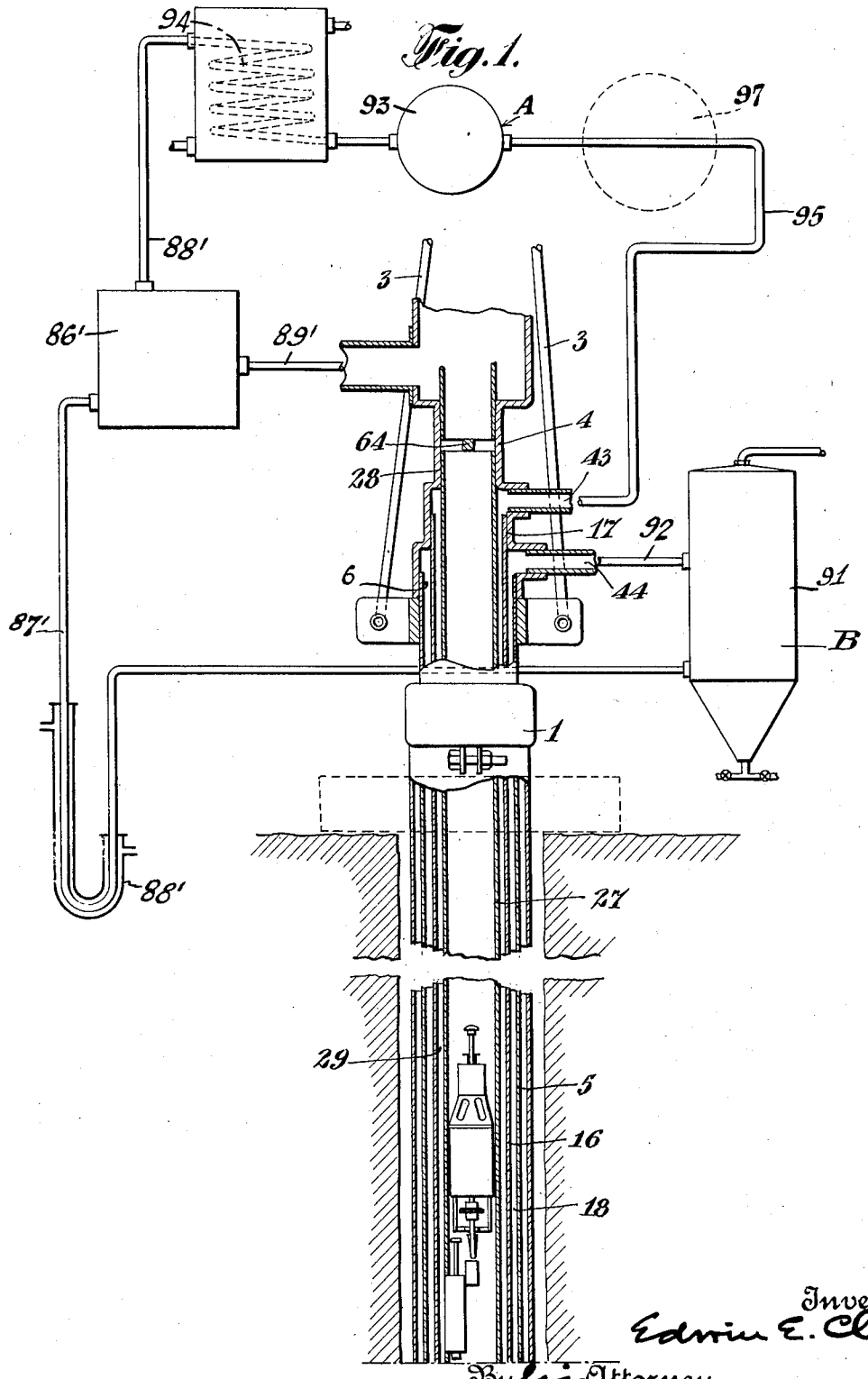
Aug. 18, 1931. E. E. CLAYTOR 1,819,994

FLUID LIFT FOR LIQUIDS

Original Filed March 4, 1925 6 Sheets-Sheet 1

Fig. 1.



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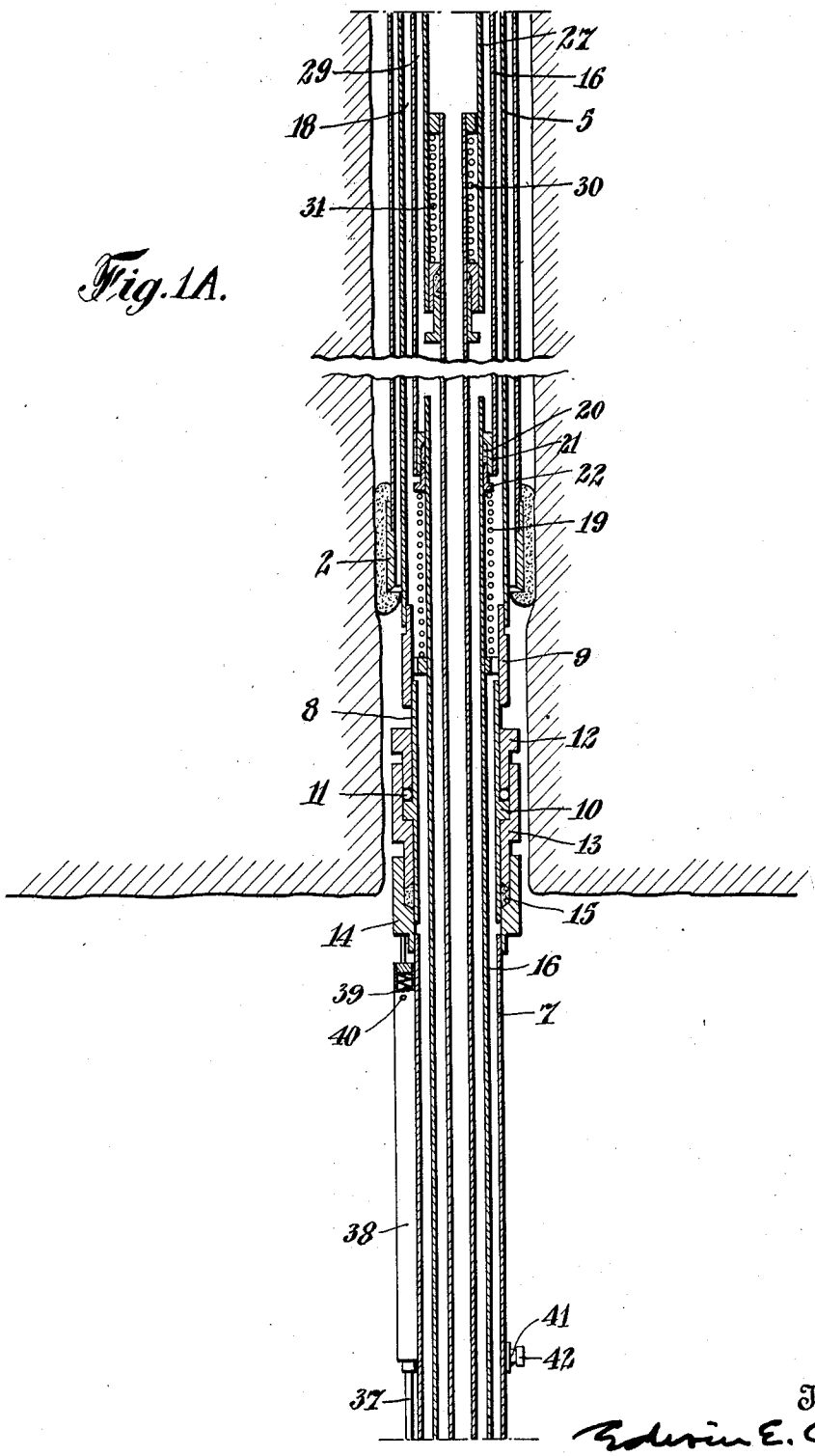
FLUID LIFT FOR LIQUIDS

Original Filed March 4, 1925 6 Sheets-Sheet 2

Fig. 1A.



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FLUID LIFT FOR LIQUIDS

Original Filed March 4, 1925 6 Sheets-Sheet 3

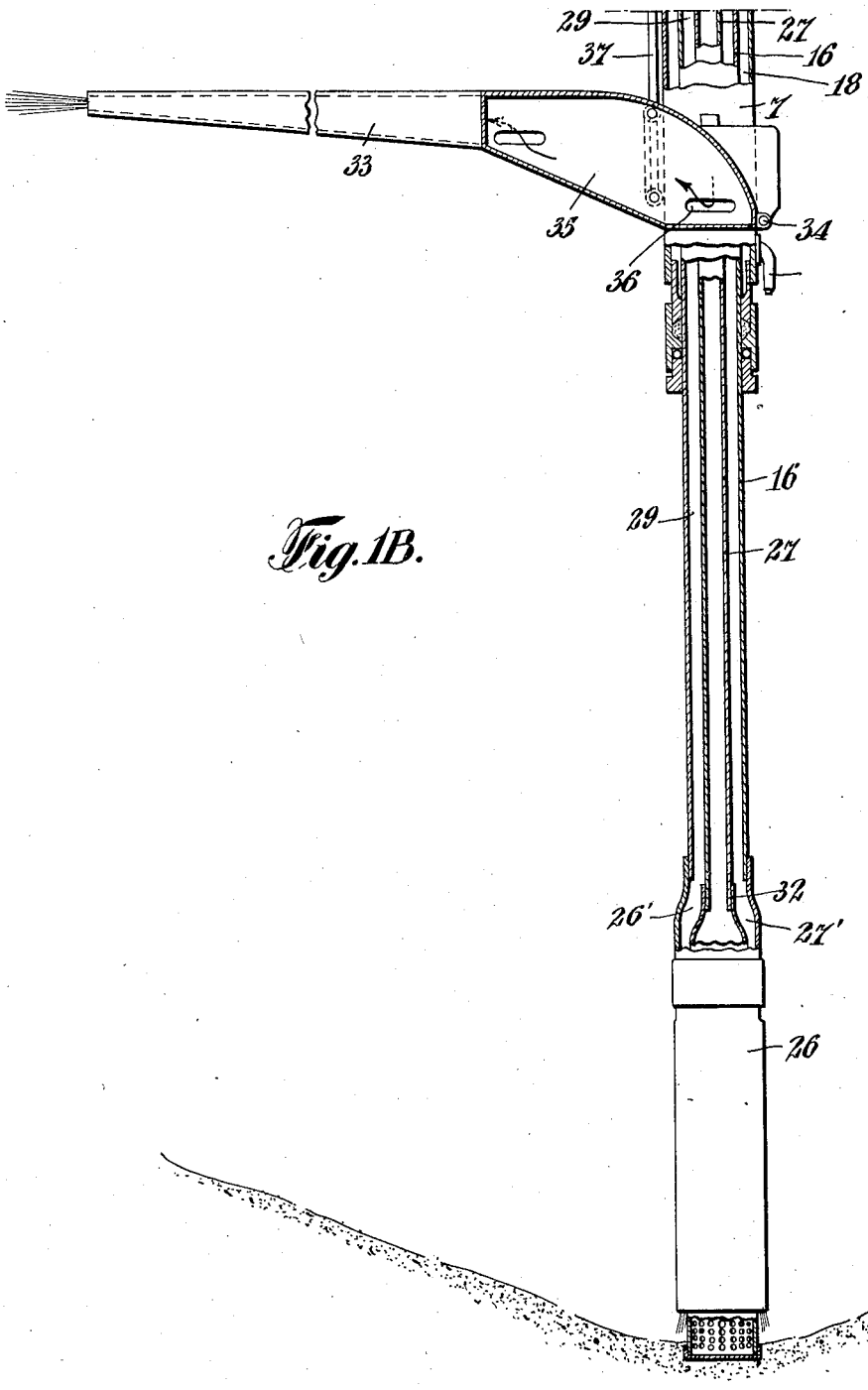

Fig. 1B.

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FLUID LIFT FOR LIQUIDS

Original Filed March 4, 1925 6 Sheets-Sheet 4

Fig. 9.

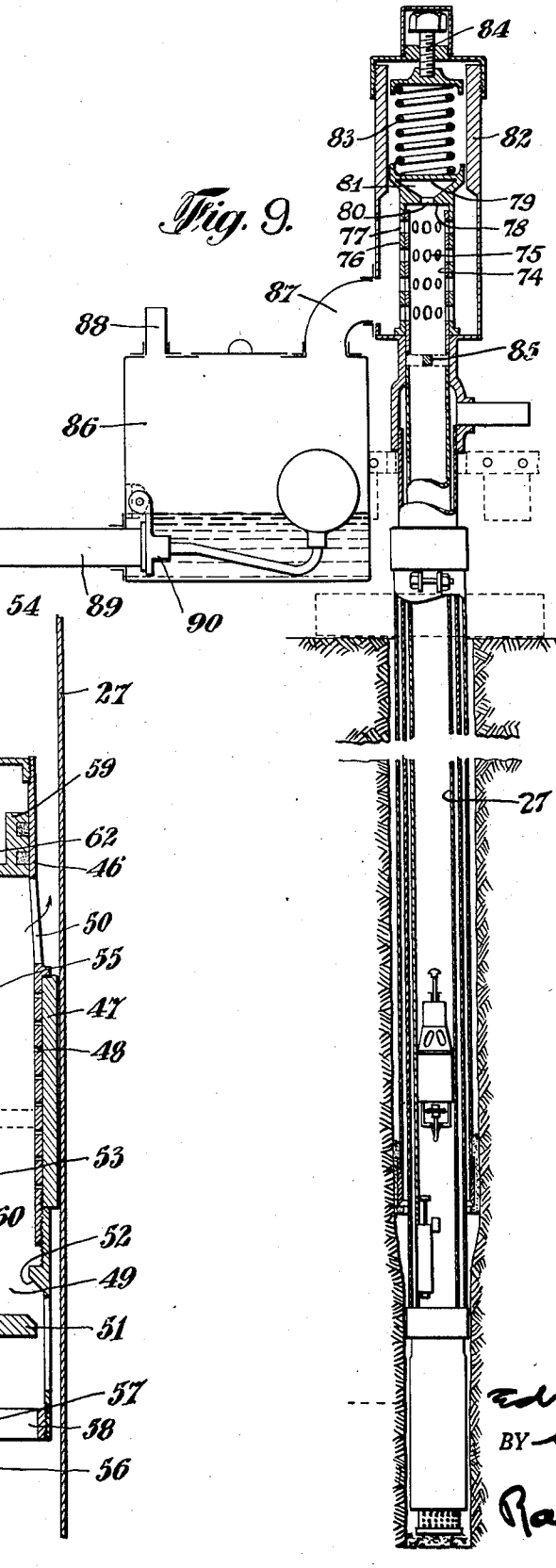
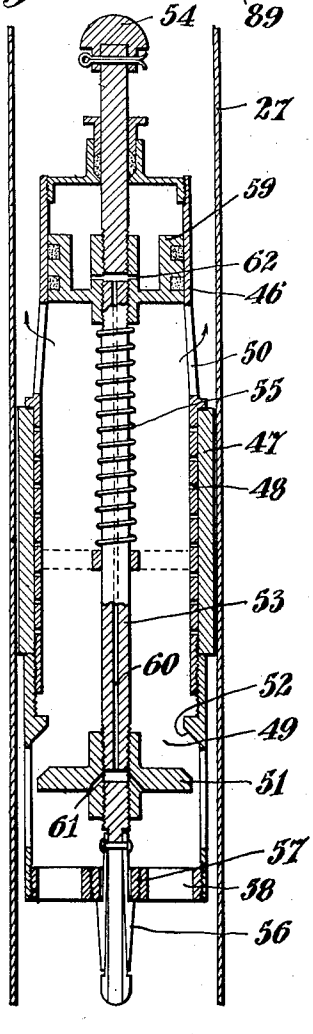


Fig. 2



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FLUID LIFT FOR LIQUIDS

Original Filed March 4, 1925 6 Sheets-Sheet 5

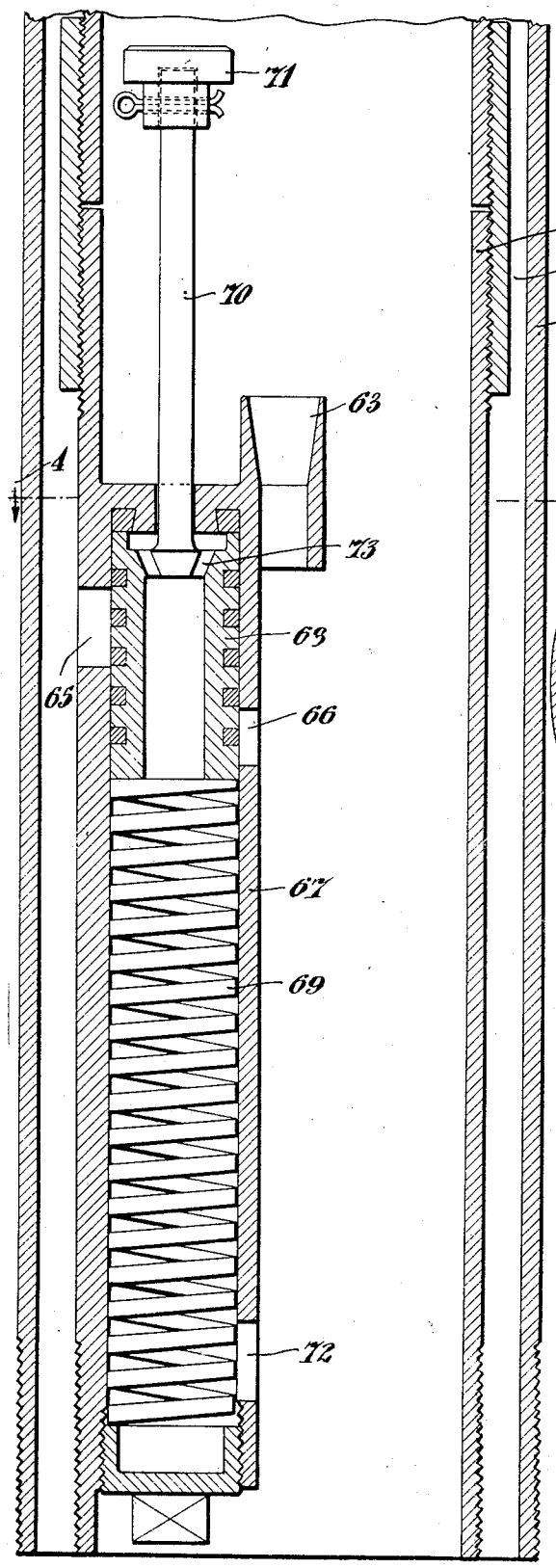

Fig. 3.

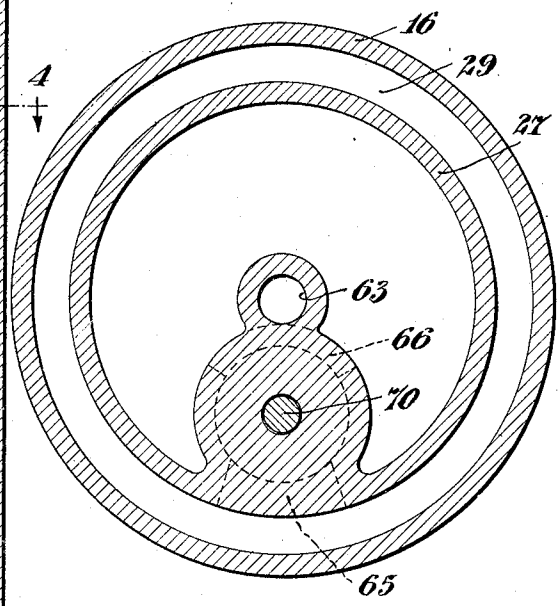

Fig. 4.

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FLUID LIFT FOR LIQUIDS

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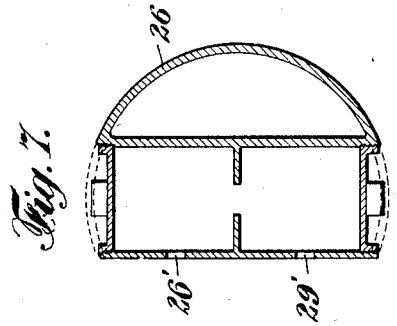

Fig. 7.

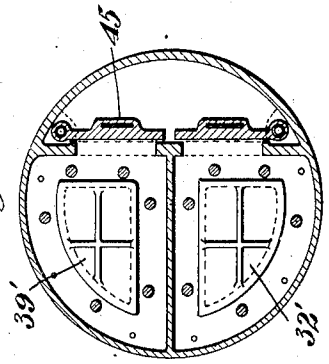

Fig. 8.

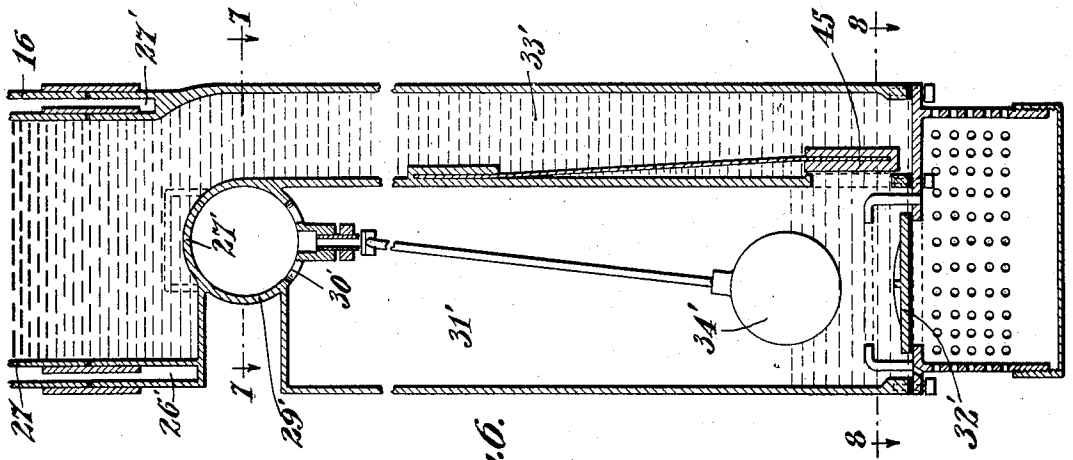

Fig. 6.

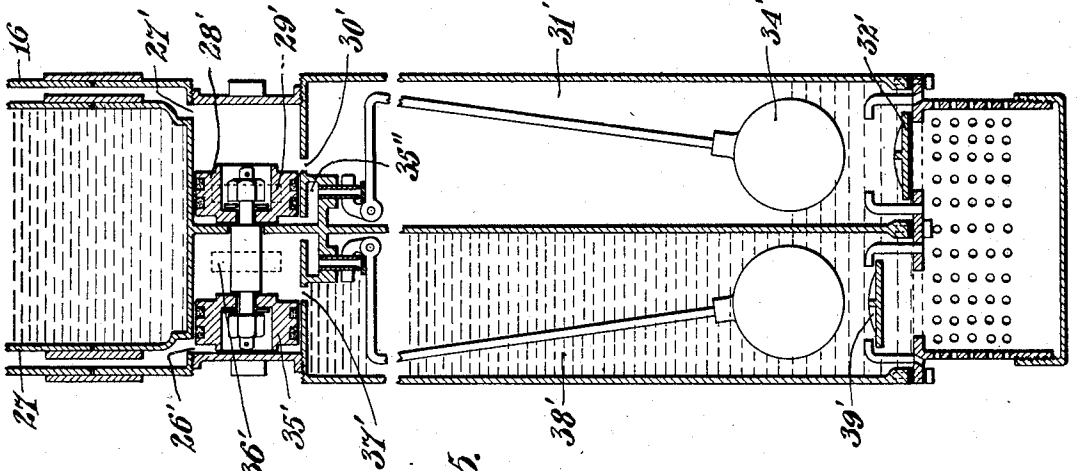

Fig. 5.

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Patented Aug. 18, 1931 1,819,994

UNITED STATES PATENT OFFICE

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FLUID LIFT FOR LIQUIDS

Application filed March 4, 1925, Serial No. 13,011. Renewed October 21, 1926.

This invention relates to the method and apparatus for lifting liquids.

The principal object of the invention is to elevate liquids to great heights if desired by the utilization of the force exerted by fluid under pressure, and by the utilization of the force developed by the expansion of a fluid under pressure.

As illustrative of the method and of the means for elevating the liquid I will describe the invention in conjunction with the elevation of oil, for instance, from a well, and will, for convenience of description, describe the operation in connection with the use of air. However, it is to be understood that the invention is not limited to this application, or to the particular elevating medium.

In the drawings, which illustrate the particular embodiment selected for the purpose of description,

Figures 1, 1A and 1B constitute a sectional view of the complete device;

Figure 2 is a sectional view of the swab employed;

Figure 3 is a sectional view of the means for controlling the flow of air;

Figure 4 is a horizontal sectional view on the line 4—4 of Figure 3;

Figure 5 is a sectional view of the pump for increasing the effective level or submergence of the liquid to be raised;

Figure 6 is a similar view taken at right angles to Figure 5;

Figure 7 is a sectional view on line 7—7 of Figure 6;

Figure 8 is a sectional view on the line 8—8 of Figure 6; and

Figure 9 is a sectional view showing another form of my device.

The embodiment of the invention illustrated includes a well casing 1, which is adapted to be lowered into a well and sealed therein by a casing shoe 2, in the usual manner. The apparatus which is adapted to be inserted in or withdrawn from the well through the well casing by means of an elevator, the links 3 of which are shown in the drawings, includes a tubing head 4. A relatively large tube 5 is attached at 6 to this tubing head and carries a "giant" at its lower end. This "giant" includes a tube 7 which is rotatably supported on the lower end of the tube 5. The means for supporting the "giant" rotatably on the lower end of the tube 5 includes a sleeve 8 which is attached to the tube 5 by a collar 9. This sleeve 8 carries a race 10 for anti-friction bearings, which, in the embodiment illustrated, are shown as balls 11. An upper race 12 carries a ring 13 which in turn carries a ring 14, between which rings and the sleeve 8 a packing 15 is disposed. The tube 7 is secured to the lower end of the ring 14.

A relatively smaller tube 16 is attached at 17 to the head 4, providing a space 18 between itself and the tube 5. This tube 16 extends within the tube 5, and is provided with a telescopic joint, the sections being urged apart by a spring 19. This yielding telescopic joint is provided to take up the shock of impact of the apparatus with the bottom of the well when it is being lowered.

The outer tube 5 is sealed at its lower end with respect to this next adjacent tube 16, but is permitted to rotate with respect thereto. This sealing is effected by a packing 20, which is confined between glands 21 and 22, carried by the lower end of the tube 5. The tube 16 carries at its lower end, in the embodiment illustrated in the drawings, a displacement pump 26, the purpose of which will later be described. A relatively smaller tube 27 is carried by the head 4, being attached thereto at 28. This tube 27 extends within the tube 16, and, being of less diameter than the latter, forms a space 29 between itself and the tube 16. This tube 27 is provided with a telescopic joint 30, the sections being urged into limited telescopic arrangement by resilient means such as the spring 31, which permits relative movement between the sections of the two when the apparatus is being lifted from the well, and thereby absorbs the shock incident to the lifting.

The inner tube 27 is attached at 32 to the pump 26, so that it may receive the liquid from the pump while the latter is in operation.

A nozzle 33 is pivoted at 34 to the outer

tube 7 of the "giant", and is provided with a head 35 which is divided into two chambers disposed upon opposite sides of the tube 7. These chambers have ports 36 therein, which, when the nozzle is in its horizontal position, register with similar ports in the tube 7. It is, of course, to be understood that in order to have the preferably fluid-tight joint between these ports it is necessary that the contacting surfaces be complemental. This effect may be produced by making the tube 7 rectangular in cross section and by making the adjacent faces of the head of the nozzle flat and adapted to contact with the flat faces of the tube. When, however, the nozzle is swung to a vertical or downwardly-extending position, the ports 36 in the head 35 are moved out of registration with the ports in the tube 7 and the unbroken surfaces of the head are moved into position to cover the ports in the tube 7.

In order that the nozzle may be automatically raised and supported in its raised or horizontal position, I have attached to the head 35 a rod 37, which operates within a housing 38, and is normally moved upwardly by a spring 39 therein. This spring is prevented from operating until the desired time by a pin 40, which maintains it under compression. The details of the construction of this portion of the mechanism are set forth completely in my Patent No. 1,612,611, dated Dec. 28, 1926.

Located above the nozzle 33 is a stationary nozzle 41, which is adapted to be closed by a cap 42 having a relatively small orifice therein.

The tube 16 has communication with an inlet 43, which extends to a suitable source of supply of compressed air, as, for instance, to the outlet of an air compressor A, so that the space 29 between the tube 27 and the tube 16 is supplied with air under pressure. Moreover, the tube 5 is supplied with a mining solution, that is to say, one which is capable of separating oil from the oil-bearing sand, when ejected from the nozzles of the "giant," through a suitable connection 44 to a source of supply B, the solution being conveyed to the nozzles 33 and 41 through the tube 5, and the "giant" tube 7. The air under pressure is conveyed through the tube 16 to the pump 26 so as to operate the same to elevate the liquid in the inner tube 27 to a point where it may be picked up and further elevated by means which will later be described.

This pump is substantially tubular in form so that it may be lowered into the well through the well casing, and is provided with a pair of inlet ports 26′ and 27′ for the compressed air. This air is adapted to escape alternately into chambers 31′ and 38′ through ports 30′ and 37′, when these ports are alternately uncovered by slide valves 28′ and 35′ each of which valves in one position opens the adjacent inlet port and in the other position opens the adjacent exhaust port 29′ or 36′. The chambers 31′ and 38′ are adapted to receive the liquid from the pool through valves 32′ and 39′ by gravity. The liquid will be expelled from these chambers 31′ and 38′ through valves 45 and thus by the air pressure elevated in the tube 27. In order that the slide valves 28′ and 35′ may be moved to alternately cover the ports 30′ and 37′ and the ports 28′ and 36′ for the air which is supplied through the ports 26′ and 27′, I have provided ports 35″ which are opened by float valve 34′ when the level of the liquid in the adjacent chamber falls to a predetermined point.

The lower end of the inner tube 27 must be closed by a valve which will permit the inflow of liquid, but prevent the outward flow. For instance, when the pump is used, a valve is located as at 45.

In order that the liquid may be raised from the level which it assumes either because of its own level within the well, or because of its elevation by the artificial means at the lower end of the inner tube 27, I have provided an automatically operable swab which reciprocates within the inner tube 27 and lifts the liquid therefrom. This swab includes a mandrel 46 which carries a packing 47 to seal the joint between the swab and the tube in the usual manner, that is to say, by the pressure of the liquid exerted on the packing 37 through the perforations 48 in the mandrel. The lower end of the mandrel is provided with an opening 49, while at the upper end there is a series of openings 50. The provision of openings 49 and 50 permits the liquid to flow through the swab. However, the opening at the lower end of the mandrel is adapted to be closed by a valve 51 which cooperates with a valve seat 52. This valve 51 is mounted on a valve rod 53, the upper end of which protrudes beyond the mandrel and is provided wth a buffer 54. The valve is normally urged into its closed position, that is to say, on to the seat 52, by means such as a spring 55, but is at times held in its open position by the engagement of releaseable means 56. This means in the form illustrated in the drawings includes flat springs which are adapted to be compressed to permit their passage through an opening 57 in a spider 58, which guides the lower end of the valve rod, or to be expanded to engage the lower surface of this spider to retain the valve in its open position.

In order that this valve may be balanced so that it will be subject to operation by the action of the spring 55, I have secured to the valve rod 53 a piston 59 which operates in the upper end of the mandrel as a cylinder. A port 60, having outlets 61 below the valve 51, extends through the valve rod and communicates at 62 with the cylinder above the

piston 59. The area of the upper surface of the piston 59 and the area of the lower surface of the valve 51 are equal, substantially, to produce a balancing effect.

Thus, when the valve 51 is moved downwardly by impact with the buffer 54, it will be locked in its open position by the locking means 56, and the fluid permitted to flow through the openings 49 and 50, at the same time the fluid will pass through the port 60 so as to exert pressure on the piston 59. When the locking means 56 is released the spring 55 will automatically close the valve 51 against the seat 52, and the flow of liquid through the mandrel stopped, and the liquid which is located above the swab will be maintained in such position.

In order that the valve 51 may be closed when the swab reaches the lowermost extent of its downward travel, I have provided a trip 63 into which the lower end of the valve rod 53 descends. The wall of the trip 63 is of inverted frusto-conical shape, so that as the valve rod descends into the trip the springs 56 will be compressed to an extent sufficient to permit them to move upwardly through the opening 57 in the spider 58, and thus permit the operation of the spring 55.

In order that the valve 51 may be opened when the swab reaches the uppermost extent of its travel, I have provided an abutment 64 within the tubing head, which abutment is engaged by the buffer 54 at the upper end of the valve rod 53. The result of this engagement is the opening of the valve 51 and the movement of the valve rod, and the locking springs 56 through the spider 58, to an extent sufficient to permit said locking springs to come into operation, that is to say, to engage the lower surface of the spider 58.

In order that the swab may be automatically moved upwardly after the swab has been submerged, or, in other words, after a quantity of the liquid has been accumulated above the swab and the valve in the swab closed, and in order that it may be permitted to move downwardly after the liquid has been ejected from the tube 27, I have provided the following means: Communication is established between the tube 16, which conducts the pressure medium from the source of supply, and the tube 27, in which the liquid is elevated, by means of ports 65 and 66, the former leading into a cylinder 67 from the tube 16 and the latter leading from the cylinder into the tube 27. In this cylinder 67 a valve 68 is adapted to reciprocate to assume positions to destroy communication between the ports 65 and 66, or to permit the establishment of communication between the two. This valve is normally urged into a position to destroy communication between the ports by automatic means, such as a spring 69, and is provided with a valve stem 70, which extends upwardly through the head of the cylinder 67 and is provided with a buffer 71. This buffer 71 is disposed in the path of movement of the swab, and is adapted to be engaged by the lower end of the same in the downward movement of the swab which engagement moves the valve downwardly against the action of the spring 69 and permits the establishment of communication between the ports 65 and 66.

In order that the pressure on both sides of the valve 68 may be equal, and the valve therefore balanced, and in order that the cylinder may at the same time be kept clear of any foreign material which would impede the operation of the valve, or of the spring 69, I have provided the cylinder 67 with an orifice 72 which admits liquid into the cylinder 67 below the valve. The face of the valve adjacent the orifice 72 is substantially equal in area to the face of the valve remote from said orifice and the valve is provided with ducts 73, which permit the liquid to pass from the cylinder 67 through the valve so that the liquid exerts its pressure against both faces of the valve to an equal extent. Thus the spring 69 will be relieved of the necessity of working against an unbalanced valve, as will also the swab. Furthermore, in the movement of the valve 68 within the cylinder, the liquid is drawn into and expelled from the cylinder so that the cylinder is effectively scoured or freed from any foreign material which might otherwise impede the action of the valve or of the spring.

When the device is to be used merely as an elevating device without the mining feature the arrangement is such as shown in Figure 9, the tube 5 of the arrangement already described being omitted. In this construction the liquid is ejected by the following means:

A pipe 74 having an open end, and a series of ports 75, is mounted on the tubing head and forms in effect an extension of the tube 27. A sleeve 76 having ports 77 therein, adapted to be moved into and out of register with the ports 75 of the pipe 74, is mounted to slide upon said pipe. The upper end of this sleeve 76 is provided with a surface 78 against which the liquid which is ejected from the tube 27 is adapted to impinge, and is provided with a second surface 79 between which and the first surface communication is established through an orifice 80. The area of the impinging surface 78 bears a definite relation to the area of the surface 79, the surface 79 being in area greater than the surface 78, so that while the liquid impinging against the smaller surface 78 gives the sleeve an initial movement, the pressure of the liquid on the larger surface 79 will give it a second movement, or will complete the movement initiated upon

the contact of the liquid with the first surface 78. The purpose of the relatively small orifice 80 is so that the liquid, after giving the initial movement to the sleeve by the pressure which it exerts upon the surface 78, will pass slowly into the chamber 81 and against the surface 79, the result being a period of rest in the travel of the sleeve for a purpose which will later appear.

Prior to the movement of the sleeve 76 the ports 75 and 77 are aligned with each other, but during the initial movement caused by the pressure exerted against the surface 78 this communication or alignment of the ports is destroyed, and the liquid exerts its pressure against the surface 78. After a momentary arresting of this movement of the sleeve, the liquid passes through the orifice 80 into the chamber 81 and exerts its pressure against the surface 79 or against any compressed air which may be built up between said surface and the upper surface of the liquid to give the sleeve a second movement into a position where the ports again register. The sleeve 76 operates in a housing 82, preferably rectangular in cross section, which may be formed as part of the tubing head. The sleeve 76 is normally urged downwardly into a position where the ports in the sleeve align with the ports in the pipe 74 by compressible means such as a spring 83. The pressure which is exerted by such means against the sleeve 74 may be regulated to adapt the sleeve to be moved upwardly by any desired pressure. When a spring such as shown in the drawings is used, this regulation may be made by means of an adjusting screw 84.

Disposed below the pipe 74, or in other words, adjacent the upper end of the tube 27, is an abutment 85, against which the buffer 54 on the end of the valve rod 53 of the valve 51 may impinge to open the valve against the action of the spring 55. The cylinder 82 communicates with a receiving tank 86, through the conduit 87, this tank being in communication with the tube 27 through the ports of the pipe 74, and the sleeve 76, when these ports are in alignment with each other. An air exhaust conduit 88 extends from the tank 86 and may be connected to a compressor (not shown) which supplies the air under pressure to the air inlet 43. This tank is also provided with an outlet 89 which is adapted to be closed by a float valve 90.

Of course it is desirable to have the mining solution which is ejected from the nozzles at a relatively high temperature to free the oil from the inert material as described in my Patent No. 1,612,611, and irrespective of the pressure of the air which is used to lift the liquid it is desirable to have the temperature of this air relatively high. In some instances, however, it is desirable to use air at a relatively low pressure, while at others is is desirable to use it at a relatively high pressure. Into a tank 91 a pipe 89 discharges the mixture of oil and mining solution through a receiving tank 86′ and a pipe 87′ having a heat exchanger 88′ therein. The constituents of the liquid and the solid material which is entrained therewith arrange themselves according to their specific gravity, and the mining solution, having separated from the oil, and the solid or inert material, is withdrawn through a pipe 92 and conveyed thereby to the solution inlet 44, where it is returned to the apparatus. The air which is exhausted from the pipe 88′ of the receiving tank 86′ (which is of the construction shown in Figure 9) is carried to an air compressor 93 having its temperature reduced prior to its entrance into the compressor by a suitable cooler 94. The air being compressed by the compressor 93 is lead to the air inlet 43 by a pipe 95. During the compression of the air its temperature is, as a result of the compression, raised to such a degree that it will enter the apparatus at the desired working temperature. Of course during the ascent of the liquid in the tube 27 it will absorb some of the heat of the air in the tube 16, and the temperature of the liquid will therefore be raised to such a degree that it is desirable to reduce it. This may be done by the heat exchanger 88′, which may be used in conjunction with the inlet pipe 87′, of the settling tank. The reduction of this temperature assures the re-entry of the mining solution into the apparatus at a lower temperature so that in its descent through the tube 5 and the absorption of heat incidental to its passage through this tube, its temperature will not be raised beyond one desirable in operation.

Under some conditions at least it is desirable to raise the temperature of the air after it passes from the compressor, and to provide for the raising of the temperature of the air I contemplate the interpolation of a re-heater 97 in the pipe 43, which extends from the compressor to the apparatus.

In operation, the mining solution is conveyed by the pipe 92 from the settling tank 91 to the inlet 44. This solution is under pressure due to the head created by the solution stored in the tank 91, and to the pressure in the system. The solution is conveyed by the pipe 5 to the nozzles 33 and 41, the nozzle 33 having assumed its operative or horizontal position after the creation of a chamber in the well in the manner such as described in by Patent 1,612,611 hereinbefore referred to. The ejection of the mining solution from the nozzle 41 causes the rotation of the tube 7 of the "giant" and consequently the rotation of the nozzle 33. The solution ejected from these nozzles 41 and 33 frees the oil and inert material from the wall of the chamber

and causes them to flow to the bottom of the well, at the same time, because of the character of the solution, it frees the oil from the inert material.

In some cases the surface level of the pool of liquid in the well will not be sufficiently high to rise above the position of the swab when it reaches the lowermost end of its travel and, in that event, the pump 26 is employed to elevate the liquid above the swab. The purpose of the pump 26 is to raise the liquid sufficiently to submerge the swab. If there is sufficient head of liquid in the well to cause it to rise high enough to submerge the swab, the pump may be dispensed with. When the swab is at the lowermost point of its travel, the valve 68 is held open thereby, that is to say, is moved against the tension of the spring 69 so that the air is permitted to enter the tube 27 through the ports 65 and 66 below the swab. At this time the valve 51 of the swab is closed, its closing being effected at the end of its downward travel by the engagement of the springs 56 with the trip 63. The entry of the air below the swab, because of its pressure, moves the swab upwardly, carrying before the swab the liquid which forms a column above it in the tube 27.

During the upward travel of the swab and the column of liquid above it, the air in the tube 27 which is arranged above the column of liquid is expelled through the aligned ports 75 and 77 of the pipe 74, and the sleeve 72. When the liquid impacts with the surface 78 of the sleeve 76 the sleeve is moved upwardly and the aligned ports moved out of alignment so that the sleeve forms in effect a closure for the perforated pipe 74.

During the period of time the sleeve 76 remains in this position, and when it is thus positioned, the swab has not yet reached the abutment 85. The pressure below the swab in the tube 27 is at this time equal to the pressure in the tube 16, so that the valve 51 automatically closes. Furthermore, the pressure on the liquid above the swab when the sleeve 76 closes the ports in the pipe 74 forces the liquid into the chamber 81 through the orifice 80, so that it will exert pressure upon the surface 79 or the air compressed against said surface, and cause the sleeve 76 to rise into such position that the sleeve will uncover the ports 75 by aligning its own ports 77 therewith. At this time the valve 51 is closed and air under pressure is confined below the swab and above the liquid which occupies the lower end of the inner tube 27. The subsequent expansion of this air causes the upward movement of the swab and the ejection of the liquid through the aligned ports 75 and 77, and into the tank 86 until the buffer 54 on the upper end of the rod 53 of the valve 51 engages the abutment 85 at which time the valve 51 will be opened. When the valve 51 is opened, the air behind the swab escapes through the aligned ports 75 and 77, and the swab automatically returns to its lowermost position for a repetition of the cycle.

The air which escapes from the pipe 74 both before and after the escape of the liquid from this pipe, passes into the tank 86 and escapes through the pipe 88 to the compressor 93 being, as hereinbefore stated, cooled prior to its passage into the compressor. It is then compressed and returned in a heated condition to the air inlet 43 to again be used.

It is, of course, to be realized that in the treatment of some oils there may be some condensible vapors formed, and these of course will pass off with the air and be condensed in the cooling and compression system, and may be recovered therefrom.

When the air passes through the tank 86, the liquid level therein is relatively low and the valve 90 closed, but as the liquid passes into the tank the level rises, and the float valve opens the tank so that the liquid may pass to the settling tank 91 as previously described.

It is to be noted that immediately upon the pressure being released from the head of the sleeve 76, the sleeve returns to its initial position, that is to say, it is lowered and the ports in the sleeve align with the ports in the pipe.

When a pump 26 of the design shown in Figures 5 and 6 is used, the air passes through the ports 26′ and 27′ from the tube 27 alternately into the pump.

When the valve 28′ is in the position illustrated in Figure 5 of the drawings, it closes the exhaust port 29′ and opens the port 30′ into the chamber 31′. This air pressure ejects the liquid in this chamber, the inlet valve 32′ being closed, through the spring-pressed valve 45 into the lower end 33′ of the tube 7 through which it is raised by the air pressure to create an artificial liquid level so that the proper submergence of the swab may be had. When the level in the chamber 31′ reaches a predetermined point, the float valve 34′ opens the duct 35 and permits air to flow behind the valve 29′. This valve, being balanced by the air in the port 26′, moves the valve 29′ to a position where it will close the port 27′ and at the same time moves the valve 35′ so that it will close the exhaust port 36′ and open the port 37′ to permit the air to force the liquid from the chamber 38′, the liquid having filled this chamber during the expulsion of the liquid from the chamber 38′ by flowing into the same through the open valve 39′. The liquid is forced from this chamber 38′ in the same manner it is forced from the chamber 31′, and this alternate operation of the pump, that is, the alternate expulsion of the liquid from the chambers, creates a constant flow of liquid upwardly in the tube 27.

Thus it will be seen that I have provided a

method and apparatus for separating the oil from the inert material and elevating the oil irrespective of the depth of the well.

It is of course to be understood that the pool of oil in the well may be natural or artificial, and in this event I dispense with the use of the nozzles and the mining solution, and use a swab and its associated parts to elevate the already existing oil of the pool. Moreover, the invention is not confined to the elevation of oil, as has hereinbefore been stated, but it is obvious that it is applicable to other uses with equal facility and satisfactory results.

What I claim is:

1. Apparatus of the character described, comprising in combination, a casing, a swab operable therein, a valve carried by the swab, latch means for holding the valve open, a spring for holding the valve closed, means carried by an upper part of the casing for opening the valve and setting the latch, means in a lower part of the casing for releasing said latch to allow the spring to close the valve, and means in the lower part of the casing, controlled by the swab, for admitting compressed gas to the casing for raising the swab.

2. Apparatus of the character described, comprising in combination a casing, means for supplying a pressure medium near the lower end of the casing, a swab movable in the casing under the action of said pressure medium, a valve carried by said swab to control flow through the swab, a spring for normally maintaining said valve in closed position and means for maintaining equal pressure on both sides of the valve.

3. Apparatus of the character described, comprising in combination a casing, means for supplying a pressure medium near the lower end of the casing, a swab movable in the casing under the action of said pressure medium, a valve carried by said swab to control flow through the swab, a spring for normally maintaining said valve in closed position and means for maintaining equal pressure on both sides of the valve, said means including a piston secured to the valve stem and operable in a cylinder which is closed by the piston and a duct establishing communication between the cylinder and the casing below the valve.

In testimony whereof, I have signed my name to this specification this 11th day of February, 1925.

EDWIN E. CLAYTOR.