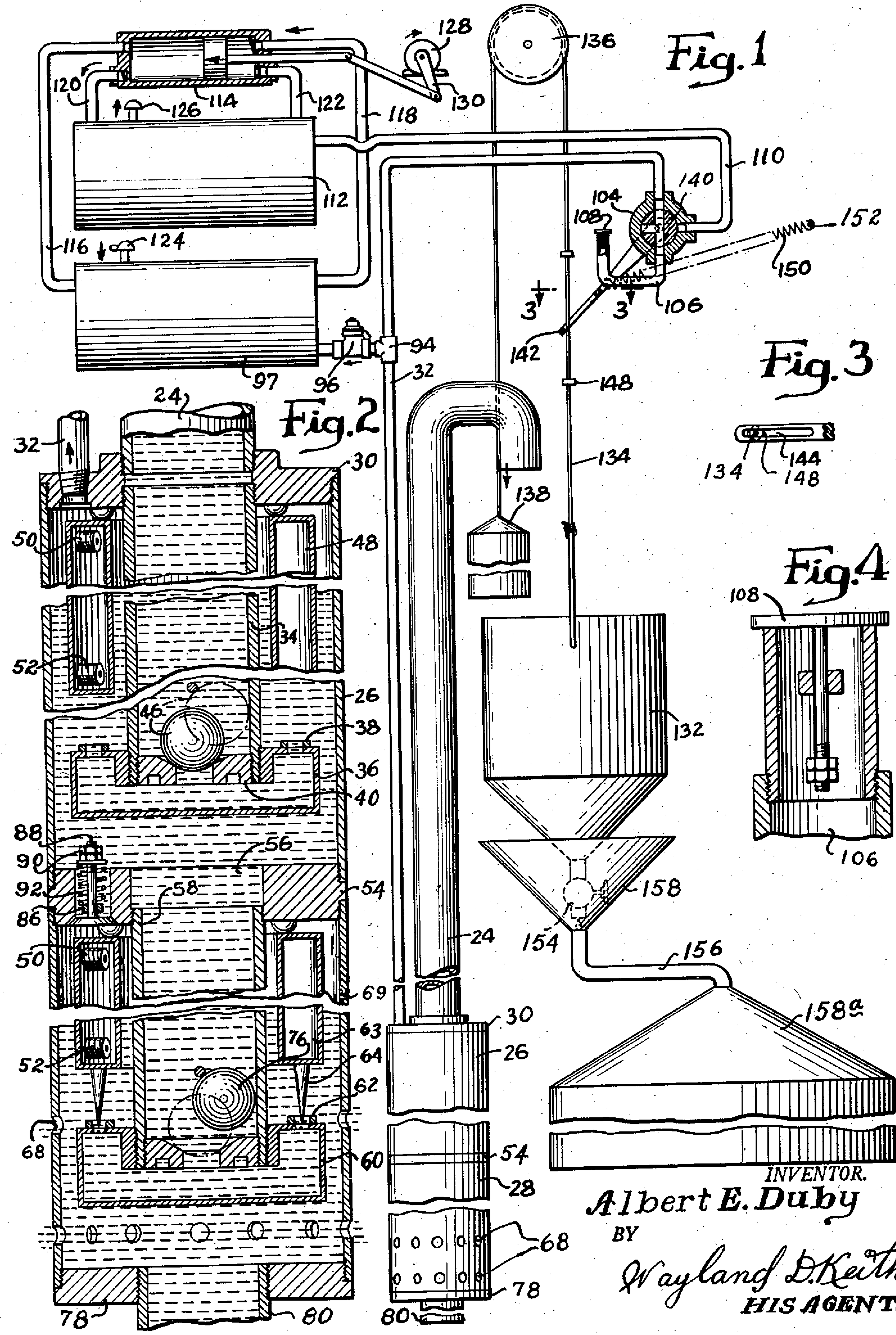
Sept. 2, 1958 A. E. DUBY 2,849,963

GAS OR PNEUMATICALLY ACTUATED DEEP WELL PUMP

Filed Feb. 9, 1954 3 Sheets-Sheet 1



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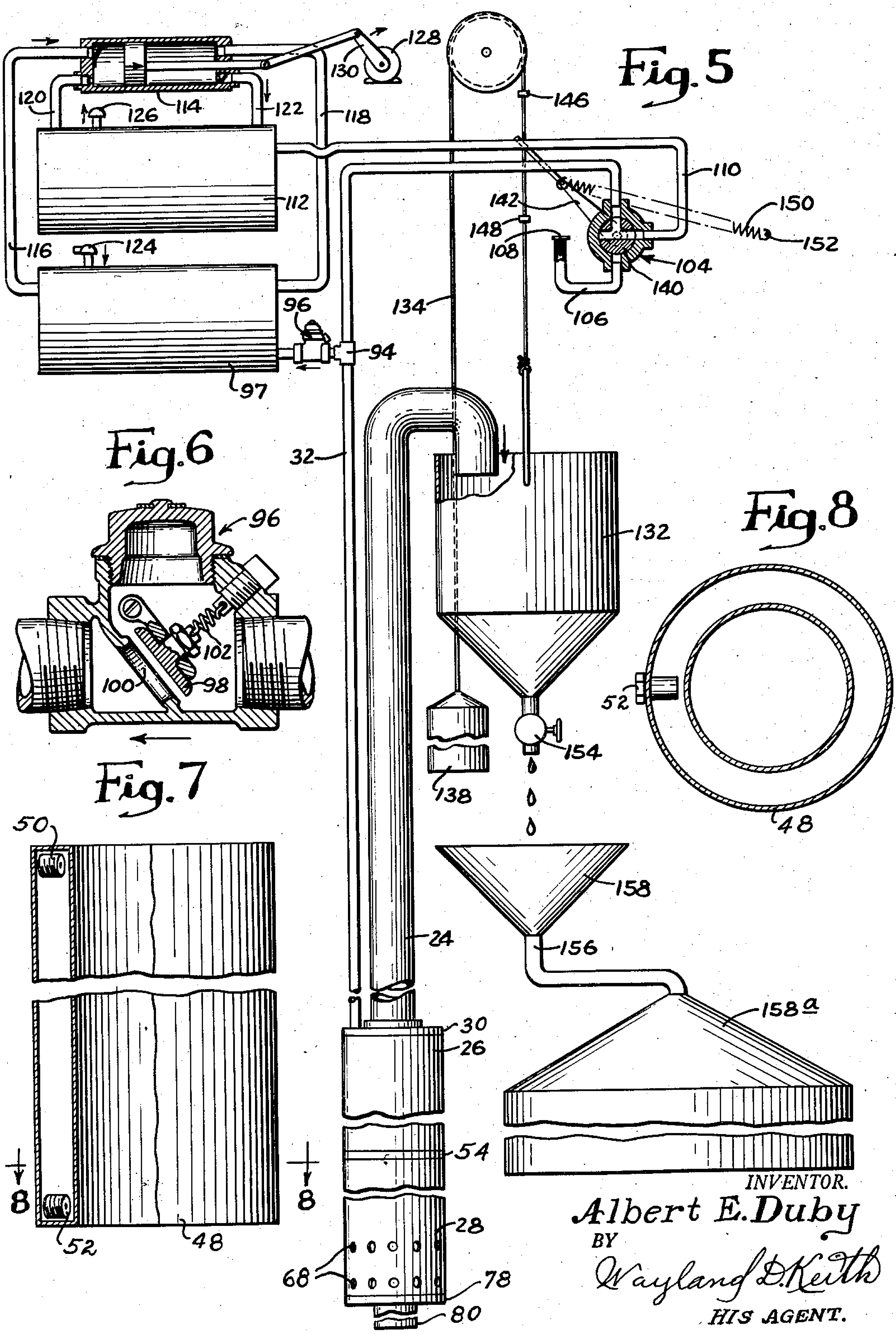

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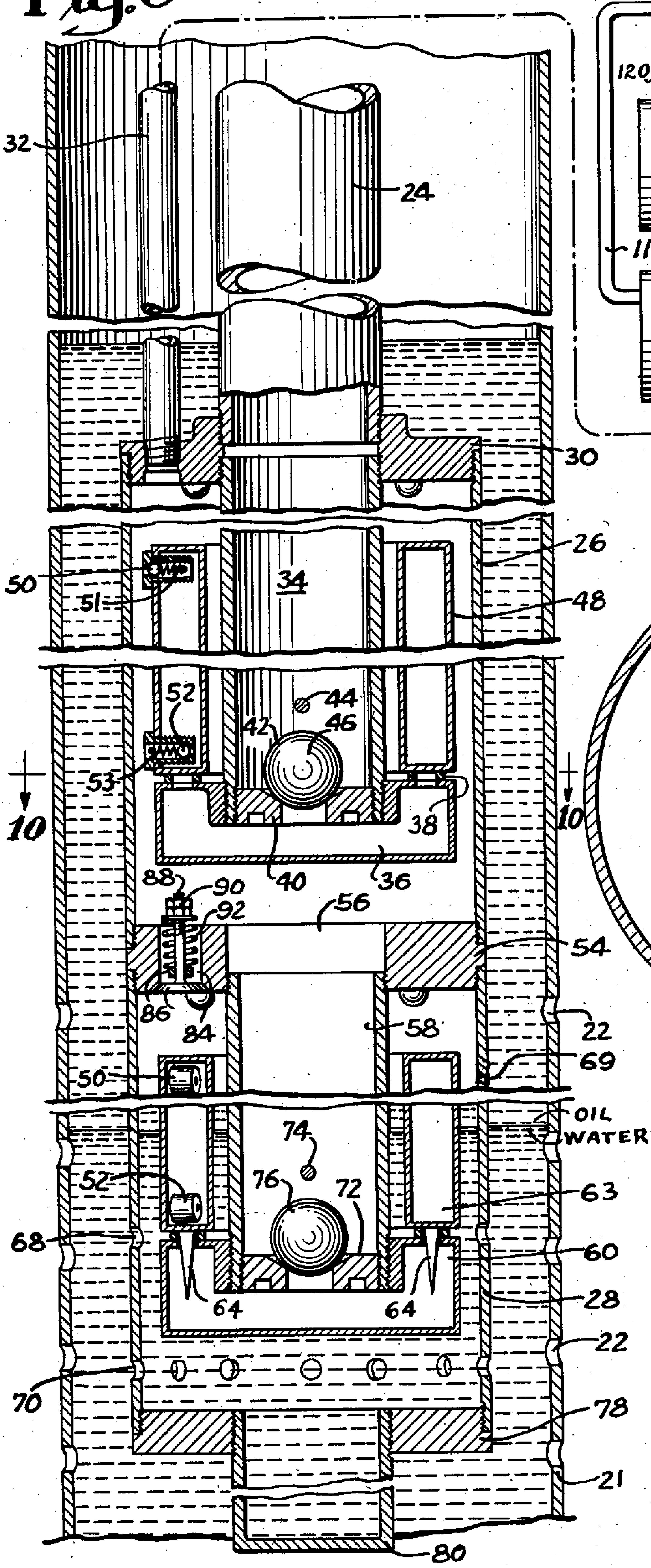
Fig. 9



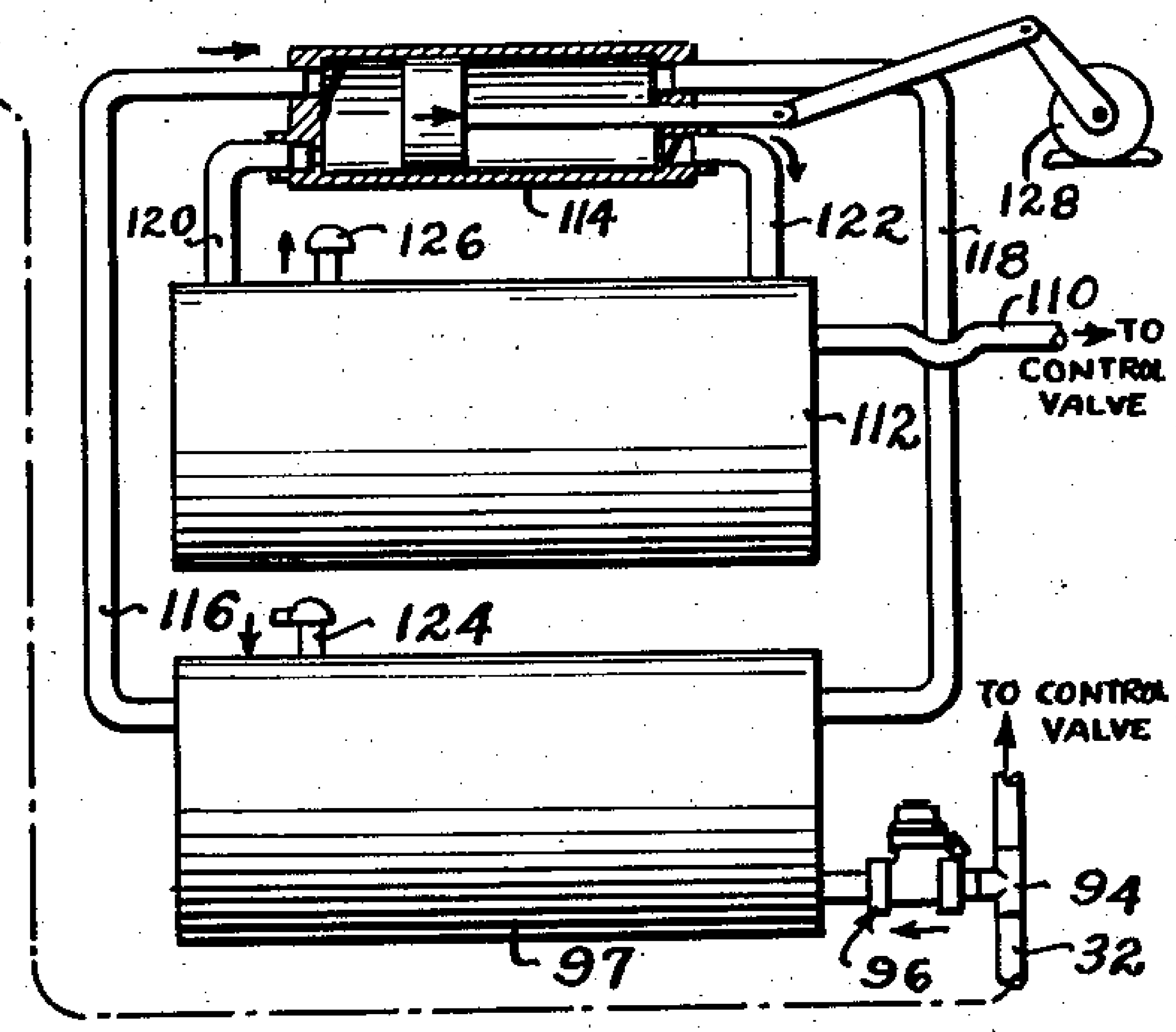


Fig. 10

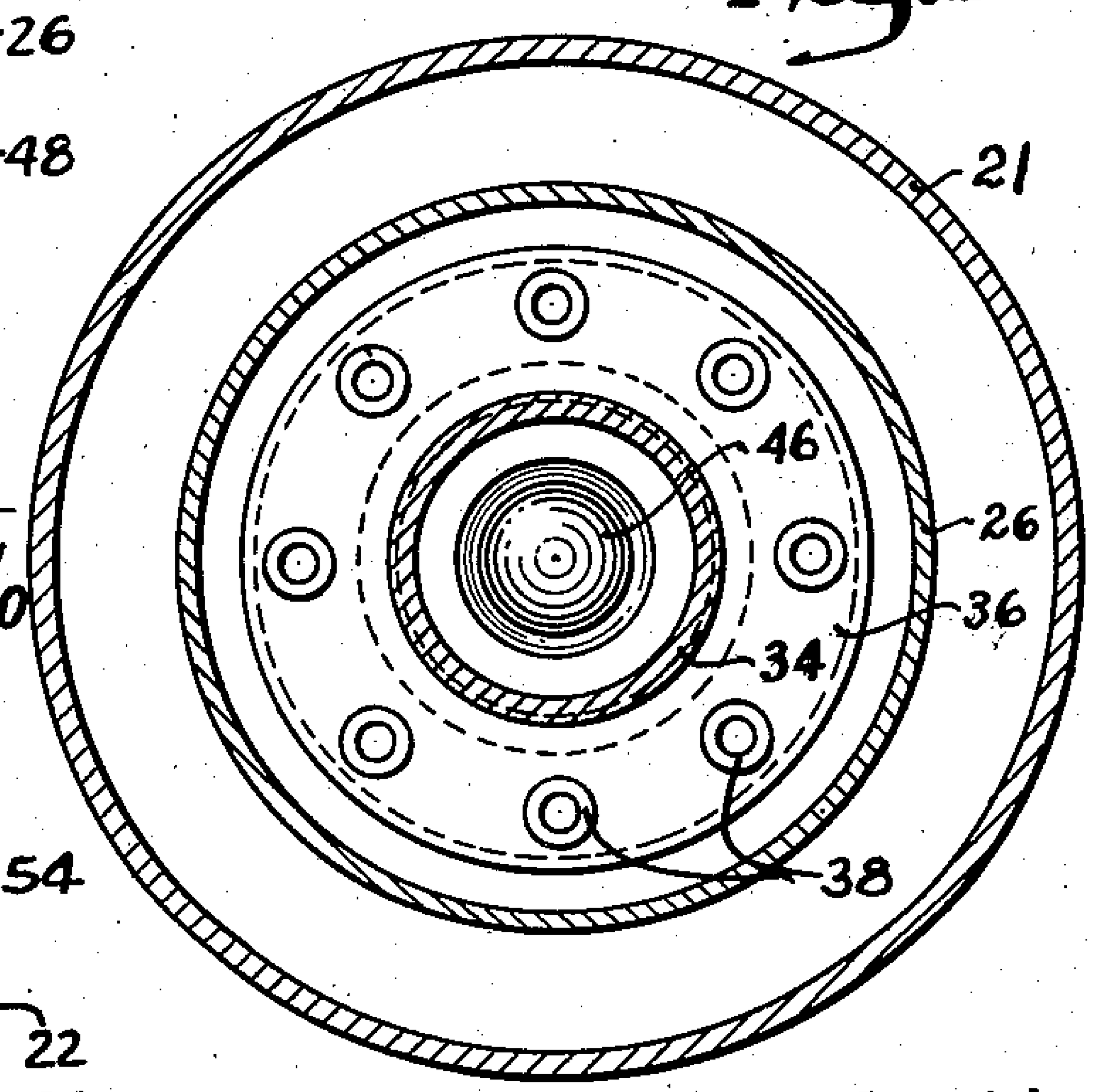
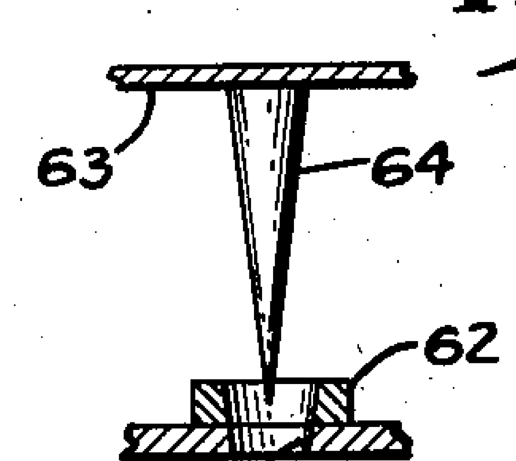


Fig. 11



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GAS OR PNEUMATICALLY ACTUATED DEEP WELL PUMP

Albert E. Duby, Graham, Tex.

Application February 9, 1954, Serial No. 409,129

1 Claim. (Cl. 103—235)

This invention relates to improvements in pneumatically actuated deep well pumps and more particularly to pumps that may be set to operate over long periods of time without attention.

Various deep well pumps have been proposed heretofore, but these for the most part, were complex in construction, and required frequent or continuous attendance to keep them in operating condition.

The present invention is adapted to intermittently create a suction within a valve cylinder and then, through a switching valve mechanism, switch to create a positive pressure within the cylinder to dispel the liquid within the cylinder into a conduit or tubing that leads to the top of the well.

An object of this invention is to provide a well pumping system that will dispense with pistons and plungers within the bore hole of the well, but at the same time will effectively pump the liquid, such as oil or water, from the well at a predetermined rate.

Another object of the invention is to provide a well pump wherein the formation is protected against pressure, while pumping the liquid from the well.

A still another object of the invention is to provide a pneumatically actuated well pumping device which may be set to pump a gauged amount of liquid.

A still further object of the invention is to provide a pump having a metered valve inlet to minimize the seating impact of the float that controls the inlet valve.

Yet another object of the invention is to provide floats which may be pressurized so as to maintain a set differential of pressure between the interior of the float and the exterior thereof to prevent crushing under extreme pressure.

A further object of the invention is to provide a liquid drainage valve and a relief valve to expel liquid from the float upon release of pressure therefrom.

Yet another object of the invention is to provide a valve member whereby a well washing fluid, such as a solvent or a heated liquid, may be selectively introduced to inject the solvent or hot liquid into the formation that is fluid bearing.

Still another object of the invention is to provide a pump, which, when used in oil wells, will pump the water out first.

A further object of the invention is to provide a multiport valve timing mechanism that will alternately permit suction and pressure on the pump cylinder.

Another object of the invention is to provide a measuring device that may be set to empty at a predetermined rate so as to control the operational cycle of the pump.

With these objects in mind and others that will manifest themselves as the description proceeds, reference is to be had to the accompanying drawings, in which like reference characters designate like parts in the several views thereof, in which:

Fig. 1 is a diagrammatic view of the vacuum-compressor mechanism together with the vacuum and pressure tanks, and showing a longitudinal cross-sectional

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view through the timing valve positioned for the suction stroke of the pump, and also showing the liquid measuring system and the tankage connected thereto;

Fig. 2 is an enlarged longitudinal sectional view through the pump cylinders at the bottom of the well, showing parts broken away and in section, and showing the ball valve within the pump in full outline for the suction cycle, and showing the ball valve in dashed outline for the pressure cycle;

Fig. 3 is a sectional view taken on line 3—3 of Fig. 1, looking in the direction indicated by the arrows;

Fig. 4 is an enlarged, longitudinal view of the pressure relief valve, with parts shown in section;

Fig. 5 is a diagrammatic view similar to Fig. 1, but showing the timing valve in position to inject air or gas under pressure into the well to discharge the oil or other liquid therefrom into a measuring device to affect a predetermined rate of pumping;

Fig. 6 is an enlarged longitudinal sectional view through a semi-balanced valve which is not responsive to closing on vacuum, but is responsive to closing by pressure in excess of a predetermined pressure;

Fig. 7 is an elevational view of a float removed from the well, showing a quarter thereof removed, and showing relief valves therein so as to enable a differential pressure to be maintained on the inside of the float with respect to the outside;

Fig. 8 is a cross sectional view taken on the line 8—8 of Fig. 7, looking in the direction indicated by the arrows;

Fig. 9 is an elevational view showing the vacuum-pressure generating system and tanks, and showing an enlarged longitudinal view of the cylinder mechanism connected thereto, with parts broken away, shortened, and shown in section to illustrate the details of construction;

Fig. 10 is a cross-sectional view taken on the line 10—10 of Fig. 9, looking in the direction indicated by the arrows; and

Fig. 11 is a fragmentary sectional view of a metering inlet valve of the lower float.

With more detailed reference to the drawing, the numeral 21 designates generally a well casing having perforations 22 in the lower portion thereof, which lower end portion extends into the fluid producing strata of the bore hole of a well. A tubing 24 is positioned axially of the well and has a pair of cylinders 26 and 28 secured to the lower end thereof. The cylinder 26 has a head 30 that is screw threaded onto the lower end of tubing 24 and into the upper end of cylinder 26, so as to form a fluid tight joint.

A second tubing 32 is also screw threaded into head 30 adjacent tubing 24 and is in communication with the interior of cylinder 26. An axial tube 34 is screw threaded into the lower side of head 30, which tube projects downward into cylinder 26 to a point near the lower end thereof and has a casing 36 which is closed at its sides and lower end, screw threaded on the tube 34. Upwardly protruding nipples 38 are circumferentially spaced around casing 36 to form inlet openings thereinto. Each nipple has the upper face thereof faced in such manner as to form a valve seat, as will be brought out more fully hereinafter.

A valve seat 40 is fitted in the lower end of tube 34. A pin 44 is positioned through tube 34 so as to form a cage in which ball valve 46 is positioned. An annular float 48, which float has closed ends, surrounds tube 34 and is adapted to work between the position as shown in Fig. 2 and that shown in Fig. 9. An outwardly seating, spring loaded check valve 50 is positioned in the upper end of float 48 and an inwardly seating, spring loaded check valve 52 is positioned in the lower end of float 48, as will best be seen in Figs. 7, 8, and 9. These springs are preferably of a predetermined resistance, which is slightly greater than the resistance that will be acted on by a complete vacuum, therefore, if springs of this character will yield at approximately 25 pounds pressure, these springs will yield before the pressure crushes the float, thereby giving a maximum variation of 25 pounds between the outside and the inside pressure, thus alleviating the crushing pressure on the float. When air or gas pressure is exerted on the upper end of the cylinder, the fluid level will be moved downward on the float and when the fluid is expelled from the chamber within the cylinder 26, the float will seat upon the face of the nipples 38 so as to form a valve with the lower end of the float, thereby preventing further escape of fluid through the openings of nipples 38. With the float seated in this manner, and with the gas or air being admitted into the upper end of cylinder 26, the valve 50 will yield when the pressure exceeds the pressure exerted by the springs thereunder, and gas or air will be admitted into the float 48, thereby preventing any undue pressure thereon. Upon release of pressure from the exterior of the float the valve 50 will seat and any excess gas within the float 48 will exert pressure therein, and if by any chance, liquid remains in the lower portion of the float, it will be forced out through check valve 52, and such air or gas as is entrapped therein is also forced out until the air or gas within the float 48 escapes through spring pressed check valve 52 until the pressure within the float 48 falls to 25 p. s. i. In this manner the float is maintained loaded with approximately 25 pounds of air or gas pressure in event the springs of this particular character are used. In this manner the float is always maintained free of any appreciable amount of liquid or condensate and is never maintained above a pressure predetermined by springs 51 and 53.

The lower end of the cylinder 26 is screw threaded into the partition or head 54, as is the upper end of the cylinder 28. The partition 54 has an axial opening 56 therein in which a screw threaded axial pipe 58 interfits. The pipe 58 is similar to pipe 34 and has casing 60 screw threaded on the lower end thereof, which casing 60 is similar to the casing 36. The casing 60 has nipples 62 circumferentially spaced around the upper face thereof, which nipples are faced to form a valve seat with the lower face of float 63. The float 63 has tapered pins 64 circumferentially spaced around the lower side thereof, which pins complementarily engage nipples 62 and tapered openings 66 in the upper face of casing 60. The upper end of cylinder 28 has a vent hole 69 therein a spaced distance from the upper end thereof so as to permit the escape of the greater portion of gas or air entrapped within the cylinder 28 to permit the float 63 to function properly, however, sufficient gas or air is entrapped above the vent 69 so as to maintain the valve 50 above the liquid level.

The float 63 is of sufficient length that the pins are maintained within the respective holes in the nipples 62 when in the uppermost position and which serve as metering valves in accordance with the rise and fall of the float so as to admit fluid into casing 60 evenly and without causing the float 63 to seat abruptly upon application of suction. The cylinder 28 has perforations 68 therein substantially at the same level as the inlet openings 66 of nipples 62 in the casing 60 and the casing 28 also has perforations 70 below the inlet perforations 68. The water is removed from the well at a level below the interface of oil and water, therefore, when the water is lowered to a point below openings 68 oil will be drawn into the inlet openings 68, thereby enabling a greater recovery of oil than if the oil was removed and permitted the water to force its way into the oil producing strata.

The lower end of pipe 58 has a seat 72 fitted there-

into and has a pin 74 passing through the tube so as to form a cage. A ball valve 76 is positioned within the cage so as to admit oil and water into the lower end of the pipe 58. The lower end of cylinder 28 has a bottom plate or head member 78 screw threaded thereinto and into which head a pipe 80 is fitted. This pipe 80 has a closed lower end so the pipe will serve as a "mud anchor" on which cylinders 26—28 and tubing 24 rest when seated within the well.

An auxiliary poppet type valve 88 is mounted within an opening 84 formed in partition 54 which valve is fitted within a guide 86. The stem of valve 88 is screw threaded to receive nuts 90 to retain springs 92 under compression the desired regulated amount, so as to hold valve 82 closed against normal operating pressure within the chamber of cylinder 26. However, valve 82 may be opened by a predetermined pressure in excess of the operating pressure so as to clean the formation, as will be more fully explained hereinafter.

The tubing 32 extends upward within the well casing 21 and is connected by a T 94 to a valve 96 that is interposed between T 94 and a vacuum tank 97, which valve is shown in detail in Fig. 6. The valve designated generally by the numeral 96 is of the check valve type and has a flapper valve 98 that is maintained away from a seat 100 by a spring 102, when fluid under pressure is being passed through the valve, as indicated by the arrows, and does not exceed approximately fourteen pounds, which is the maximum working pressure exerted by a vacuum at normal altitudes, the fluid will pass therethrough. However, upon application of pressure in excess of the predetermined setting, which would usually be about twenty pounds, the rush of air or gas pressure, as indicated by the arrow Figs. 1, 5, and 6, will cause the flapper 98 of the valve 96 to seat upon seat 100, as will be more fully explained hereinafter.

The tube 32 extends to and connects with a three-way valve generally designated at 104. A tube 106 also connects with the valve 104 and has a pressure relief valve 108 thereon, as is shown in detail in Fig. 4. A third tube 110 connects to the three-way valve 104 and leads to a pressure tank 112. A compressor 114 is connected by lines 116 and 118 with vacuum tank 97 and by lines 120 and 122 to pressure tank 112. The compressor is of the usual double acting valved type to withdraw air or gas from tank 97 and discharge air or gas into pressure tank 112.

A vacuum relief valve 124 is provided for the tank 112 and a pressure relief valve 126 is mounted on tank 112 to relieve the tank of excess pressure above a predetermined setting. With this arrangement suction is maintained on tank 97 thereby maintaining a partial vacuum therein and pressure is maintained in tank 112 sufficient to force oil upward at the desired velocity. The compressor may be operated by a motor, as indicated at 128 to which a crank 130 of the compressor connects.

A measuring or weighing tank 132 is suspended by means of a cable 134, which cable passes over a pulley 136 and a weight 138 is attached to the other end of cable 134, which weight 138 will lift the tank 132 when the tank is empty, but which tank will over-balance the weight when the tank is filled.

The valve 104 has a plug 140 therein to which is secured an arm 142 that has an elongated loop 144 therein near the outer end thereof. The cable 134 passes through the loop 144 and cable clamps 146 and 148 are mounted above and below the arm 142 and the respective clamps are adapted to travel a distance slightly below and slightly above respectively of the center point of travel of arm 142. A spring 150 is secured to arm 142 and to an anchor point 152 at a spaced distance outward from the arm on a medial line passing through the center point of travel of the arm and the valve, so as to give a toggle action to hold the valve in alternate positions when moved by cable clamps 146 and 148.

The measuring or weighing tank 132 has a valve 154 in the lower end thereof so as to "bleed" or pass a given amount of oil out into a conduit **156** which may have a hopper **158** thereon. The conduit **156** leads to a storage tank **158***a*.

Operation

Prior to the operation of the device, the valves **46** and **76** will be seated on the respective seats, as will best be seen in Fig. 9. Upon starting the compressor **114**, air or gas will be evacuated out of vacuum tank **97**, and if gas is used as an actuating fluid a gas line may be connected to the inlet side of vacuum relief valve **124**, however, if air is used, no supply line need be connected to the valve **124**. The air or gas that is evacuated from the vacuum tank **97** is directed through lines **116** and **118** into compressor **114** between the respective valves within the compressor and out through the respective discharge check valves and through lines **120** and **122** into pressure storage tank **112** and with the valve **104** in the position as shown in Fig. 1, a suction will be exerted on line **32** to evacuate the air or gas from the chamber within cylinder **26**, and with valve **46** seated the suction exerted on cylinder **26**, will in turn, direct suction on pipe **68** to cause valve **76** to open whereupon liquid will be drawn through open perforations **68** and **70** into cylinder **28** and with an ample supply of liquid in the subterranean reservoir, the float will occupy the position as shown in Fig. 2 and oil will be withdrawn upward through pipe **58** through opening **56** and into the chamber within the cylinder **26**, causing the float **48** to move upward when the suction on pipe **32** has continued for a predetermined length of time and with the valve **104** in position as shown in Fig. 1 the tank **132** is relieved of the weight, as by the liquid passing out through valve **154** and the tank **132** rises under the influence of weight **138** until the cable clamp **148** contacts arm **142** to move it about toggle center line of valve **104**, whereupon, the spring **150** will cause the arm **142** to snap upward into the position as shown in Fig. 5, which will switch the valve, so that air or gas pressure will be directed through pipe **110** through valve **104** into line **32**, whereupon, the sudden surge of pressure directed against flapper valve **96** will close valve **96** and direct pressure downward into chamber of cylinder **26**. The initial pressure will cause the fluid level to move downward. The upper end of the float **48** and the valve **50** are always above the liquid level and as the pressure increases gas will pass into the float **48**. The oil level will move downward and the float will recede to seat upon the top of nipples **38**, which will close off the flow of oil that has been forced through the openings thereof into casing **36** and upward through valve seat **40** into tubing **34** to flow the oil, by positive displacement, to the top of the well, which oil will discharge into measuring or weighing tank **132**, which is in position as shown in Fig. 5, until the liquid within the tank reaches a predetermined level, as determined by counter-balancing the weight **138**, whereupon, the tank **132** will move downward to trip the toggle action valve **104** into position as shown in Fig. 1.

The weighing tank **132** will remain in this position until sufficient liquid has been bled from the tank through valve **154** or an orifice to permit the weight **138** to over-balance the tank and return to the position as shown in Fig. 5. However, when the tank **132** moves into position as shown in Fig. 1, after a normal pressure cycle, the pressure in line **32** will pass outward through tube **106** and relief valve **108**. As this pressure is relieved, the valve flapper **98** will move into open position under the influence of tension springs **102**, as shown in Fig. 6, whereupon, the suction or vacuum within tank **97** will draw air or gas up through line **32** to fill the cylinder **26** with liquid, in the manner described above.

It is to be pointed out that by the valve arrangement herein shown, a suction or vacuum may be placed upon the producing formation to withdraw the liquid from the producing strata into the chamber of cylinder **26**. However, upon application of normal pumping pressure to cylinder **26**, the float **48** will seat upon faced nipples **38** to prevent entrance of air or gas pressure into the formation. However it is further pointed out, that due to the construction of float **63**, the tapered pins **64** will form metering valve members, which will gradually seat within valve seat **66** and prevent sudden seating when the float **63** is near the seating point on nipples **62**. Furthermore, with the float arrangement as shown herein, the suction is prevented on the formation, if the liquid is exhausted therefrom, thereby preventing damage to the formation by "pulling in" loose sand or other detritus that may have accumulated within the well. However, any sand that may be drawn into the pump will be discharged therethrough without material detriment to the pump.

A spring loaded valve **88** is provided within partition **54** intermediate cylinders **26** and **28** so when it is desired, a solvent or a heating media, such as steam or hot air, may be connected to the line **32** and the pressure raised a predetermined amount above the normal operating pressure, which will cause spring **92** to yield to permit the solvent or heated media to pass out through perforations **68** and **70** and **22** into the fluid producing formation, so as to clean the formation of paraffin, scum, mud or other retarding agents so that the liquid may be produced more abundantly from the formation.

After the treating media is introduced into the cylinder **28**, it is preferable to raise the air or gas pressure temporarily to a pressure equal to the treating pressure, whereupon the valve **50** in float **63** will admit gas into the float until the float is charged with a pressure as determined by the springs **51** and **53** therein. Whereupon, the release of pressure from the chamber within cylinder **28**, any liquid that may have accumulated within float **63** will be expelled out through valve **52** which will reactivate the "water logged" float without having to remove the pump from the well.

It is to be pointed out that each of the floats **48** and **63**, constructed with valves of the character described, will not collapse regardless of the pressure exerted on the floats.

After initially starting the pump, and once the weighing tank **132** is filled with liquid, the pump will continue to pump a gauged amount of liquid so long as the compressor **114** is operated.

While the pump has been illustrated and described in one embodiment thereof, it is to be understood that changes may be made in the minor details of construction and adaptations made to particular installations without departing from the spirit of the invention or the scope of the appended claim.

Having thus described the invention, what is claimed is:

In a well pumping device for pumping liquid from deep wells, a vacuum and pressure generating system, a liquid discharge conduit extending into said well and having a pair of interconnecting, axially aligned cylinders located on the lower end thereof, a second conduit extending into said well and connecting to one of said cylinders for directing pressure and exerting suction onto said cylinder, said vacuum and pressure generating system being connected to said second conduit, a centrally positioned discharge conduit in each of said cylinders and in communication with said first mentioned discharge conduit, each of said centrally positioned conduits having an upwardly facing, apertured valve seat thereon, an annular float surrounding each of said centrally positioned discharge conduits and having a complementary seating surface on the lower end thereof to complementarily seat on said upwardly facing, apertured valve seat on the respective centrally positioned discharge conduits, a standing valve within each of said centrally positioned discharge conduits, which valve retains fluid passing through said valve thereabove, a switching valve within said vacuum, pneumatic pressure generating system to cause the switching of said suction and said pressure upon one of said cylinders upon the pumping of liquid from said well for a predetermined period of time.

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