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L. D. LIBBEY.

DREDGING AND MINING PUMP.

No. 599,104. Patented Feb. 15, 1898.

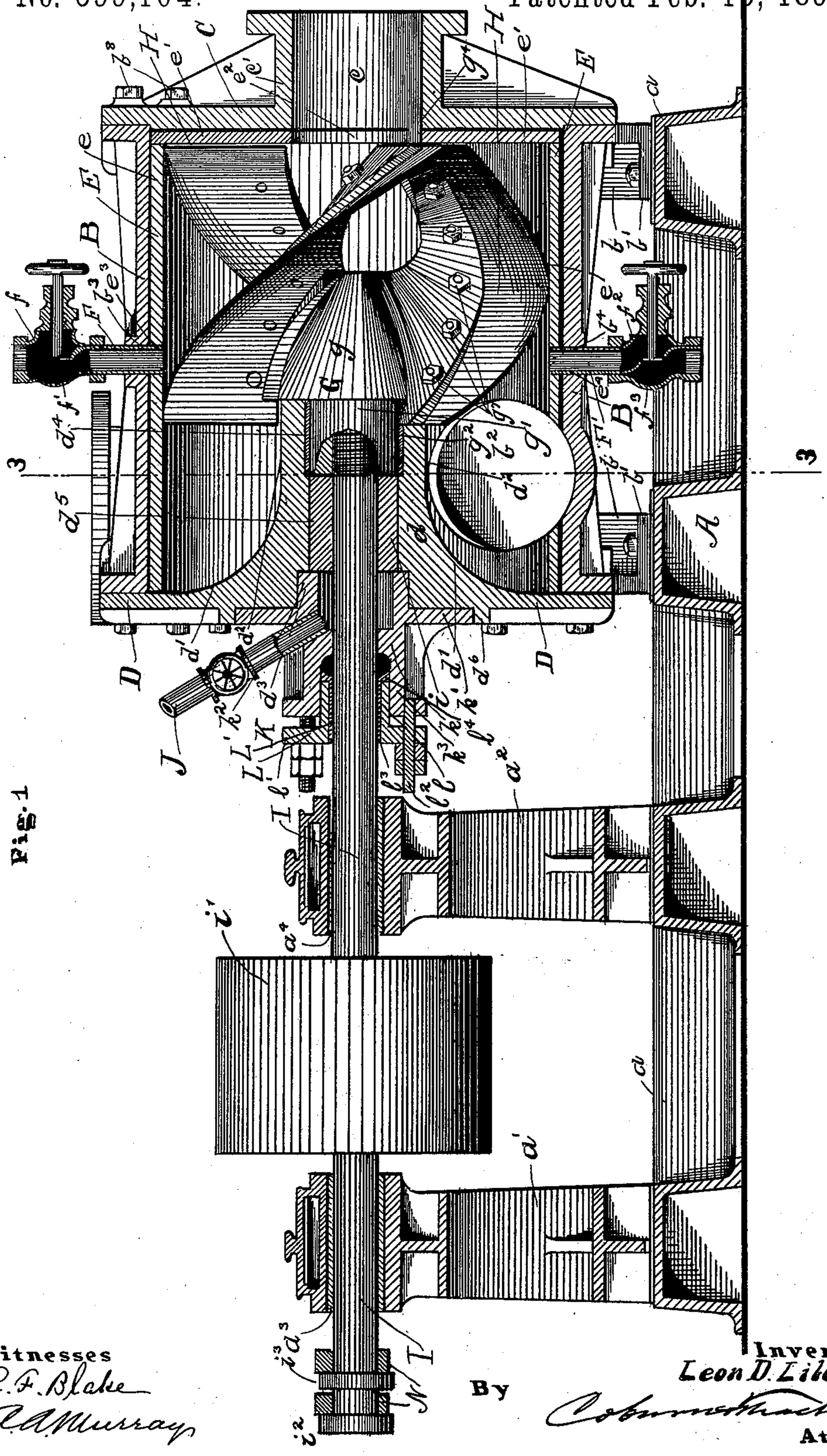

Fig. 1.

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(No Model.) 5 Sheets—Sheet 2.

L. D. LIBBEY.

DREDGING AND MINING PUMP.

No. 599,104. Patented Feb. 15, 1898.

Fig. 2.

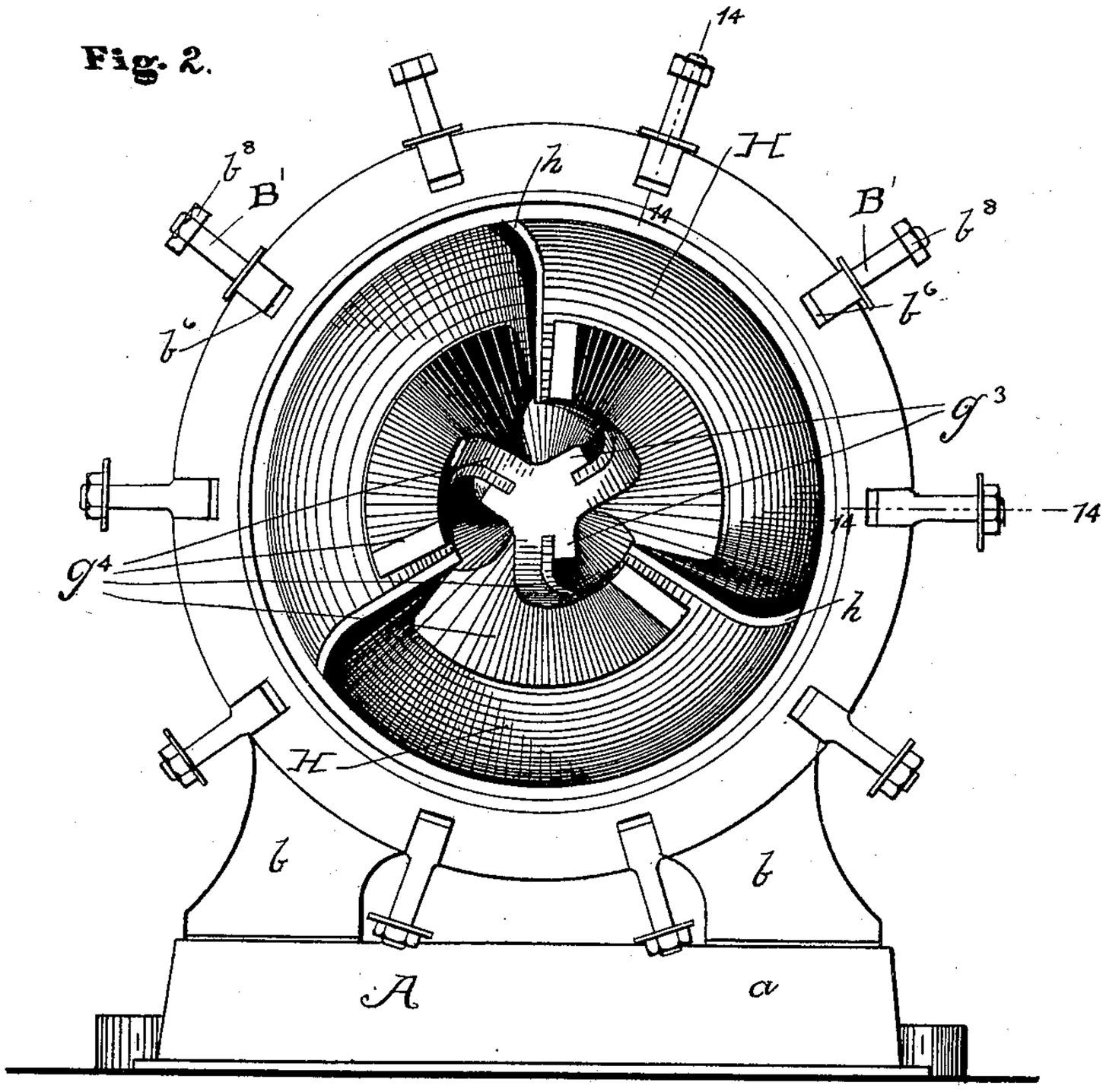


Fig. 4.

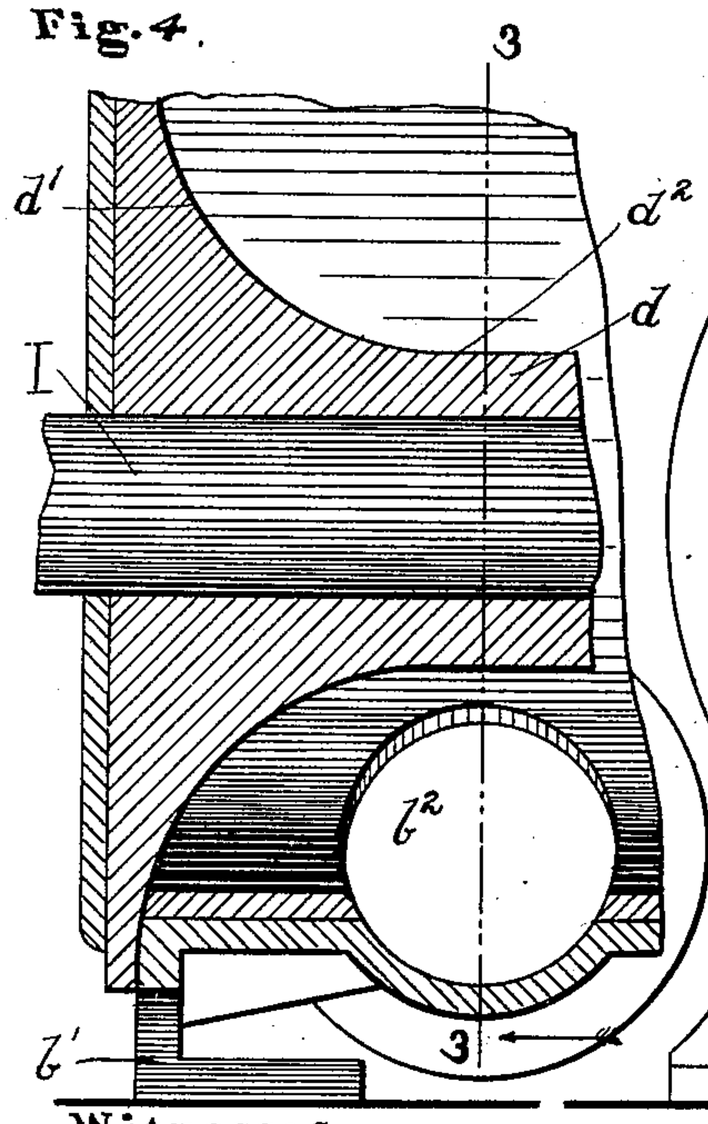
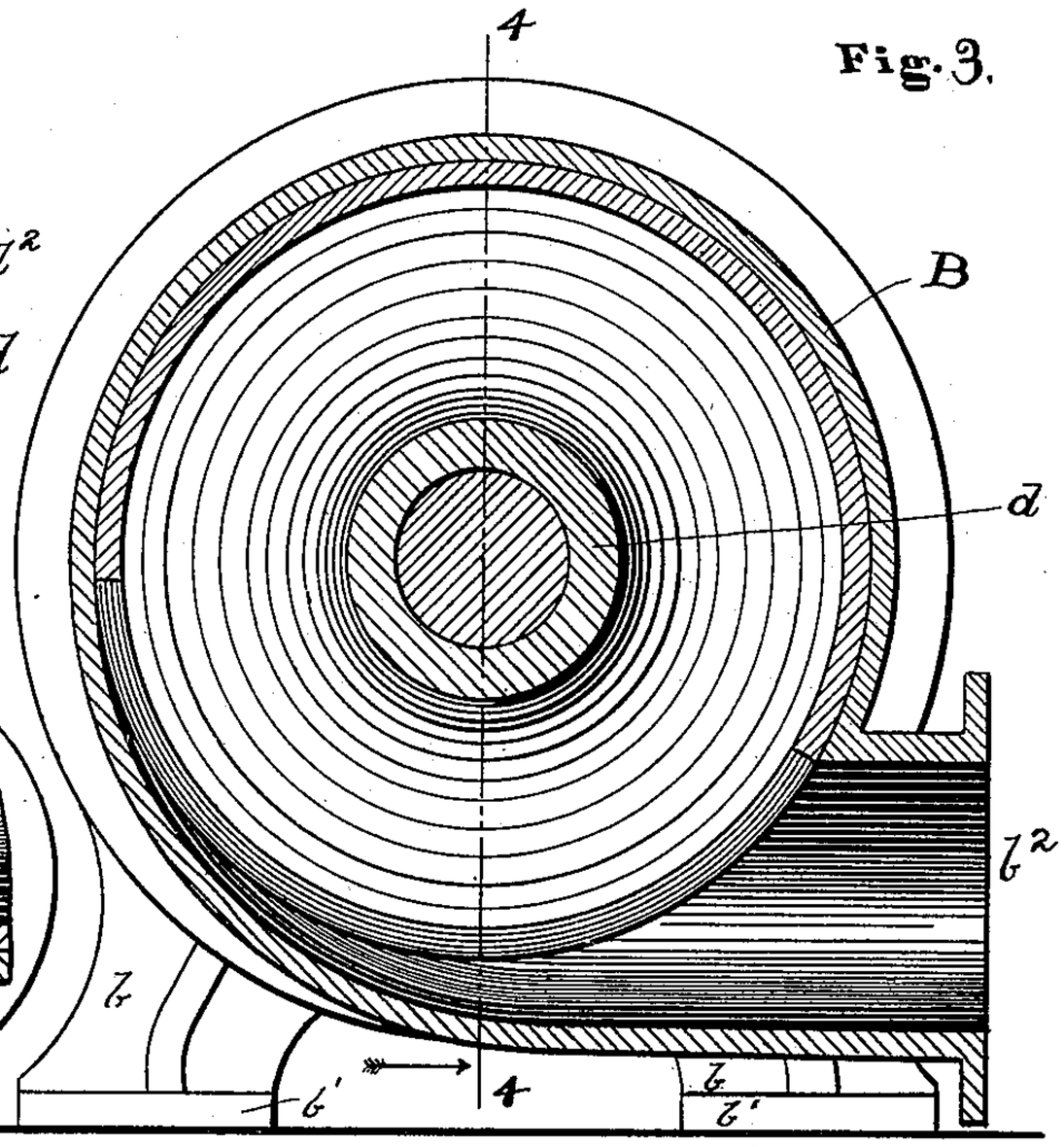


Fig. 3.



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L. D. LIBBEY.

DREDGING AND MINING PUMP.

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Fig. 5.

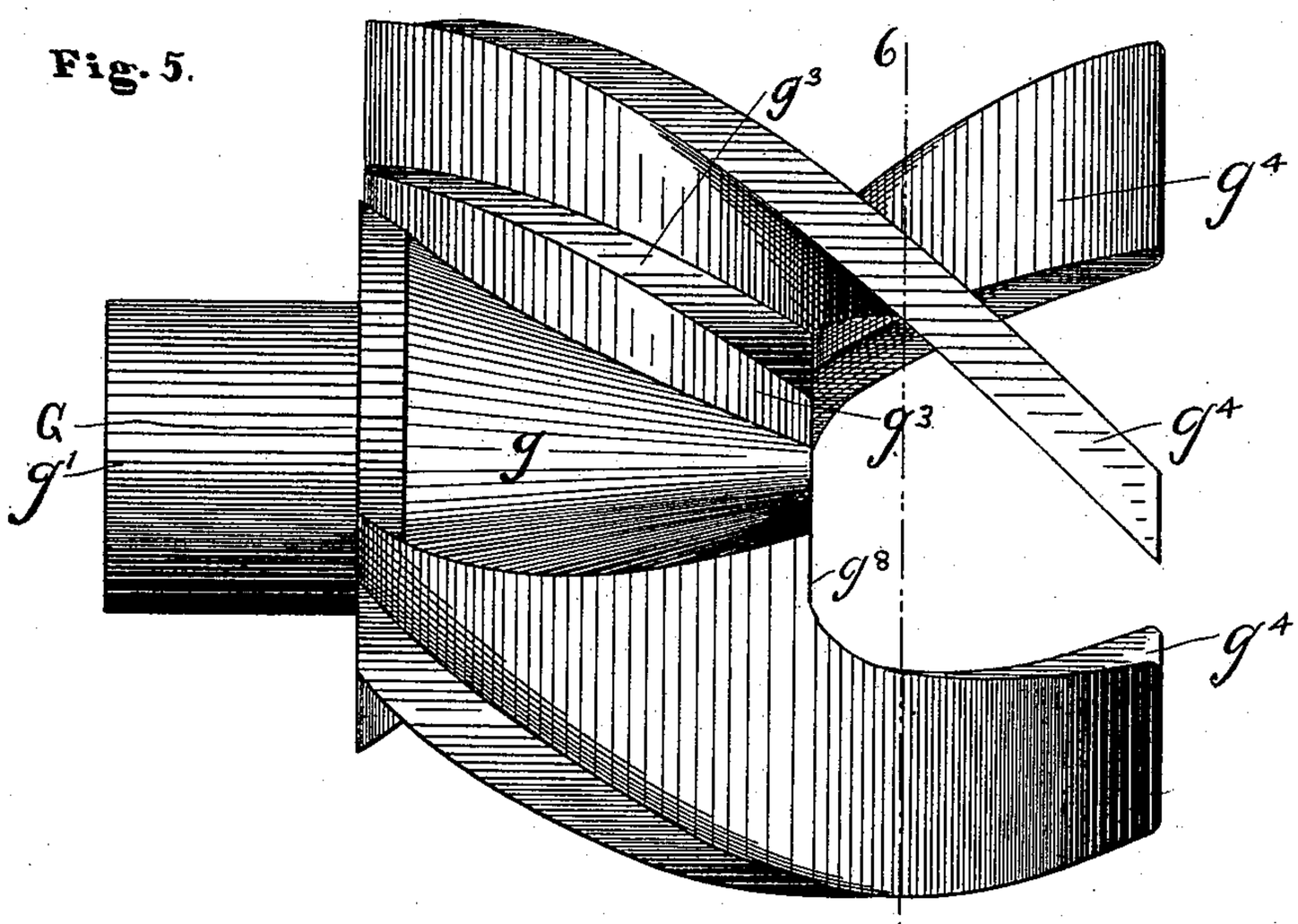
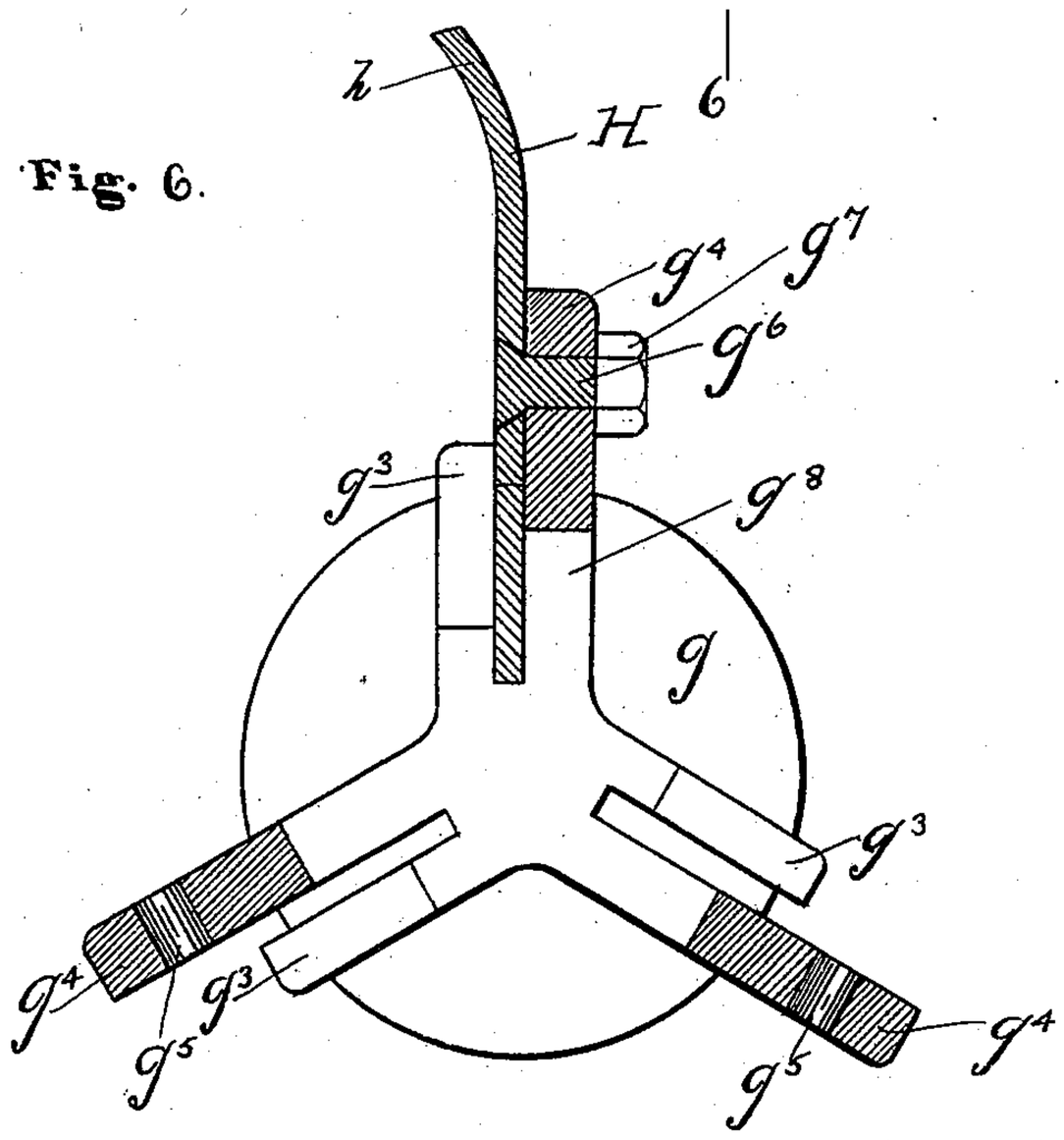


Fig. 6.



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L. D. LIBBEY.

DREDGING AND MINING PUMP.

No. 599,104. Patented Feb. 15, 1898.

Fig. 9

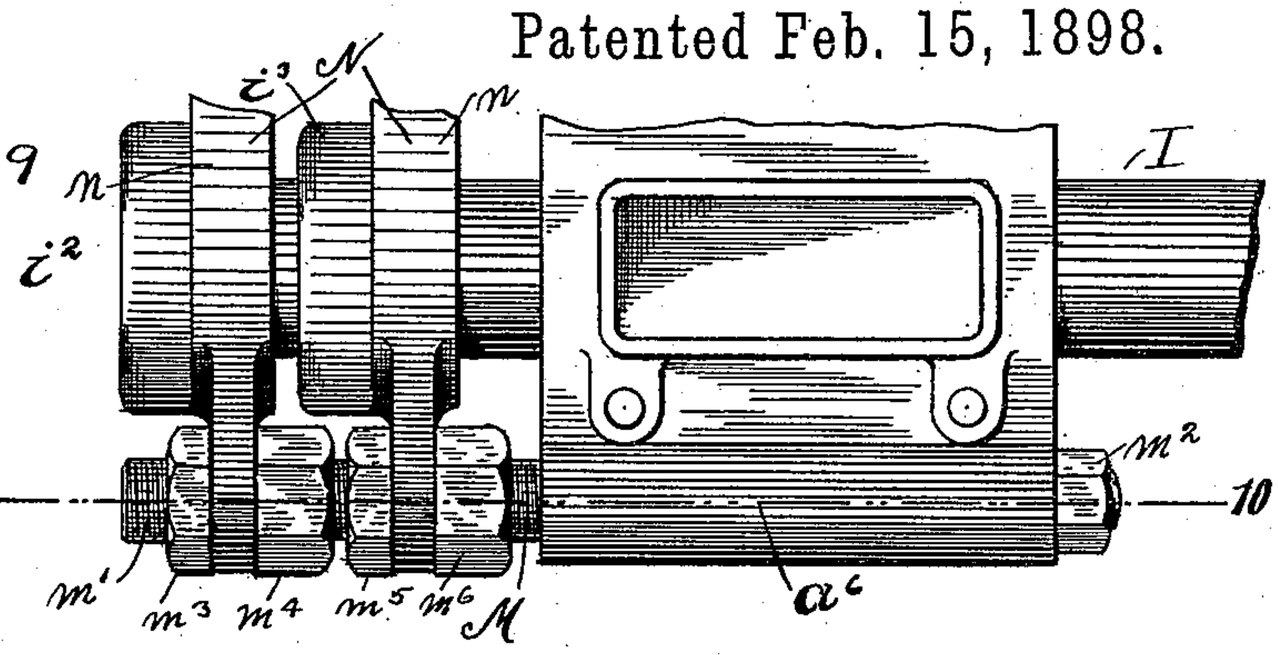


Fig. 12.

Fig. 11

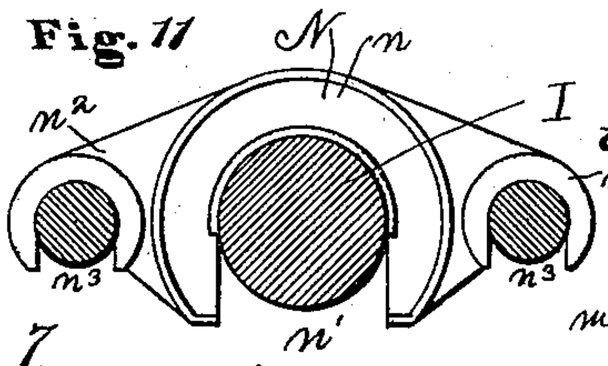


Fig. 10

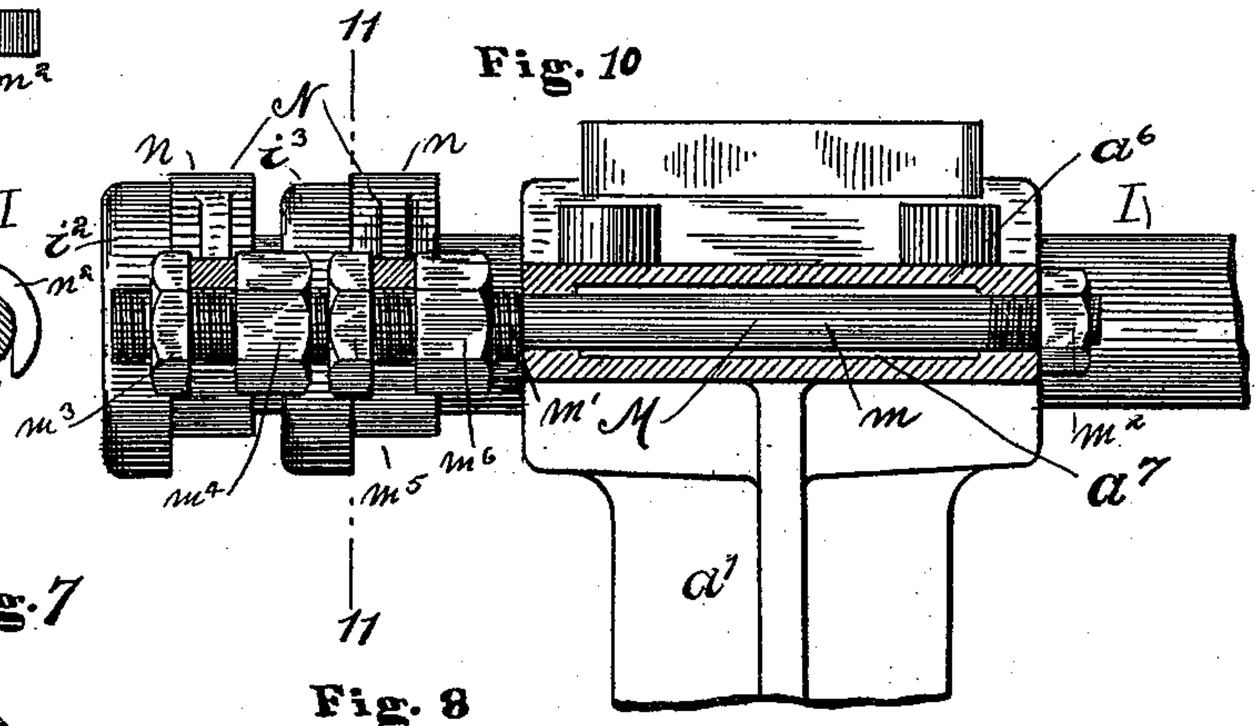
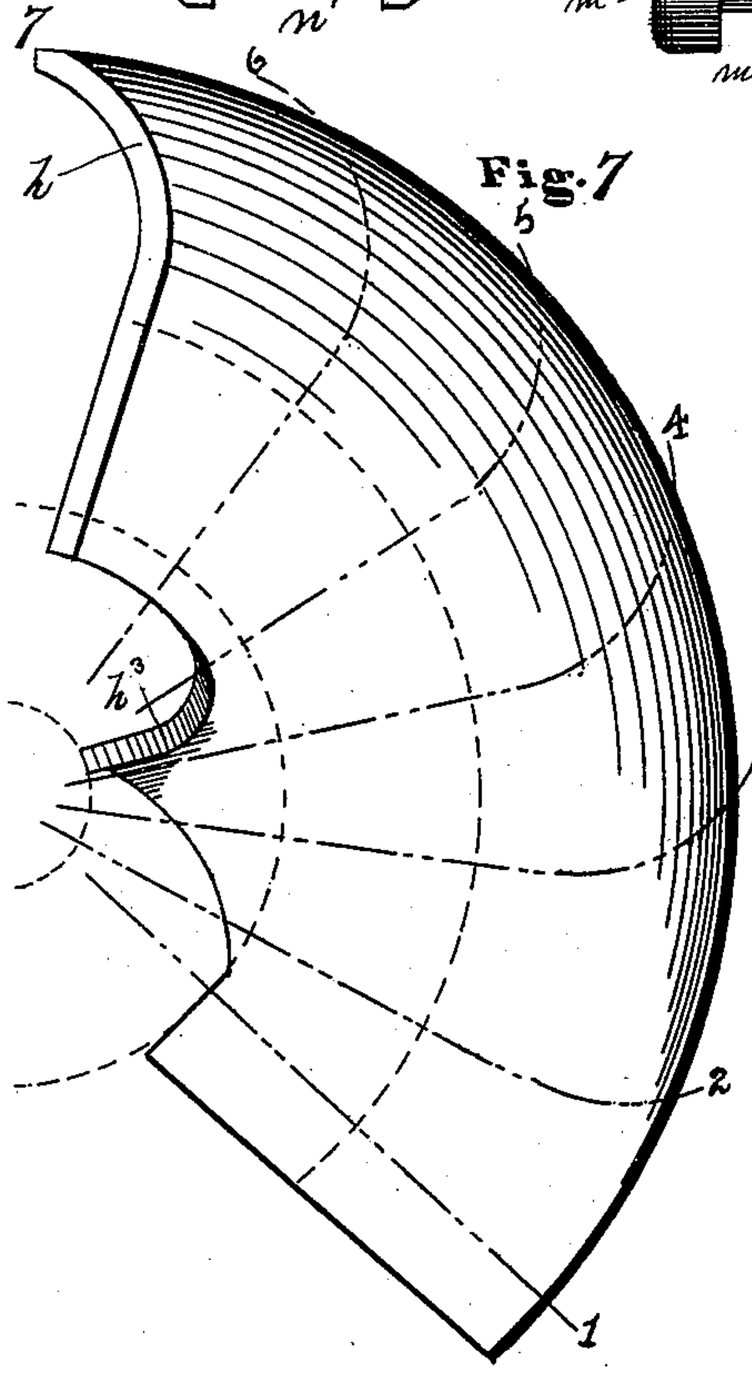


Fig. 8

Fig. 7



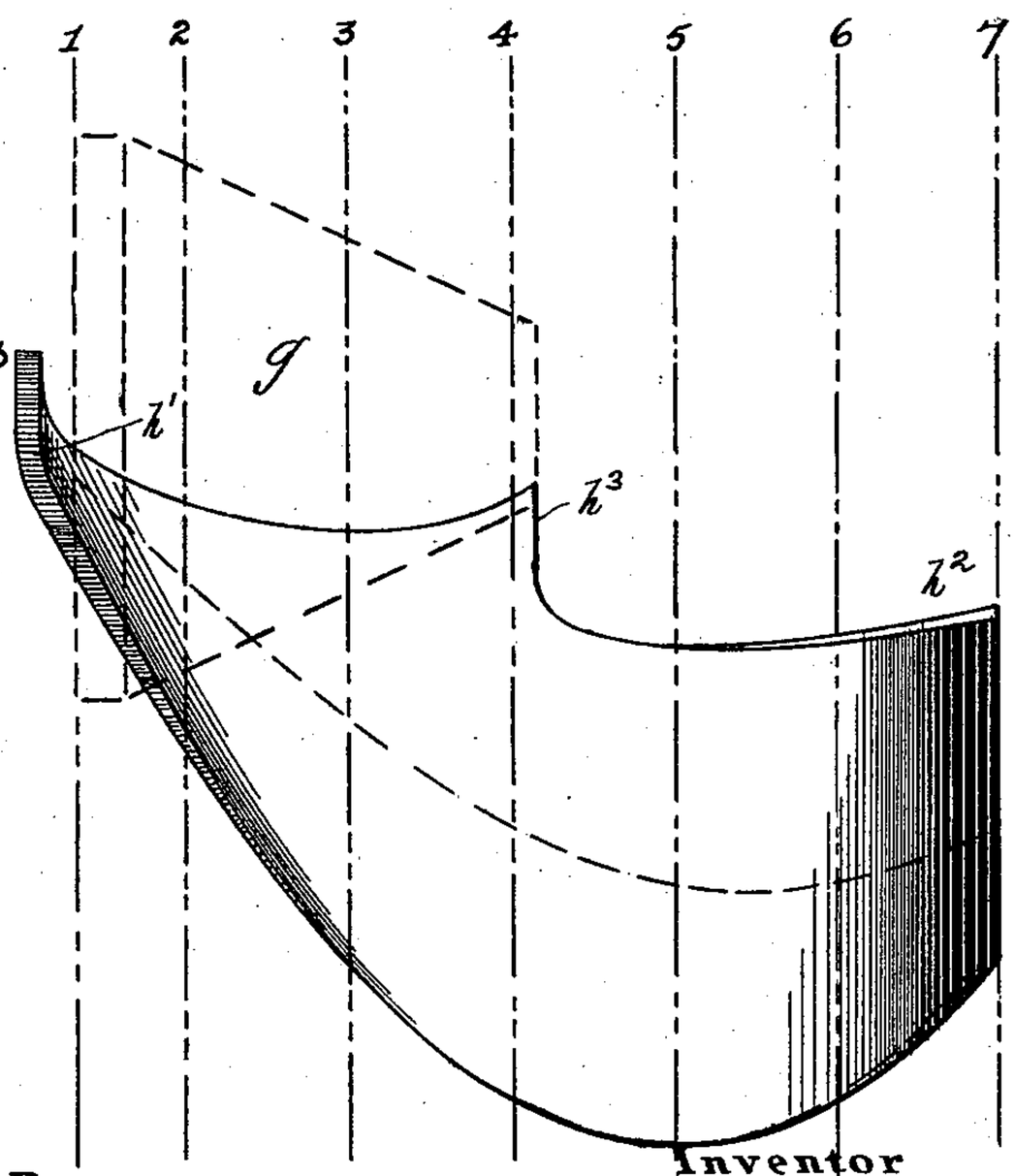


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Fig. 13.

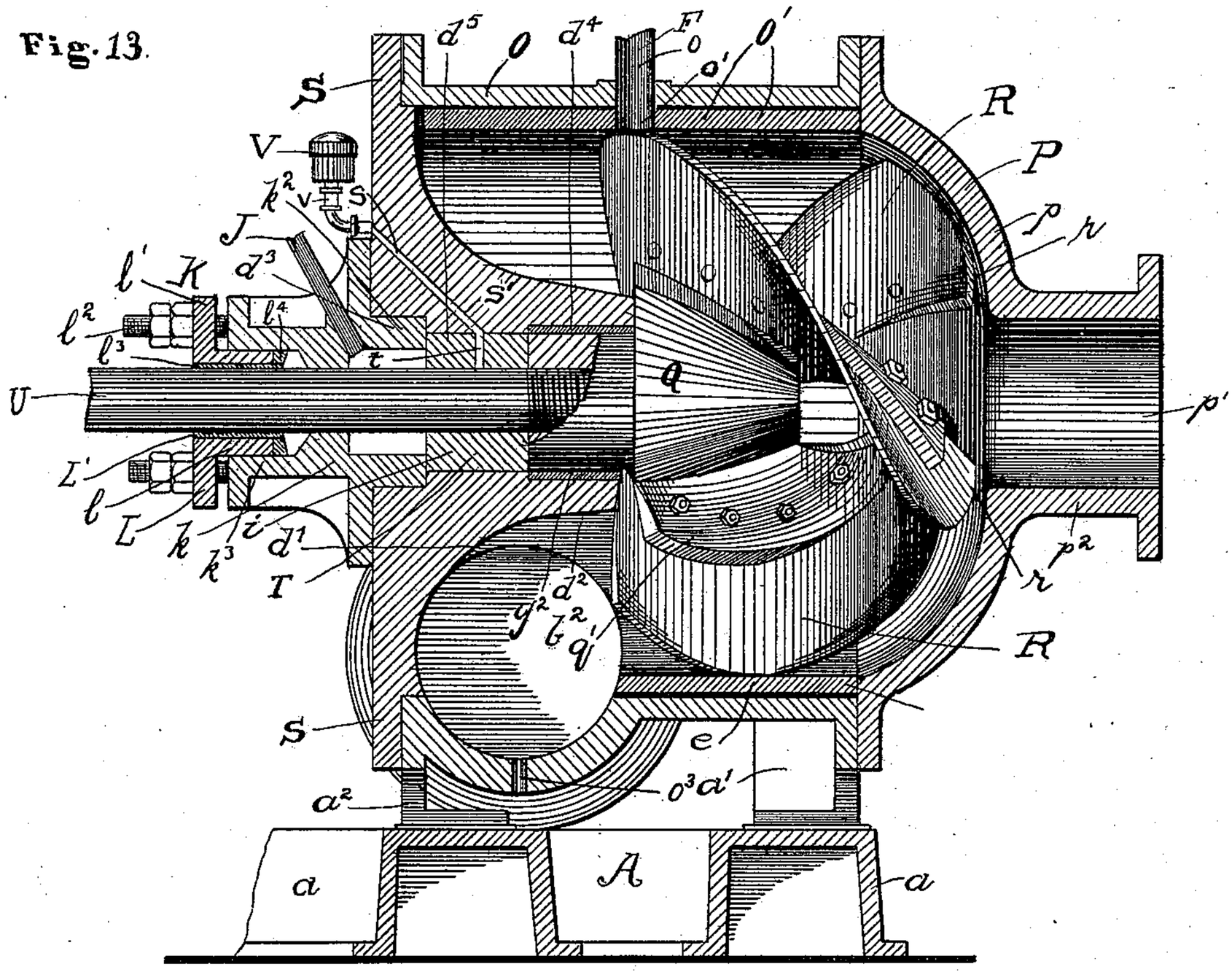
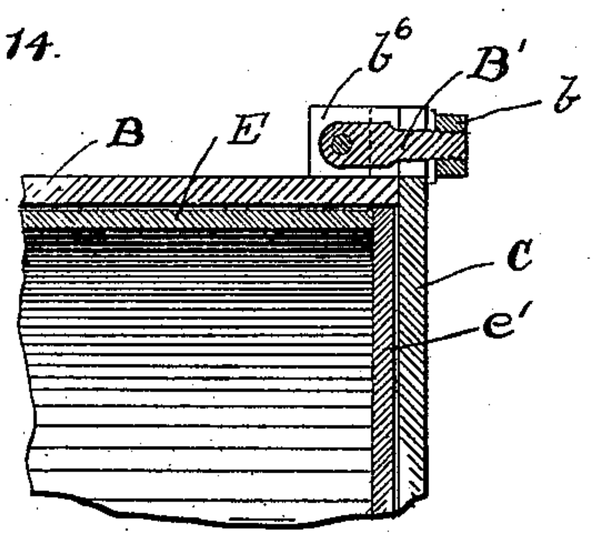


Fig. 14.



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UNITED STATES PATENT OFFICE.

LEON DELBERT LIBBEY, OF DULUTH, MINNESOTA, ASSIGNOR TO DE WITT CLINTON PRESCOTT, OF WEST DULUTH, MINNESOTA.

DREDGING AND MINING PUMP.

SPECIFICATION forming part of Letters Patent No. 599,104, dated February 15, 1898.

Application filed March 27, 1895. Serial No. 543,380. (No model.)

To all whom it may concern:

Be it known that I, LEON DELBERT LIBBEY, a citizen of the United States, residing at Duluth, in the county of St. Louis and State of Minnesota, have invented certain new and useful Improvements in Dredging and Mining Pumps, which are fully set forth in the following specification, reference being had to the accompanying drawings, in which—

Figure 1 represents a longitudinal vertical section of a pump embodying my invention, the shaft and driving-pulley thereon being in full lines; Fig. 2, a front end elevation of the same with the head removed; Fig. 3, a cross-section thereof, taken on the line 3 3 of Figs. 1 and 4; Fig. 4, a detail longitudinal section taken on the line 4 4 of Fig. 3; Fig. 5, a side elevation of the revoluble head or forcing device of the pump detached; Fig. 6, a vertical section thereof, taken on the line 6 6 of Fig. 5; Fig. 7, a plan view of one of the blades of the revolving head detached and on the outer or convex side thereof; Fig. 8, a similar view of the same on the inner or concave side; Fig. 9, a detail plan showing one side of the outer mounting of the driving-shaft; Fig. 10, a detail section taken on the line 10 10 of Fig. 9; Fig. 11, a detail section taken on the line 11 11 of Fig. 10; Fig. 12, a plan view of one of the horseshoe-collars detached; Fig. 13, a longitudinal section of the pump proper alone, taken on the same line as in Fig. 1 and showing a modification in construction; and Fig. 14, a detail section taken on the line 14 of Fig. 2.

In the drawings, Figs. 1, 2, 13, and 14 are upon one scale, Figs. 3 and 4 upon another and enlarged scale, Figs. 5, 6, 7, and 8 upon a third scale, still more enlarged, and Figs. 9 to 12, inclusive, upon a fourth and still further enlarged scale.

My invention relates to a pumping-machine which is designed not only to move large bodies of water, but also to move coarse gravel and sand—in fact, stones of quite large size—thereby providing a pump which may be practically used as a substitute for dredges and steam-shovels in deepening harbors, canals, and rivers, and is applicable to successful use in placer-mining or mining in streams or rivers where gold exists, especially in mountainous regions.

What may be called the "fundamental" features of this structure are a circular cylinder or case and a revoluble winged or bladed head arranged within said cylinder and acting as the real forcing device of the machine, the case or cylinder being provided with an inlet-opening at one end and an outlet-opening at the other. I am aware that a revoluble pumping device is old and well known; but the construction and operation of the device, which, broadly speaking, may be thus termed in the present case, are quite different from anything heretofore known to me. In the present invention this revoluble forcing device is a head or short shaft within the cylinder, armed or provided with a series of wings or blades, which, in general terms, may be said to run lengthwise of the head, but are arranged spirally thereon. These blades and the head to which they are attached are arranged lengthwise of the cylinder, but extend only a part way of the cylinder length, the space which they occupy being at the inlet end of the cylinder, while at the outlet end quite a portion of the cylinder is practically an unoccupied chamber, though, as will appear later on, it is not intended by this expression that there is nothing whatever in this end of the cylinder. In operation the shaft carrying the winged head is revolved with great rapidity, and the peculiar shape of these blades, in connection with the arrangement of this device and the cylinder, is such that water or any other substance is drawn into the cylinder at the inlet, where it is acted upon by the said blades in very much the same manner as propeller-blades act upon water; but, as will hereinafter appear, the peculiar form of the blades results in deflecting the water or other substance drawn in at the inlet toward the center of the cylinder, which may be called the "pump-cylinder," and at the same time drives it back with great force toward the comparatively free space at the outlet end of the cylinder. This construction and relative arrangement of the main features referred to produce a pump which, while in general terms it may be called a "rotating" pump, obviously differs in construction and operation from what are generally known as "centrifugal" pumps.

The invention consists in these fundamental features of the structure mentioned above and also many more specific details in particular devices and combinations thereof which need not be specifically pointed out at this stage of the description. They will all appear in the detail description which I will proceed to give of the construction and operation of a pump embodying my invention, with reference to the accompanying drawings, illustrating the same, after which the improvements which I believe to be new and desire to secure by Letters Patent will be more definitely stated in claims.

In the drawings, A represents the main or supporting frame of the pump, consisting of a base or platform a and standards a' a^2, the former at what may be called the "rear" end of the platform and the latter some distance in front of the same. This frame is preferably of metal, and the platform may be of any desired form of construction. In the drawings it is skeleton, being made with side bars and cross-bars, as indicated in Fig. 1. The pump is mounted on this base-support, the cylinder being mounted on and secured to the front portion thereof. This cylinder is constructed in a special way, which will now be described.

An outer cylinder or shell B is made of slightly-larger diameter than actually required. At each end on its under side it is provided with short legs or standards b, having flanges b' at their lower ends, by means of which they are bolted to the two cross-beams at the forward end of the base, as seen in Figs. 1 and 2. When this cylinder is properly mounted on the base, it is located horizontally thereof, and at one side, near its rear end, it is provided with a large side opening b^2, which is the outlet of the cylinder. This cylinder is also provided with a side opening b^3 about midway of its length, which is at the top of the cylinder when the latter is mounted in working position, and at the opposite or under side is a similar aperture b^4. A head C is constructed to close the front end of this cylinder, being fitted and firmly secured thereto in any ordinary way. Different means for this purpose are so well known that is not necessary to make any specific description of such devices here. This head is provided with a large central aperture c, around which is a flange c', projecting outward from the head and forming a kind of tubular passage to and through the head, which is the inlet to the cylinder. The head D, at the opposite or rear end of the cylinder, is in a general way like the front head C and is secured to the rear end of the cylinder in substantially the same way as the head at the front end thereof; but in some important particulars this rear head differs from the one in front. The latter has a plain interior face; but the rear head is provided with a large strong projection d, arranged centrally of the head and extending inward nearly half the length of the cylinder. This projection or nose on the rear head commences quite near the outer edge thereof and extends inward on a curved line, so that it gradually decreases in circumference for about half its length and then follows a straight line the remaining distance, so that the exterior surface of this piece will present two sections, one, d', gradually tapering on a curve and the other, d^2, perfectly straight. This interior projection of the rear head is intended as the journal-bearing for the main shaft, as will presently be described, and for this purpose is bored centrally through head and projection, the opening, as seen in the drawings, consisting of three sections—a short outer one d^3, one, d^4, at the inner end a little longer and a little less in diameter than the former, and a middle section d^5 between the two and contracted more than either of them. On the outer face of the head D there is a circular flange d^6, projecting outward a short distance and surrounding the central opening in said head, being arranged at a little distance outside the latter.

Within the cylinder B there is also arranged a second cylinder E, fitting closely within the outer cylinder and consisting of a body e and a loose head e' at the front end thereof just within the front head of the outer cylinder and provided with a central aperture e^2, corresponding to the similar aperture in the adjacent head of the outer cylinder. This inner cylinder is not provided with a head at its inner or rear end, but fits directly against the inside of the said head. This inner cylinder is also provided with side apertures e^3 e^4, which correspond and register with the similar openings b^3 b^4 in the outer cylinder. The complete cylinder or case is therefore composed of two separate parts—an outer and an inner cylinder, the latter being fitted nicely within the former and held therein by its respective heads. The inner cylinder is removable bodily from the outer by detaching the front head and certain side pipes which will be hereinafter explained. The means for securing the heads of the outer cylinder to the body thereof, as shown in the drawings, are adapted to facilitate the attachment and detachment of the heads for various purposes, including the removal of the inner cylinder just mentioned, and a description thereof will be given to avoid any misunderstanding. At the end of the said cylinder there is an annular flange projecting outward at right angles to the cylinder axis and provided with a series of recesses or notches b^6. The cylinder-head is larger than the cylinder proper, its circumference corresponding to the outer edge of this flange, and it is provided with a series of notches or recesses b^7, corresponding to those in the flange. Short arms or bolts B' are hinged at their inner ends to the cylinder, just back of the flange thereon, and are adapted to swing down into the adjacent notches located, respectively, in the body and head of the cylinder, as described above, and

upon their outer ends, which project a little beyond the cylinder-head when swung down into the notches strong nuts b^8 are turned, by means of which the parts are securely fastened together, while at the same time they may be easily released for detachment, as may be required. The construction at the opposite end of the cylinder is substantially the same, and the above description applies thereto. A short pipe F is set in the side openings of the two cylinder-cases, terminating at its outer end in a valve-case f, in which is seated a valve f' for controlling the passage through this pipe into the interior of the cylinder. A similar pipe F′ is inserted in like manner in the under side openings of the cases, terminating also in a valve-case f^2, in which is seated a valve f^3, by means of which the passage to the bottom of the cylinder is also controlled. Both of these pipes are detachable to permit the taking apart and putting together of the several parts of the cylinder. A revoluble pumping device is mounted in this cylinder, which will now be described.

A hub G is constructed with a cone-shaped head g, from the larger end of which projects a short cylindrical section g' of less diameter than the larger diameter of the cone, this section being adapted to enter the inner section d^4 of the central opening in the rear-head projection, this extension from the cone being the journal of the latter, and the opening d^4 the bearing thereof, in which it is neatly fitted by a bushing-sleeve g^2. The greater diameter of the cone is equal to or perhaps a little greater than the diameter of the inner end of the head projection d, so that when mounted in the latter the back of the cone will set up against the end of the projection. It may be here stated that this particular feature of construction in which the cylindrical section g', integral with the cone, is journaled in the opening d^4 of the projecting rear head has very marked advantages over one in which the shaft alone furnishes the bearing, inasmuch as in the latter case the great weight of the head would be borne by the shaft alone, producing a bending and shearing stress upon it, while by my construction a great portion of the weight of the head is sustained directly by the projection d. The increased diameter of the section g' furnishes an adequate diameter for the journal-bearing and also a length of the bearing sufficient to withstand the severe stress to which the revolving head is subjected. The cone g is provided with a series of flanges arranged in pairs on the surface of the cone, running lengthwise and spirally thereof. One of these flanges g^3 may be called the "front" flange, because it lies first in the revolution of the head. Just a slight distance back of each of these flanges is a flange g^4, similar to the front flange, except that it is considerably wider, so that it projects outward beyond the latter. These two flanges are parallel to each other and obviously provide a narrow groove or channel between them. The wider or back flange is also provided with a series of apertures g^5, extending lengthwise thereof and just above the outer edge of the front flange. Blades H are made of a peculiar form and adapted at their inner ends to be set into the spaces between the respective pairs of flanges on the cone, and are secured thereto by means of bolts g^6, passing through openings in the respective blades and the apertures g^5 in the wider flanges, the bolts being secured by nuts g^7, by means of which the blades are firmly fixed in place after they are mounted in their respective seats. In the drawings three such seats are shown on the cone, thus providing for mounting three blades thereon, which is the number preferred, though it is not intended to limit this invention to any particular number of blades. Each of the blades is formed on a regular spiral twist, which is determined by good judgment and taste. The spiral twist of the flanges on the cone is the same as that determined for the blades, so that the latter will be accurately seated in each pair of flanges. The blades are not perfectly straight-faced—that is, the lines on a straight cross-section of the blades will not be straight their entire length. Each blade is curved at its outer edge, this curve being toward the front—that is, in the direction in which the device is to be rotated. This curved edge h is shown in Figs. 2, 6, and 7 of the drawings, and is also indicated in Figs. 5 and 8, from which it will be seen that the edge of each blade is curved inward and forward. Each blade is also constructed with a short curved section h' at its rear end—that is, the end at the rear or largest portion of the conical head. The bend or curve of this section is inward, the same as the edge bend, but it is backward instead of forward and its direction is lengthwise instead of crosswise of the blade. These blades are considerably longer than the conical head on which they are mounted—in fact, they are nearly twice as long—and their outer or front ends h^2, projecting beyond the conical head, are somewhat narrower than the portion of the blade lying along the said head, the cut being made on the inner edge of said blades, these front ends being only a little wider than the rear ends, from which point each blade is gradually widened to correspond with the cone, at the outer end of which there is a sharp cut outward again, making rather a straight shoulder h^3 at this point, which sets the inner edge of each blade out considerably from the cone the rest of its length. The wider or back flange g^4 is, however, extended out beyond the cone, this extension being along the whole length of the corresponding blade, the said flange being also cut away at the outer end of the cone in about the same way as the blade, producing a like shoulder g^8 and following the inner edge of the blade, to which it is bolted its entire length. This extension or continuation of the said flange obviously

strengthens the outer projecting ends of the blades.

A steel shaft I is mounted in suitable journal-bearings on the standards or pedestals a' a^2, and thence passes forward into the central opening in the rear cylinder-head and its projection to the journal of the blade-cone, into the end of which it is secured by a threaded connection, as seen in the drawings, or any other means suitable for the purpose. This is the main or driving shaft of the pump, and it has a bearing within the projection on the rear cylinder-head, formed by a sleeve-bushing i set in the middle section d^5 of the said projection. The shaft is also supported just in rear of the cylinder by a kind of journal-bracket K, which consists of a head k, projecting beyond the cylinder and provided with a bearing for the shaft. Just inside of this journal-section there is a flange k', extending outward some distance, circular in form and adapted to closely fit within the flange on the outside of the rear end head, and inside of this flange there is a tubular extension k^2, adapted to fit the largest section d^3 of the bearing in the projection d, the opening of this last-named section and the flange being larger than the shaft, so as to provide a space between the two and between the sleeve i and the head k of the bracket, as seen in Fig. 1. A pipe J passes through the bracket and opens into this space, through which water may be delivered into the said space. This pipe may be connected with a tank or any suitable device for delivering clean water into this space or chamber under pressure. The central opening in the outer or projecting head k of the bracket is enlarged part way, thus providing an opening or kind of socket k^3, somewhat larger than the main shaft, and therefore there will be an annular space between the two. A separate bearing-box L is constructed to fit into this enlarged opening in the bracket, being composed of a tubular section l, adapted to fit into the said bracket, and a flange l', projecting therefrom, by which it is secured to the bracket by means of pins l^2, secured to the bracket and threaded for the application of nuts outside of the box. The central opening through this bearing-box is a little larger than the main shaft to permit a bushing L' to be inserted between the two, the bushing being in the form of a short tube l^3, at the inner end of which is a flange l^4, adapted to set up against the inner end of the said bearing. These parts are intended to be adjusted so as to leave some space between the inner end of this box-bushing and the central portion of the bracket, which closes around the shaft like a bearing, which space may be used for lubricating purposes or to receive some of the lubricating material slowly coming through from the larger chamber in front. The bearings of the main shaft in the pedestals a' a^2 are also supplied with bushing-sleeves a^3 a^4, the former on the rear pedestal a', and the shaft I is provided with a driving-pulley i', fastened thereto and arranged between the two pedestals, as shown in the drawings, though of course this particular arrangement is not an absolute necessity. In the operation of this pump-shaft, armed with blades, as shown, it must be obvious that the pump in action is essentially a pressure-pump, as will be hereinafter more fully explained. There is, therefore, a very strong thrust-pressure endwise of the shaft and toward the bladed end thereof. It is of special importance, therefore, to provide a strong and safe resistance to this end thrust; otherwise the utility and durability of the pump are uncertain. The devices for this purpose will now be described.

The rear end of the main shaft is extended some distance beyond the rear pedestal a' and is provided with one or more collars, either made independent of the shaft and fastened securely thereon or preferably forged with the shaft. In the drawings two such collars are shown, one, i^2, at the extreme rear end of the shaft and the other, i^3, a little distance in front of the other. The head or cross-bar a^5 of the rear pedestal, in which the main shaft is journaled, is extended at each side of the said shaft, forming a kind of projecting flange or wing a^6, the outer edge of which is enlarged and is perforated by an aperture a^7, extending lengthwise thereof and enlarged from the extremities most of its length, as seen in Fig. 10. In each of these perforated wings there is mounted a strong rod M, one end of which, m, is adapted in size to the apertures through the wings—that is, the smaller or end portions thereof. The other end or outer section, m', of the rod is larger than the former, and the smaller end of each rod is thrust in through the perforated wing from the rear thereof until the shoulder formed by the enlargement of the outer section of the rod strikes against the said support, when the front end of the rod will project slightly beyond the front of the pedestal-wing, and, being threaded, a nut m^2 is turned thereon, by means of which the rod is secured in its mounting as firmly as may be desired. The rear or larger ends of these rods, projecting backward from the rear of the pedestal, are threaded, as seen in Figs. 9 and 10, and extend about as far as the shaft. On these threaded ends are fitted suitably-threaded nuts, which are intended to be arranged in pairs, corresponding to the number of collars on the main shaft. Two of these collars being shown in the drawings, there are therefore two pairs of nuts to correspond, one pair m^3 m^4 being at the rear end of the rods and adjacent to the rear collar on the main shaft, the former being the extreme outer or rear nut and the latter inside thereof. The other pair m^5 m^6 are similarly arranged with reference to the second or inner collar and in the same order, respectively. One or more collars N, the number of these collars corresponding to the fixed collars on

the shaft, are provided, being adapted to be placed upon and embrace the main shaft and also the side rods. In general features they are of the construction sometimes called "horseshoe-collars" and are constructed with a central portion n of considerable thickness to give strength, with a recess or large notch n' opening inward at one edge thereof and concave at its inner wall, producing a form something like a horseshoe, as seen in Fig. 11. From each side of this central portion projects a short arm or flange n^2, somewhat narrower than the central section and each provided with a notch or recess n^3 in one edge, corresponding in shape and arrangement to the central opening, but considerably smaller. The central opening of this horseshoe-collar is adapted to fit over and embrace the main shaft, while the openings in the side projections are adapted in like manner to fit over and embrace the respective side rods. In adjusting these devices for operation the main shaft must be at rest and thrust to the rear as far as possible. The nuts on the enlarged threaded rear ends of the rods are set in such relation to the members of the respective pairs that one of these horseshoe-collars may be applied to the main shaft and the respective side rods, as stated above, their extremities dropping into the space between the respective pairs of nuts. The outer or rear nut of each pair is set out before this application so far that the horseshoe-collar may be forced up firmly against the fixed collar on the main shaft immediately in rear thereof by turning up the front nuts of each pair against the ends of the horseshoe. The rear nuts are then turned up against the other side of the horseshoe ends to hold them firmly in position. This mounting is shown in and will be understood from an examination of Figs. 9 to 12. The side rods mounted in the rear pedestals are held firmly against a forward thrust by reason of the shoulders at the front ends of the threaded sections, which set up against the supports of the rods, as already explained. Then the horseshoe-collars are firmly set in position by means of the nuts on the threaded rear ends of these rods, the nuts on the latter being sufficient to set these horseshoe-collars up against the fixed collars on the main shaft with all the force desired. The thrust force exerted on the shaft in operation therefore will be distributed among these parts and a very strong and sufficient resistance to such thrust force will be provided. The horseshoe-collars are preferably faced with bronze or some other good antifriction metal to secure a suitable contact with the fixed collars on the shaft.

The operation of this pump is as follows: The inlet to the cylinder is of course connected by a suitable conveyer with the body of water or any other material which the machine is adapted to move and the outlet is properly provided with any usual discharge and conducting device. The driving force is then set in operation and the main shaft rotated at a very high rate of speed, the rotation being in the direction indicated by the arrows in the drawings. Obviously this movement of the main shaft produces a corresponding rapid rotation of the hub G, with the spiral flanges mounted thereon. The effect of this rapid rotation of the winged hub will be to draw the water or other material through the inlet into the cylinder and force it back into the open space of the cylinder in rear of the blades, which may be called the "receiving-chamber." The shape of the blades is such that their action in this revolution is different from what are known as "rotary pumps" or "centrifugal pumps." In these latter well-known structures the normal action of the blades is to force the water or other material outward against the inside of the casing, but in the present improvement the action is almost directly opposite. The inward and forward curves of the blade edges described above act in their rapid revolution to turn the material inward toward the center of the cylinder or case instead of outward, and then their spiral form produces the usual effect of forcing the material backward, so that the rapid revolution of these blades draws the material into the cylinder or casing and then forces it backward therein, at the same time turning it in toward the center of the cylinder and driving it with great power into the receiving-chamber of the cylinder or casing in rear of the revolving hub and blades. The cutting away of the inner edges of the blades in front of the cone facilitates this action, as it provides a kind of free central space for the admission of material through the inlet. The function of the spiral blades in forcing the material back into the receiving-chamber is also facilitated by the backward bend at the rear end of each blade, which obviously assists in forcing the material into the receiving-chamber as it is delivered at the rear end of the revolving wings, for being bent backward it relieves the resistance to this delivery, the action being something in the nature of an incline acting to move some substance forward. This action would not be obtained if the rear end of the blade were straight instead of curved backward, and if the bend were in the opposite direction—that is, forward—it must be obvious that it would act in the opposite way and tend to obstruct rather than assist the forcing of the material into the receiving-chamber. The real effect of the revolving hub and blades is complex. The tendency when the material first enters is outward from the hub, but is also at once turned inward by the bent edges of the blades, so that the real movement is approximately central along the blades into the receiving-chamber, into which it is forced by this action, the result being facilitated by the backward bends at the rear ends of the blades. The water and other material which enter the pump are therefore forced into the receiving-chamber with a high

pressure, and under this compression they are forced out of the said chamber through the discharge or outlet opening.

The power of this pump is so great that it is adapted to effectually act not only on bodies of water, but also for pumping sand and gravel, even very coarse gravel, so that it is available as a substitute for dredges or steam-shovels in deepening harbors and rivers and other like purposes. As stated early in the description, the outlet is at the bottom of the receiving-chamber. Water of course will be driven out readily. Heavier material, such as sand and gravel, will fall by gravity more or less to the bottom of the receiving-chamber and will be carried out therefrom by the swirl and pressure caused by the rotating spiral blades. It is evident that the great force of the revolving hub and blades mentioned above will result in a very severe thrust force upon the main shaft in the direction of its length and toward the front end of the pump. An ordinary mounting of the shaft would be hardly sufficient to withstand this force, but the collar-mounting at the rear end thereof, described above, obviates this difficulty and resists the thrust force with perfect success. The main shaft is of steel. The hub, with conical head and flanges, is of cast iron, steel, bronze, or any suitable metal, and the spiral blades of steel. The inside cylinder and loose head serve as metallic linings for the pump, and preferably are made of chilled iron or steel, but any other metal may be used which will resist the wear to which it is subjected. It will be understood from the description that these linings may be removed from the outside cylinder or casing by detaching the front head of the latter and the pipes entering the sides thereof, thus providing for repairs or for the substitution of new lining, if required by wear. The tapering projection on the inside of the back cylinder-head, as described, is not lined; but, if desired, this head may also be lined with bronze or any material which is suited to resist the wear to which this part is subjected by the forcible movement of material around it through the action of the revolving blades. The side pipes entering the cylinder or casing are for the purpose of admitting water for priming the pump and for drawing off what may be left in the bottom of the cylinder, the pipe at the under side serving for the latter purpose and the upper pipe for the former.

In the description reference is made to the driving of the main shaft by means of a band-pulley thereon, which is shown in the drawings, but obviously the required motion may be given to the said shaft by gearing or any other suitable mechanism for applying force from its origin to the device to be driven.

The discharge-opening from the cylinder is arranged in the side of the cylinder, so that the front portion thereof will extend a little beyond the path of travel followed by the rear ends of the blades in revolution, as indicated in Fig. 1. This lapping of the blades slightly over the outlet facilitates the discharge, for the water and other material are taken promptly from the bent rear ends of the revolving blades.

In regard to the particular shape of the blades and their relation to their hub it is to be noted that the curvature or bend along the edges of the blades is of varying degree. The curve is greatest at the front end of the blade and is gradually decreased thence toward the rear end, where it is either entirely terminated or is very slight. This is indicated in Figs. 7 and 8, in which the dotted lines from 1 to 7 indicate the same transverse lines on the two figures and show that there is a gradual falling off in this edge curvature from the front to the rear end thereof.

The relation of the spiral blades is illustrated especially in Fig. 2, from which it will be seen—taking note of the narrow free spaces appearing at the rear or farther end of the blades in said figure—that the rear end of each blade is about on a line lengthwise with the front end of the next blade, the twist of the blades being calculated to accomplish this result, so that three blades practically cover and control the entire space and are therefore sufficient in number for the purpose intended. The suction is directly into the central opening at the front ends of the blades, where the inflow is caught immediately by the latter, thrown outward by first impulse, and then turned inward and backward by the peculiar shape of the blades, which are twisted spirally lengthwise and bent inward and forward at their edges.

The water-chamber in rear of the hub-bearings is another important element. The introduction of clean water into this little chamber under strong pressure keeps out of the bearings in front all of the fine sand which might otherwise work into the bearing of the hub in the tubular projection on the rear head. The pressure on the water introduced into this little chamber must be so great as to force it out through the bearing, like a lubricator, with sufficient power to prevent the entry of fine sand. The discharge of the small quantity of water required will of course be into the receiving-chamber of the pump.

A modification in the construction of the pump in some features is illustrated in Fig. 13 of the drawings. As shown in this figure, the outer shell O and the inner cylinder or lining O′ are the same as in the construction already described. The front head P, however, is different. Instead of being plain-faced it is bulged outward on circular lines, so that the shape of the body p is cancavo-convex, the outer or front surface being convex, while the inner surface is concave. A central nozzle p' projects from the front of this head, as in the former construction, and it is provided with a flange p^2, like the former. This construction is designed to accompany a change

in the revoluble pumping device. The rotating hub Q is the same as already described, and it is provided with like flanges q q' for the reception and fastening of the blades R. These blades are also in all main features like those heretofore described; but the relative arrangement of the parts is such that the front ends of the blades will project a little way from the front end of the cylinder when the latter is open. The concavo-convex form of the front head is designed to accommodate this arrangement of the blades, so that when the head is applied and fastened in position these front ends of the blades will be protected the same as before; but in order to permit this arrangement the front ends r of the blades are rounded upon a curve corresponding to that of the head. In other respects the construction is substantially the same as that shown in the other figures; but this change in the form of the front head and the front ends of the blades permits the cylinder proper to be shortened and yet perform the same amount of work as with the longer cylinder and straight-faced head first described and shown in the other figures, which obviously is some advantage in the manufacture of this machine. There is also another slight change shown in Fig. 13. The rear head S is in all respects the same as heretofore described, except that a small passage or channel s is run from the outside diagonally inward and downward to the central bushing for the main shaft U in the nose or projection s' on the inside of the back head. An aperture t is made in the bushing T, which is arranged so that this passage registers with the diagonal passage in the head. This is a passage for lubricating this bearing of the main shaft, which is accomplished by means of a can or ordinary oil-reservoir V, mounted outside of the back head and having a pipe v connecting with this passage. The upper side openings o o' in the cylinders are the same as in the construction previously described; but the opening o^2 at the under side of the cylinder is removed to the bottom of the discharge or outlet o^3 of the cylinder, and as the inner cylinder or lining does not extend over this the said aperture is only through the outer cylinder or main case.

It is also to be noted that in the construction of the cylinder, both as shown in Fig. 1 and in Fig. 13, the revoluble hub and spiral blades mounted thereon may be readily removed without dismantling the entire machine. In the construction shown in both figures the front head is readily detachable, as explained in the description above, and the front-head lining in the construction shown in Fig. 1 is separate and readily removable when the head is detached. Now, as already described, the blade-hub and main shaft are secured together by a threaded connection, and therefore when the front head of the cylinder is removed, as just described, the hub and blades may be detached from the shaft by simply turning backward while the shaft is held at rest. This action will soon disconnect the hub from the shaft, when the hub and blades are easily drawn out from the open end of the cylinder. This important part of the pump may therefore be connected to and disconnected from its driving-shaft readily and without serious disturbance of the other parts of the machine.

This connection is also advantageous for the reason that the thread on the spindle is cut in a direction so that it will tighten as the strain is imparted, and therefore the head never becomes loose on the spindle.

As already stated above, the mode of operation in this pump is different from that in rotary pumps heretofore known—such, for instance, as those called "centrifugal" pumps. As distinguished from such older and well-known pumps the present machine might be called a "rotating central-suction and central-discharge pressure-pump," which indicates the improved action of this pump.

In details of construction there may be many other modifications, and such mechanical changes are contemplated in the actual use of the pump without losing the essential features of the invention.

Having thus described my invention, what I claim to be new, and desire to secure by Letters Patent, is—

1. In a pump, a cylinder having inlet at one end and outlet at the other, in combination with a revoluble hub mounted in said cylinder; and blades fixed on said hub, twisted spirally lengthwise, and having their outer edges curved forward and inward as at h; substantially as described.

2. In a pump, a cylinder having an inlet at one end and outlet at the other, in combination with a revoluble hub mounted in said cylinder and blades fixed on said hub, said blades being twisted spirally lengthwise and having their rear ends curved slightly inward and backward, the curve being in a direction lengthwise of the blade.

3. In a pump, a cylinder having inlet at one end and outlet at the other, in combination with a revoluble hub mounted in said cylinder; and blades fixed on said hub, twisted spirally lengthwise, having their outer edges curved forward and inward as at h and their rear ends bent slightly backward as at h'; substantially as described.

4. In a pump, a cylinder having a central inlet in its front head and a side outlet at the bottom thereof and a little in front of the rear head; a revoluble hub mounted within the cylinder; and spirally-curved blades secured to said hub and extending back from the front cylinder-head a little beyond the front portion of the discharge-opening; substantially as described.

5. In a pump, a cylinder provided with suitable inlet and discharge openings and having a projection on the inside of the rear head, in combination with a revoluble hub; a cylin-

drical section, g', integral with the hub, and journaled in said projection; spiral blades secured to said hub; a main or driving shaft also journaled at one end in the rear cylinder-head, the said two journal-bearings being separated to provide a small annular chamber around the shaft; and a water-pipe opening into said annular chamber, whereby water may be forced into said space under pressure; substantially as described.

6. In a pump, a cylinder having its front head provided with a cylinder-inlet opening, and air-outlet opening at the rear head of the cylinder, in combination with a revoluble hub journaled in the cylinder and located at a point between the said inlet and outlet openings, blades, curved spirally lengthwise, fixed to the hub and extending outward therefrom to the front cylinder-head, and having the inner approaching edges of their outward-extending portions cut away on a substantially straight line from the edge of the inlet-opening to the hub to provide a free space between these edges around the inlet, substantially as described.

7. In a pump, a cylinder, in combination with a revoluble hub mounted within said cylinder, having a conical head provided with flanges, g^3 g^4, standing a slight distance apart in pairs, and running spirally lengthwise of said head; and blades bent spirally lengthwise and having their inner edges set into the spaces provided by the respective pairs of flanges and secured thereto; substantially as described.

8. In a pump, a cylinder provided with inlet and outlet openings, in combination with a revoluble hub, G, journaled within the cylinder, and constructed with a cone-shaped head, g, having flanges, g^3 g^4, running spirally lengthwise of the cone, with the back flange, g^4, considerably wider than the other; and blades, H, bent spirally lengthwise, to correspond with said flanges, seated in the respective spaces provided by the respective pairs of flanges and fastened to the latter; substantially as described.

9. In a pump, a cylinder having its front head provided with a central inlet-opening, in combination with a conical hub mounted to revolve within the cylinder at a point in rear of the front head, a series of blades fixed on the conical portion of said hub and extending outward therefrom to the front cylinder-head and having the inner approaching edges of their outwardly-extending portions cut away to provide a free space between these edges and the peripheral edges of the inlet-opening, said blades being curved spirally lengthwise on a pitch which brings the front end of each blade about in the same plane with the rear end of the next preceding blade, substantially as described.

10. In a pump, a cylinder, in combination with a revoluble hub mounted therein; and blades on said hub, bent spirally lengthwise and curved forward and inward at their outer edges, the said edge curve being widest at the front end of the blade and gradually diminishing in width toward the rear end thereof; substantially as described.

11. In a pump, a cylinder provided at its front end with a central inlet-opening, at its rear end with an annular chamber surrounding a projection upon the rear wall and with a tangential discharge-opening; a shaft journaled in the said rear wall projection; a conical hub mounted on the end of the shaft within the cylinder, some distance back from the inlet-opening; and blades secured to the cone of the hub, twisted in both spiral and volute form, and extending out in front thereof to the front cylinder-head, the inner edges of the said projecting ends being cut away, the outer edges of the blades being curved inward as at h, and their rear ends bent backward as at h'; substantially as described.

12. In a pump, a cylinder having an inlet at one end and an outlet near the other, in combination with a revoluble hub arranged in said cylinder at a point between the said inlet and outlet openings, and blades fixed on said hub, twisted spirally lengthwise and having their front portions projecting forward to near the front head of the cylinder, and their rear portions terminating on a line substantially parallel with the rear end of the hub so as to leave a free annular space around the hub-bearing between the blades and rear head of the cylinder.

13. In a pump, a cylinder having an inlet at one end and a side outlet near the other, in combination with a revoluble hub arranged in said cylinder at a point between the said inlet and outlet openings, and blades fixed on said hub, twisted spirally lengthwise and having their front portions projecting forward to near the front head of the cylinder, and their rear portions terminating on a line substantially parallel with the rear end of the hub so as to leave a free annular space between the blades and rear head of the cylinder, said blades having their outer edges curved forward and inward as at h and their rear ends bent slightly backward as at h', substantially as described.

LEON DELBERT LIBBEY.

Witnesses:
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