be raised and lowered without breaking the suction and flow. 105 110

59. A rotary excavator with inward delivery, in combination with a non-rotating suction-pipe mounted upon strong trunnions or equivalent joints, to permit the excavator and outer end of the suction-pipe to be raised and lowered to suit the depth at which the work is progressing. 115

60. A rotary bottomless-bucket excavator-wheel having detachable cutting-edges secured to said buckets, with driving-shaft and suitable bearings, in combination with a suction-pipe, exhausting apparatus, and dredge-boat. 120

61. A rotary bottomless-bucket excavator-wheel with suitable inner bearings and inner delivery, in combination with a suction-pipe, exhausting apparatus, and dredge-boat. 125

62. A rotary excavator carrying sharp cutting-edges with inward delivery, in combination with a non-rotative suction-pipe and dredge-boat. 130

63. A rotary excavator having edges cutting parallel with the axis of rotation, with other edges cutting perpendicularly to said

axis, for the purpose of slicing up and subdividing the spoils, in combination with a suction-pipe and exhausting apparatus.

64. A rotary excavator having a screen secured to and in combination with said excavator.

65. A suction-pipe and rotary excavator, in combination with a device for excluding coarse substances from said pipe.

66. A rotary excavator and receiving-pipe, and pump for freeing said pipe of the excavated material by suction, in combination with a device for excluding from said pipe substances too coarse to pass through the pump.

67. A rotary excavator having ring-knives *d* arranged at intervals around its periphery, to slice and subdivide the material to enter the conduit.

68. A rotary excavator, in combination with a device for screening the spoils and preventing obstructions from entering said excavator.

69. A rotary excavator with inward discharge, combined with a pump, a suction-pipe, and devices to exclude from the suction-pipe substances too hard to be cut and too coarse to pass through the pump.

70. Cutting, protecting, and screening knives passing across the mouth of, secured to, and in combination with an excavating-bucket.

71. An excavating-bucket, in combination with a screen or bars for screening the material and preventing the coarser portions from entering said bucket.

72. A rotary excavator having buckets or scoops on its end adapted to cut and deliver the material inward and through said excavator, for the purpose of allowing said excavator to cut and advance in the line of the axis of rotation, in combination with a conduit for discharging said material, said excavator being arranged to deliver its contents directly into said conduit.

73. A rotary excavator having projecting excavating devices on its lowermost part, and provided with strengthening braces to re-enforce the supports that carry said devices, in combination with a suction-pipe and exhausting apparatus.

74. A rotary excavator having projecting excavating devices on its lowermost part, and provided with a strengthening-ring to re-enforce the support which carries said devices, in combination with a suction-pipe and dredge-boat.

75. In dredging-machines, a non-rotating suction-pipe, in combination with a rotary excavator provided with excavating devices arranged to deliver inward to a space in the interior of said excavator.

76. In combination with a dredging-machine, a non-rotating suction-pipe and hollow rotary excavator provided with buckets or scoops having an inward delivery through said excavator.

77. A rotary bottomless-bucket excavator-wheel provided with ring-knives *d*, substantially as described.

78. A rotary bottomless-bucket excavator-wheel having ring-knives *d*, detachable knives S, and cutting-lips *c*, substantially as set forth.

79. A rotary excavator with inward delivery, in combination with an inner stationary chamber arranged to form a bottom to the buckets as they revolve around said chamber until said buckets reach the place of discharge.

80. A rotary excavator with inward delivery, in combination with an inner hollow chamber having an opening through which the excavator discharges into said chamber.

81. The self-adjusting steam counter-balance H, in combination with hawser L and a dredging device, substantially as described.

82. The combination, with the excavator, of a hawser, L, passing from a counter-balance, through the suspending-block *g*, and around suitable guiding-sheaves to the hoisting apparatus, to raise and lower the excavating apparatus without interrupting the action of the counter-balance.

83. A hydraulic hoist, in combination with a dredge-boat, rotary excavator, and suction-pipe.

84. A hydraulic hoist, in combination with an excavating device.

85. In combination with a dredge-boat, winding-drums, and warping-lines, the blocks U U, anchored substantially as described.

86. In combination with a dredge-boat and warping-line, a block, U, anchored to the bottom or to the shore, around which said warping-line passes for the purpose of swinging and warping said boat, substantially as described.

87. In combination with a dredge-boat having devices for swinging and working said boat with a side feed, a hauling-line having connection direct from the anchorage to the excavator-support and near the point of resistance, and arranged to throw a large portion of the strain of the side feed on the outer end of the apparatus carrying the excavating device.

88. In combination with the discharge-conduit of a mud-forcing apparatus, guys 6, for holding said conduit in position.

89. In combination with a mud-transporting apparatus and discharge-pipe having branches and valves, as described, and relay-pump, the mud-receiver X, substantially as and for the purpose set forth.

90. In combination with a dredging-machine, discharging apparatus, and relay-pump, a floating vessel carrying said relay-pump.

91. A floating mud-barge having inlet and valve Z^3, arranged to admit water for diluting the spoils.

92. A mud-receiver having a suction-pipe, with a branch and valve through which the mud is exhausted from said receiver, substantially as described.

93. A floating mud-barge having inlet and valve Z^3, with branch pipes and orifices to admit water for diluting the spoils.

94. In combination with a floating mud-

barge having inlet and valve Z^3, and a pipe through which the spoils are withdrawn, the pump B′, or equivalent exhausting apparatus.

95. In combination with a dredge-boat and discharge-pipe, the valve Y, for the purposes specified.

96. A floating mud-barge having an exhausting device and pipe with branches and valves Z Z′, for the purpose set forth.

97. In a mud-receiver, the pipe C″, with branches and valves Y Z Z^3.

98. In a floating mud-receiver, the pipe C″, with branches and valves Y Z′ Z^2.

99. In a floating mud-receiver having inlet and valve Z^3, the pipe C″, with its branches and valves and an exhausting apparatus for withdrawing the spoils.

100. A floating vessel and mud-transporting apparatus, in combination with a dredge-boat, to continuously receive and transport through a discharge-pipe to a place of deposit the spoils as delivered by said dredge-boat.

101. In combination, a suction-pipe and exhausting apparatus for raising and a conduit for discharging spoil, said conduit being provided with openings for separating the spoil from a large percentage of the water which passes the openings and is discharged farther on.

102. The combination, with a rotary excavator, suction-pipe, and exhausting apparatus, of a conduit-discharge having openings in said conduit for delivering spoil, while a large portion of the water passes by and is discharged farther on.

103. An excavating-bucket provided with a fender, to prevent said bucket from catching upon obstructions.

In testimony that I claim the foregoing I have hereunto set my hand in the presence of two attesting witnesses.

A. B. BOWERS.

Witnesses:
HENRY F. TERRY,
OLWYN T. STACY.