

July 31, 1934.

A. BOYNTON

1,968,633

AUTOMATIC HEADING DEVICE

Filed Oct. 21, 1932

2 Sheets-Sheet 1

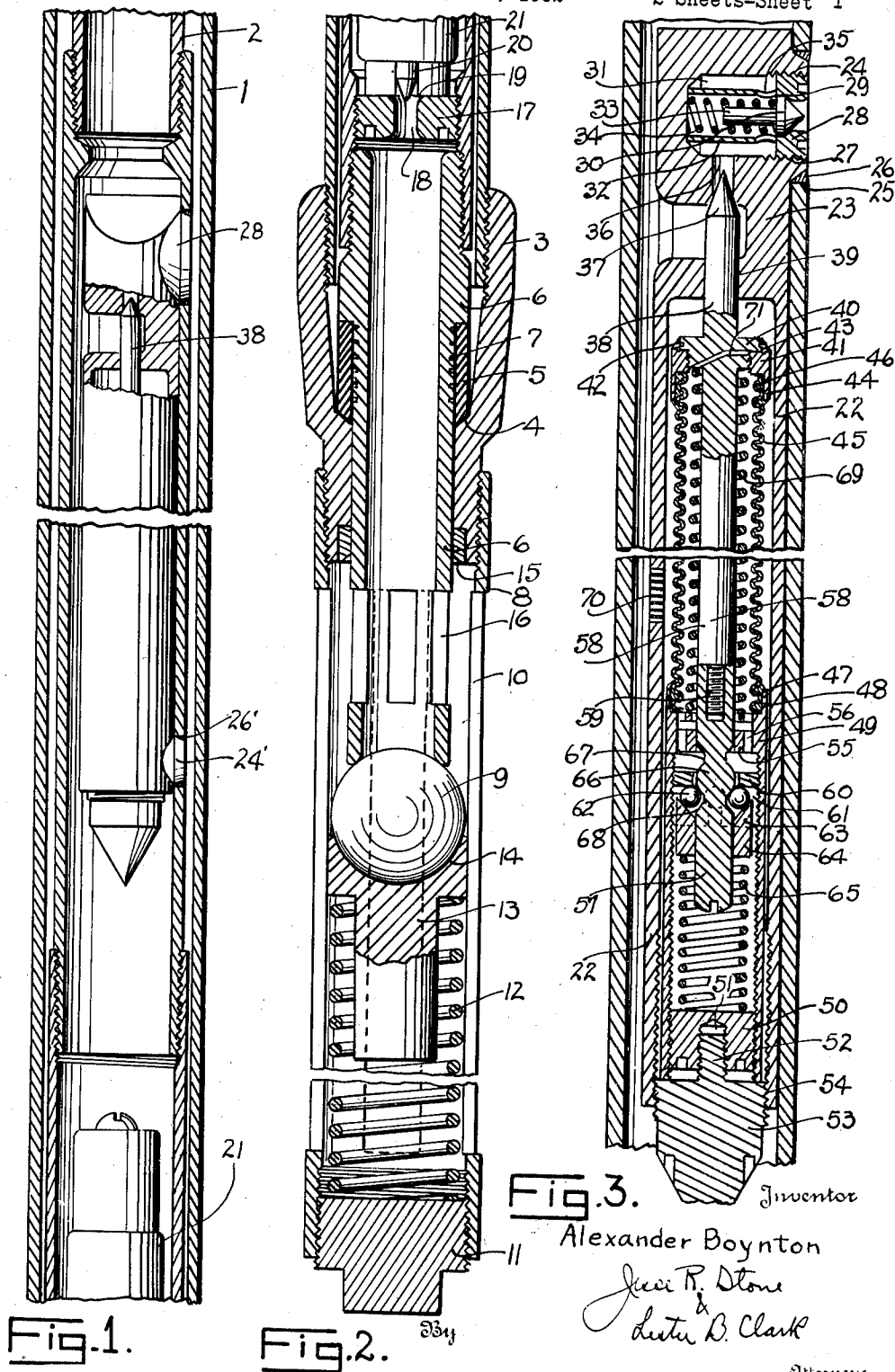


Fig. 3.

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2 Sheets-Sheet 2

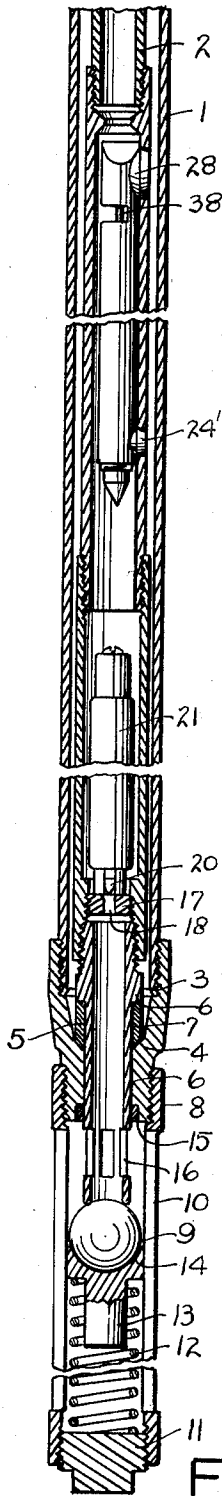


Fig. 4

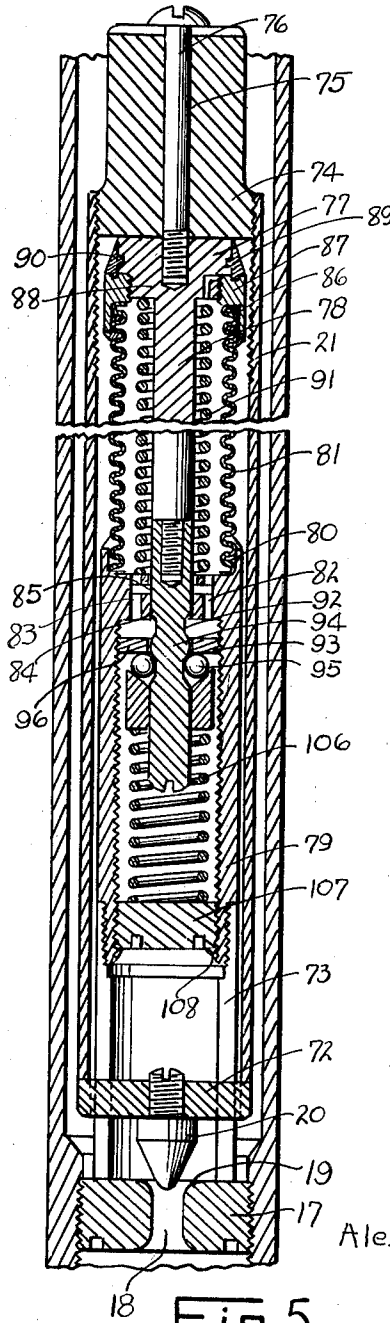


Fig. 5.

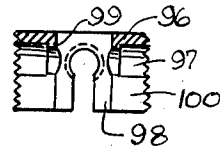


Fig. 6.

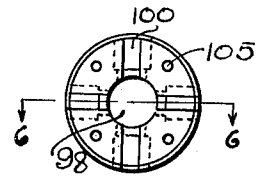


Fig. 7

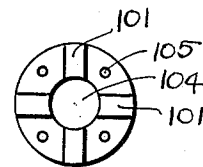


Fig. 8.

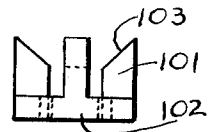


Fig. 9.

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UNITED STATES PATENT OFFICE

1,968,633

AUTOMATIC HEADING DEVICE

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Application October 21, 1932, Serial No. 638,858

12 Claims. (Cl. 103—234)

My invention relates to devices for raising fluid from wells, and pertains particularly to the apparatus whereby a charge of the liquid is admitted into the eduction tube and whereby air or gas under pressure is then admitted below the charge to raise it to the surface.

I have as an object of my invention to provide means for automatically closing the eduction tube when a predetermined load of liquid has entered said tube.

I desire to regulate the amount of liquid which is to be admitted and then raised by the pressure fluid to the surface.

The invention also contemplates an automatically operating device for admitting the air or gas under pressure below the load of liquid so as to move it upwardly in the eduction tube.

I contemplate the use of a valve in the inlet passage for the air or gas which will automatically operate when the proper amount of liquid has been admitted, to open and allow the entrance into the eduction tube of the air or gas by which the charge is to be raised.

I also contemplate means to cause the valve to operate abruptly both during its opening and closing movements.

The invention is illustrated by a preferred embodiment of the device shown in the drawings herewith in which Fig. 1 is a central longitudinal section through a portion of my device showing the relative relationship of the control device for the air inlet and the control device for the liquid inlet.

Fig. 2 is a similar section through the device showing the lower end of the tubing below the portion shown in Fig. 1.

Fig. 3 is a longitudinal section on a slightly enlarged scale illustrating the control device for the air inlet.

Fig. 4 is an assembly view in central longitudinal section illustrating my invention.

Fig. 5 is an enlarged longitudinal section showing my liquid control valve.

Fig. 6 is a sectional detail of the ball retainer in my latch member, said section being taken on the line 6—6 of Fig. 7.

Fig. 7 is a bottom plan view of the latch member.

Figs. 8 and 9 are top and side elevations, respectively, of the ball rider.

This application is adapted to be used with the structure shown in my co-pending application, Serial No. 637,710 filed October 13, 1932, in which the well casing and the equipment for the upper end of the well is disclosed. This equipment for

the upper end of the well is no part of the present invention, and only includes a seal between the tubing and the outer casing and a means to introduce air between the pressure tube 1 and the eduction tube 2 shown herein.

The pressure tube 1 which serves to conduct the air or gas under pressure below the charge of liquid to be elevated, is connected at its lower end to a swaged coupling 3. This coupling is reduced in diameter downwardly and formed with an inner seat 4 upon which the sealing member 5 mounted on the nipple 6 on the eduction tube, is seated. The sealing ring 5 is preferably formed of lead or other soft metal poured in place or soldered to the eduction tube and molded within lateral notches 7 in the side of the nipple. The lower end of the packing ring is beveled to fit the seat 4. It is urged upon the seat by the weight of the flow tubing, and forms a fluid tight seal therewith to prevent the passage of the air downwardly into the well.

The lower end of the coupling 3 is threaded externally for engagement with an elongated cage 8 for a check valve 9. This cage is made up of a section of tubing slotted at 10 to allow the entrance of liquid thereto, the lower end being closed by a threaded plug 11. Within the cage is a coiled spring 12 supporting a valve retainer 13 having a concaved recess 14 to sustain the valve 9. While in operation the nipple 6 upon the eduction tube contacts at its lower end with the ball 9 and forces it downwardly away from a valve seat 15 fitted within the lower end of the coupling 3.

The eduction tube 2 is formed with separate control devices for the liquid inlet and the air inlet. The liquid inlet is mounted in the eduction tube adjacent the lower end thereof, and is connected therewith above the upper end of the nipple 6. This nipple is slotted at 16 adjacent the lower end to allow the entrance of liquid above the valve 9. There is a partition or plate 17 secured within the lower end of the eduction tube above the nipple 6 formed with a central opening or orifice 18 for the liquid. The upper end of said opening is formed into a valve seat 19 to receive the valve 20.

The means for operating the valve 20 to close when a predetermined load of liquid has entered the eduction tube is shown in Fig. 5. The valve member 20 is adapted to fit within the seat 19 in the closure plate 17. A liquid passage 18 through said closure plate is controlled by the operation of said valve 20 engaging within the seat 19.

The valve 20 is mounted within a cross bar 72.

Said bar is secured to the lower end of the housing 21 and is slidable within a longitudinal slot 73 in the sleeve 73' projecting upwardly from the closure plate 17. The housing 21 is tubular in shape and is threaded at its upper end to receive the plug 74, which closes the upper end of the housing. There is a longitudinal passage 75 through the plug 74, which receives the cap screw 76 extending axially through the plug and engaging within the head 77 upon the latch shaft 78.

At the upper end of the slotted sleeve 73' is secured the latching barrel 79. This barrel extends upwardly within the housing and is secured at 80 to the bellows-shaped diaphragm 81. Below the connection 80 the upper end of the barrel has a transverse partition 82 having a plurality of longitudinal passages 83 therethrough. There is also a central passage 84 therethrough to receive the lower extension 85 upon the latch shaft 78.

The bellows-shaped diaphragm 81 is made of thin flexible sheet metal and is transversely corrugated either by annular folds or corrugations or spirally arranged corrugations. At the upper end of the said diaphragm the same is secured to the ring 87 by welding or solder at 86, so as to form a tight seal at that point. A connection is thus made with the ring 87, which is screwed upon the lower end 88 of the head 77. There is a small duct or passage 89 extending upwardly and laterally in the head 77 to provide a vent in the adjusting of the bellows during assembly. In this operation the interior of the bellows and the barrel 79 are filled with a non-corrosive liquid and the diaphragm is compressed longitudinally to its position of greatest compression or slightly beyond that point and the liquid within the diaphragm finds a vent to the passage 89. The diaphragm is then allowed to expand and the ring 87 is connected with the head 77 and a hermetical seal is then provided by a bond of welding material 90 around the upper end of the ring 87. It will thus be noted that all connections to the diaphragm or bellows are hermetically sealed so that no fluid whatever can enter the same.

The latching shaft 78 extends axially downward through the bellows and through the partition 82 to the barrel 79. There is a compression spring 91 within the bellows bearing at its upper end against the head 77 and at its lower end against the partition 82, thus tending to hold the bellows diaphragm extended.

The lower end of the latching shaft 78 is made detachable from the main shaft for purposes of assembly. This extension has, at a point spaced from the lower end, annular grooves 92 and 93. Between these grooves the portion 94 of the latching shaft is made rounded so as to allow the operation of the latch as will be noted. Latching balls 95 are adapted to engage within the groove 92, said balls being held in latching position by my ball cage which will now be described. With reference particularly to Figs. 6 to 9, inclusive, I have shown the construction of this cage. There is a ball retaining member 96, which is threaded to screw within the interior of the barrel 79. Said member has four radial openings 97 leading to the central passage 98 through which the latch shaft extends. Each of the passages 97 is adapted to receive one of said balls 95 and a small inwardly projecting flange 99 in said passage limits the inward movement of the said balls against the shaft. Below the radial passage 97 are slots 100, which permit the extension upwardly there-

through of arms 101 on the ball rider which supports the balls.

Said ball rider is shown particularly in Figs. 8 and 9. It comprises a lower plate 102 with spaced upwardly extending arms 101 thereon, said arms being beveled at 103 to engage against the balls. There is a central passage 104 through the ball rider which fits about the lower end of the latching shaft. Both the cage 96 and the ball rider 102 have longitudinal passages 105 to allow a passage of liquid therethrough.

Said ball rider is held resiliently upward against the balls so as to move them inwardly into the grooves 92 and 93 by means of a spring 106. Said spring bears at its lower end against a plug 107 which closes the lower end of the barrel. After said plug has been screwed in position a bond 108 of solder or welding material about the plug tends to tightly seal the barrel to prevent the escape of the lubricating liquid within the barrel and the bellows, as previously noted.

During assembly, the interior of the diaphragm and the barrel are filled with a non-corrosive liquid as previously noted. The diaphragm is then compressed and, after again expanding the diaphragm to allow the entrance of air through the vent 89, the connection is made between the ring 87 and said head and a tight seal at that point is made. Slightly above this lowest compressed position the balls 95 lie in position within the groove 93, and this groove will be formed in the shaft at that elevation to accommodate the balls. When the bellows is compressed and air drawn inwardly through the vent 59 to fill the place of the discharged liquid, the sealing connection is then made. Better results may sometimes be obtained under certain conditions by sealing the bellows after the expulsion of the liquid. Thus, to provide a vacuum above the liquid filler, and in still other cases, the bellows should be sealed only after a partial expulsion of the liquid in order to provide a partial vacuum above the lubricating liquid.

In the operation of the device the liquid passing upwardly through the opening 18 and above the diaphragm will exert a pressure upon said diaphragm depending upon the head of liquid which rises in the eduction tube. When this head of liquid is high enough to compress the bellows sufficiently the bellows will contract and will force the shaft 78 downwardly past the latching balls so that said balls will snap abruptly into the upper groove 92. The valve 20 will thereby be forced to closed position. As long as the head of liquid, or combined force of liquid plus air or gas pressure, admitted by valve 37, is sufficient to hold the bellows compressed, the liquid inlet valve will remain closed. However, when the pressure around the bellows decreases sufficiently due to the raising of the head of liquid from the eduction tube, the force of the spring 91 will throw the shaft abruptly upwardly so as to latch it in position with the valve 20 open.

Above the controlling device for the liquid inlet is a controlling device for the air inlet. This is shown particularly in Fig. 3. It includes a cylindrical housing 22 fitting within the eduction tube and supported against one side thereof. Above the housing is an extension 23 having a lateral projection 24 thereon which is tapered outwardly and adapted to fit within an opening 25 in the wall of the eduction tube and to be secured therein by a bond of solder or welding material 26. A similar projection 24' at the lower

end of the housing is preferably extended through the wall of the tube and welded thereto as shown at 26' in Fig. 1. However, this lower securing member may be omitted as shown in Fig. 3.

5 The upper end of the extension 23 has an inlet for the air or gas to the eduction tube. This includes an opening threaded at 27 to receive an annular nut or washer 28, the inner end of which is formed at 29 into a valve seat to receive a back pressure valve 30.

10 Said valve is mounted within the recess 31 inside the valve seat. The valve fits within a tubular housing 32, and has a stem 33 thereon about which is placed a compression spring 34 which 15 bears against the valve and tends to normally hold it in closed position. Lateral openings 35 in the wall of the housing 32 allow the passage of pressure fluid therethrough.

The purpose of the check valve is to prevent 20 liquid from escaping from the flow tubing into the pressure tubing if the air or gas valve should open at a time when there would be less pressure in the pressure tubing than is necessary to lift the slug. The check valve causes the load to 25 remain constant, and wait, so to speak, until enough pressure appears in the pressure tubing to expel the slug. Were it not for this check valve the liquid in the flow tubing would run out into the pressure tubing if the air or gas valve 30 opens when there is less pressure in the pressure tubing than in the flow tubing. This would result in increasing the load by exactly the weight of the liquid that would so escape into the pressure tubing, because the liquid in the pressure 35 tubing would be forced back into the flow tubing ahead of the air or gas when the proper pressure again appeared in the pressure tubing. Excessive pressure would, therefore, be required to start the well after a lapse of pressure in the pressure 40 tubing except for the action of the check valve.

The chamber 31 has a lower vertical extension 36, the lower end of which has a seat to receive the valve 37 formed upon the valve stem 38.

The valve stem 38 fits closely through an opening 39 in the upper wall of the housing 22. It 45 has a bearing therein which forms a guide for said valve stem retaining said valve in accurate alignment. The lower end of the stem within the housing has a head 40 to which the connecting 50 ring 41 is secured. There is a flange 42 on said head overlying the end of the ring 41 and a bond of solder or welding material 43 is ordinarily employed to make a fluid tight seal between said head and said connecting ring. Said ring has a 55 downwardly extending flange 44 within which the upper end of the bellows shaped diaphragm is secured by solder or welding 46.

Said diaphragm is a multiple diaphragm of thin sheet metal, the wall of which may be of one 60 or more thicknesses depending upon the strength and degree of flexibility which is desired. The corrugations may be ring-shaped about the diaphragm or may be spirally formed in one continuous corrugation from the upper to the lower 65 end thereof. The lower end of the diaphragm is soldered at 47 within a flange 48 on the upper end of the latching device housing or barrel 49.

The latching device housing or barrel 49 extends downwardly from the bellows. It is threaded 70 on its interior and is closed at its lower end by a plug 50. Said plug has a threaded recess 51 into which is engaged a threaded shank 52 of the adjusting nut 53. Said nut is threaded externally to engage at 54 within the lower end of the housing 22. The upper shoulder thereon

engages the lower end of the latching barrel 49 and enables the same to move said barrel in vertical adjustment.

80 Adjacent the lower end of the bellows diaphragm is an inwardly extending flange having longitudinal passages 56 therein for communication of the liquid within the bellows and the latching barrel. Said flange has a close seat about the extension 57 upon the latching shaft 58, said extension being connected to said shaft 85 at 59.

Below the flange 55 is the latching device. Said latching device includes a ball cage 60 with 90 drilled passages 61 to receive the latching balls 62. The drilled passages 61 are, at the inner extremity of slightly less diameter than the balls to prevent the balls from falling out when the latching shaft extension is removed for inspection or repairs. The lower end of the ball cage 95 is slotted to receive upwardly projecting arms 63 upon the ball rider 64. These arms are beveled inwardly and downwardly at their upper ends to engage against the balls and hold them inwardly toward the latching shaft extension 57. Said ball rider is held resiliently upward by means of 100 a spring 65 bearing at its lower end against the plug 50.

The latching shaft extension 57 is formed adjacent said balls with an approximately spherical 105 portion 66, thus forming upper and lower recesses 67 and 68, respectively, into which said balls 62 may engage and latch the shaft in adjusted position.

The latching shaft 58 extends axially through the bellows-shaped diaphragm. There is a spring 110 69 about said shaft which bears at its lower end against the latching barrel and tends to hold the diaphragm in elongated position. A wall of the housing 22 has a screening opening 70 therein through which the liquid from the eduction tube may enter, the strainer or screen acting to keep out coarse abrasive material which might otherwise enter.

In assembling my device, the bellows shaped diaphragm is connected at its lower end to the latching barrel and at its upper end to the ring 41 and the latching barrel and the bellows is then filled with a non-corrosive liquid such as glycerine. The latching shaft 58 is then inserted in position and the diaphragm is compressed longitudinally to the maximum extent to which it is contemplated it should be compressed in use. The excess glycerine within the tube will escape through a passage 71 in the upper end of the latching shaft, and when the bellows is then allowed to elongate through the action of the spring, air will enter through the passage 71 and fill the space emptied of the glycerine. The latching 115 shaft is arranged to be marked by contact with the balls 62 when this operation takes place, and the shaft may be then withdrawn and the latching recesses 67 and 68 then accurately formed therein after which the shaft extension may be hardened, and the shaft will then be again inserted in position. The upper end of the 120 bellows will be sealed by the solder 43 as previously noted, and the diaphragm and shaft will be adjusted vertically by means of the nut 53 to force the valve 37 to the seat with a predetermined pressure. The device will then be ready for operation.

When the device is introduced into the well the pressure tube will be inserted first, and when thus being introduced into the well the valve 9 will be held firmly within the seat 15 by the spring 12. 125

When the pressure tube is in place the eduction tube may be inserted, and when said tube reaches a sealing position in the seat 4 of the swaged coupling 3, the lower slotted end of the eduction tube will engage the valve 9 and unseat it to allow liquid to enter the eduction tube.

When the proper amount of liquid has entered the tube, the valve 20 will be automatically closed to prevent the entrance of further liquid. The liquid entering the eduction tube will exert a pressure upon the multiple diaphragm or bellows 45 which tends to collapse the same longitudinally and open the valve 37 to allow the admission of the air from the outside below the load of liquid in the eduction tube, and thus raise the liquid to the surface.

When the air or gas valve operating device shown in Fig. 3 is acted upon by the load of liquid in the well, the pressure will quickly increase upon the corrugations of the diaphragm 45 tending to move the valve 37 out of its seat. This movement will be resisted by the action of the latching balls 62 engaging resiliently against the shaft extension 57. When the pressure reaches its predetermined value, however, the shaft will snap downwardly past the balls to abruptly open the valve and admit the air or gas from the pressure tubing. When the load has been lifted and the pressure on the diaphragm decreased, the action will take place in the reverse direction, and the effect of the spring 69 will be to eventually snap the valve 37 back to closed position as will be readily understood.

The abrupt operation of the valve assures good seating of the valve and that the operation will be sufficiently rapid to prevent excessive wear about the valve due to the passage of abrasive substances in the air or gas during its opening and closing action, as would result with gradual opening and closing of the valve.

The air or gas valve 37 must be set to open against somewhat less pressure than is required to close liquid intake valve 20. As soon as the air or gas valve opens and admits the relatively greater pressure from the pressure tubing into the flow tubing, the additional pressure required to close valve 20 is quickly supplied. The liquid intake valve 20, therefore, always closes immediately after air or gas valve 37 opens. It is, consequently, the adjustment of valve 37 that in fact determines the weight or length of the slug to be expelled. This, for the reason just stated, is true even if the liquid intake valve 20 were set to close at much higher pressure if acting alone. The difference between the relatively low pressure at which the air or gas valve opens, and the relatively high pressure at which the liquid intake valve closes is the margin of safety that insures opening of the air or gas valve, for, if the liquid intake valve should close before the air or gas valve opened, the air or gas valve would never open, and the device would become inoperative. It is to avoid this condition that the air or gas valve is set to open just before the liquid intake valve closes.

The maximum compression travel of a bellows (unless the travel is sooner arrested by a liquid filler as will be hereinafter discussed) is always the sum of the distances between the internal walls of the several corrugations, these distances being measured on a line parallel to the lengthwise center line of the bellows, and at such distance from said center line as will intersect each corrugation where the opposing walls would first touch if compressed by external

pressure. This maximum compression travel of a bellows such as shown is approximately 30 per cent of its free length. The usual working travel of such a bellows is much less than 30 per cent of its free length, and depends upon the pressures to which it is exposed, the force required to compress the spring, and the length of the air pocket above the liquid filler. A maximum working travel of slightly more or less than one inch will be found very satisfactory for the purpose of this invention. Maximum working travel as provided in the device for extremely high pressures will practically never occur, the actual working travel being from 1/50 to 1/30 of the bellows length. Under such working conditions such a bellows has proven extremely durable.

The bellows wall is preferably of two or more laminations. A plurality of laminations in the bellows wall causes the bellows to be more sensitive to pressure than if made of one lamination of equal thickness. A plurality of laminations also adds to the life of the bellows and makes it less apt to leak. The bellows may be made of any metal or alloy that will afford the proper resiliency and strength. An alloy of 85 per cent copper and 15 per cent zinc has been found quite satisfactory.

Glycerine or other lubricating liquid should always be placed in the bellows up to slightly below the level of its maximum travel, leaving an air pocket to occupy the space between the glycerine and the top of the bellows. This air pocket becomes a cushion which yields to all compression force upon the bellows, and the liquid filler serves to arrest the compression travel. The travel thereby permitted is the maximum working travel above mentioned. While the air pocket above the liquid filler is usually to be employed, the bellows action is quite satisfactory if a vacuum be provided above the liquid filler.

The potent fact should not be overlooked that a bellows when assembled as herein specified does not, in fact, resist high pressure wholly from without because the pressure inside is always equal to the pressure outside, less only the expansive force of the spring. To illustrate: if the bellows in assembly be filled with glycerine to within one inch of the top, and the spring would compress one inch under 100 pounds per square inch applied externally to the bellows, then there would never be more than 100 pounds difference between the external and internal pressures. If then there should be 10,000 pounds per square inch of external pressure, there would be 9,900 pounds of internal pressure, leaving a net force of only 100 pounds per square inch acting externally on the bellows. The bellows wall thus becomes impinged between two fluid forces, the external of which can never exceed the internal by more than 100 pounds regardless of how great the external pressure may be. Hundreds of hydraulic compressions up to 5,000 pounds per square inch administered to such a bellows assembly, the bellows having a wall thickness of only .008 inch, has never resulted in the slightest damage to the bellows, nor in any way impaired its operation. Hydraulic pressure in excess of 10,000 pounds per square inch has frequently been administered to bellows assemblies, the bellows having a wall thickness of approximately .030 inch, with no resulting damage. It being possible to fabricate bellows with wall thickness greatly in excess of .030 inch, it is apparent that this type of construction will safely

withstand the highest pressures to be encountered.

The office of the spring 69 is to return the bellows 45 to its maximum free working length after the bellows has been subjected to compression. At this point the contracting or pull together force of the bellows (due to the set caused by maximum compression) is balanced by the expansive force of the somewhat compressed spring, (the spring being longer than the bellows, the spring is somewhat compressed when assembled). A further compression of the spring results from the fact that the bellows shortens or takes a certain set when subjected to the maximum compression travel in the assembling operation that forces out the glycerine to that level. The spring, therefore, will return the bellows to a length somewhat shorter than its original length. This length to which the spring returns the bellows after maximum compression, is the maximum free working length of the bellows. Henceforth the spring and bellows act together as a unit within the limits of the working travel lengthening with diminishing external pressure, and shortening with increasing external pressure exactly (or nearly so) in proportion to the force of such pressure.

The air or gas intake valve is adjusted to open just before the liquid intake valve closes and to close before all of the slug has been expelled, because the compressed air or gas under that part of the slug still in the flow tubing will continue to expand under the lightened load, and thereby expel the remainder of the slug. Such synchronized adjustment of the two valves causes a gentle puff of air or gas to follow the slug; whereas a hard blow, with resulting loss of energy, would follow the slug if the entire slug were expelled before the air or gas valve closes. The volume and pressure of air or gas so admitted by the air or gas valve should also be regulated so as to expel the slug at proper velocity. The pressure is, of course, regulated in the pressure line. The volume of air or gas which the air valve admits is regulated by the diameter of the air or gas intake passage above the valve and by the permitted travel of the valve.

The length of the uniformly convexed circular surface between the grooves, the depth to which the balls engage these grooves, the force required to compress the bellows, and the compression force of the adjusting spring are controlling factors in the opening and closing operation of both valves.

The air or gas valve should slam wide open to lift the slug as a whole rather than aerate it, as would be done by slow or partial opening of this valve. The air or gas valve should remain wide open to speed up the movement of the slug until such time as the air or gas under the slug will completely expel it from the well. This valve should then slam shut to provide a tight seal off while the next liquid slug is being admitted, by the other valve.

In my device thus constructed it will be apparent that I can control the inlet of liquid to the eduction tube so as to provide only the amount of load which my lifting device will effectively raise to the surface at the available pressure in the pressure tubing. The inlet of the air to the eduction tube will automatically take place when the desired load has entirely entered the tube, and may act to elevate the load to the surface without exerting any back pressure from the pressure fluid upon the formation. The valve control means, both for the air and the liquid, are sensitive to pressure and will operate accu-

ately for long periods of time. The use of a liquid within the bellows diaphragm will prevent undue collapse thereof, making it possible to employ my valve control means under high pressures. The further advantages of the structure will be apparent to those skilled in the art.

Having described my invention, what I claim is:

1. In a device of the character described, a pressure tube, an eduction tube spaced within said pressure tube, a seal between said tubes adjacent the lower end thereof, a liquid inlet valve in said eduction tube, means to close said valve when a predetermined load of liquid has entered said tube, an air inlet to said eduction tube above said valve, a valve controlling said air inlet, and means connected with said air inlet valve responsive to the load of liquid in said tube to open said valve and admit said air at a liquid pressure slightly lower than that necessary to close said liquid inlet valve.

2. In a device of the character described, a pressure tube, an eduction tube spaced within said pressure tube, a seal between said tubes adjacent the lower end thereof, a liquid inlet valve in said eduction tube, means to close said valve when a predetermined load of liquid has entered said tube and to open said valve when said load has been removed, an air inlet to said eduction tube above said valve, a valve controlling said air inlet, and means connected with said air inlet valve and operating in response to the pressure of fluid in said tube to open said air inlet valve, said means operating when said fluid pressure is reduced to a point where said liquid inlet valve is opened, to close said valve.

3. In a device of the character described, a pressure tube, an eduction tube spaced within said pressure tube, a seal between said tubes adjacent the lower end thereof, a liquid inlet valve in said eduction tube, an air inlet to said eduction tube above said liquid inlet, an air inlet valve and means controlling each of said valves both operative by pressure of liquid entering said eduction tube to close one valve and thereafter to open the other of said valves to allow entrance of further liquid.

4. In a device of the character described, a pressure tube, an eduction tube spaced within said pressure tube, a seal between said tubes adjacent the lower end thereof, a liquid inlet valve in said eduction tube, an air inlet to said eduction tube above said liquid intake valve, an air inlet valve and means controlling each of said valves both operative by pressure of liquid entering said eduction tube to open and close said valves, said liquid inlet valve being adjusted to close after said air inlet valve opens.

5. In a device of the character described, a pressure tube, an eduction tube spaced within said pressure tube, a seal between said tubes adjacent the lower end thereof, a liquid inlet valve in said eduction tube, means to close said valve when a predetermined load of liquid has entered said tube, an air or gas inlet to said eduction tube above said valve, a valve controlling said air or gas inlet, pressure releasable means to latch said air inlet valve in both open and closed position, and means connected with said air inlet valve, responsive to the load of liquid in said tube, to open said valve and admit said air or gas, said liquid inlet valve being adjusted to be closed at a fluid pressure thereon slightly higher than that necessary to open said air or gas inlet.

6. In a device of the character described, a pressure tube, an eduction tube spaced within

- said pressure tube, a seal between said tubes adjacent the lower end thereof, a liquid inlet valve in said eduction tube, means to close said valve responsive to a predetermined fluid pressure thereon in said tube, an air or gas inlet to said eduction tube above said valve, a valve controlling said air or gas inlet, and control means connected with said air or gas inlet valve, said control means including a diaphragm connected with said valve and adapted to be acted upon by fluid pressure to open said valve under predetermined fluid pressures less than those closing said liquid inlet valve and to close said valve when said pressures are relieved and said liquid inlet valve has opened.
7. An air inlet control device including an inlet orifice, a housing, a valve stem in said housing, a valve thereon fitting within said orifice, an hermetically sealed bellows diaphragm connected with said stem, a rigid support for the end of said diaphragm remote from said valve, said diaphragm being responsive to a predetermined fluid pressure outside thereof to contract and open said valve, and means to cause said valve to move abruptly.
8. An air inlet control device including an inlet orifice, a housing, a valve stem in said housing, a valve thereon fitting within said orifice, a bellows diaphragm connected with said stem, a rigid support for the end of said diaphragm remote from said valve, a latch shaft on said valve stem longitudinally of said diaphragm, latching means engaging said shaft to retain the same resiliently in either open or closed position of said valve, and means engaging said valve responsive to fluid pressure to either open or close said valve abruptly.
9. A method of raising liquid from wells including filling the lower end of the eduction tube to a predetermined height with liquid, opening an inlet for air below the load of liquid, then closing off the entrance of more liquid and forcing air through said inlet to raise said liquid load to the surface opening the liquid inlet and then closing the inlet for air before said load is entirely discharged.
10. A method of raising liquid through an eduction tube in a well including admitting a predetermined load of liquid to the said tube, maintaining an open passage outside said eduction tube for pressure fluid, admitting air under pressure below said load, then employing the pressure fluid to assist in closing the lower end of said tube to liquid, forcing said load of liquid upwardly by said air and closing off the admission of air before said load is discharged.
11. In a device of the character described, a pressure tube, an eduction tube spaced within said pressure tube, a seal between said tubes adjacent the lower ends thereof, a liquid inlet valve in said eduction tube, means to close said liquid inlet valve responsive to a predetermined fluid pressure thereon in said tube, an air or gas inlet to said eduction tube above said liquid inlet valve, a valve controlling said air or gas inlet, and control means connected with said air or gas inlet valve, said control means including a diaphragm connected with said air or gas inlet valve and adapted to be acted upon by fluid pressure to open said valve under predetermined fluid pressures less than those closing said liquid inlet valve, and to close said air or gas inlet valve when said pressures are relieved down to a value somewhat in excess of the pressure at which the liquid inlet valve will again open.
12. A device of the character described including a pressure tube, an eduction tube spaced therein, a seal between the lower ends of said tubes, a liquid inlet to said eduction tube, a valve in said inlet, means automatically closing said valve when a predetermined head of liquid has entered said tube, an air or gas inlet to said eduction tube above said liquid inlet, a control valve in said air or gas inlet, a check valve for said air or gas inlet, means on said air or gas inlet valve responsive to fluid pressure thereon to open said valve to allow an inlet of air or gas, said liquid inlet valve being adjusted to close after the air or gas inlet valve opens, and to open after the air or gas inlet valve closes.

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