

Dec. 22, 1959

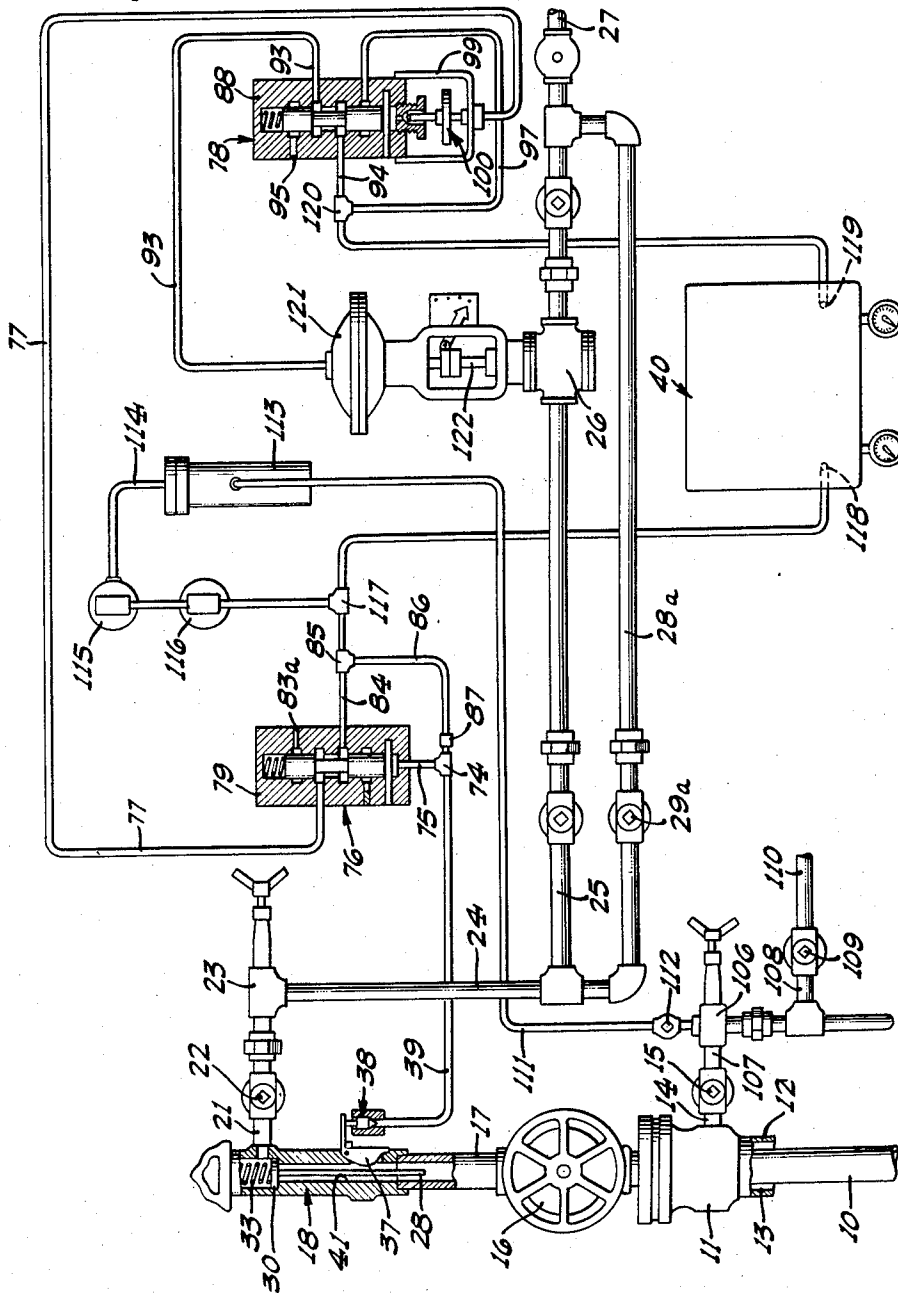
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2,918,015

FREE PISTON PUMPING DEVICE FOR GAS WELLS AND OIL WELLS

Filed Sept. 2, 1958

6 Sheets-Sheet 1



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6 Sheets-Sheet 2

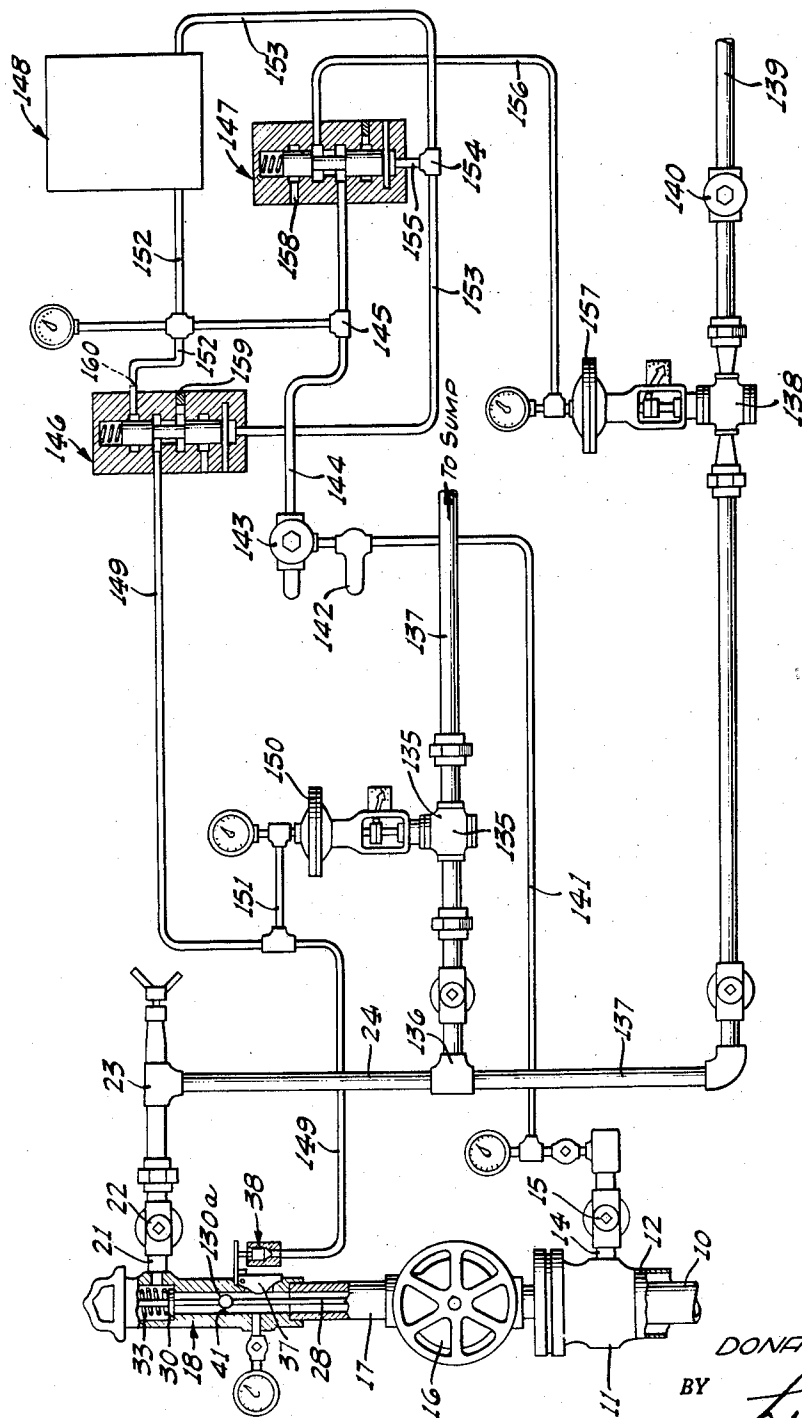


FIG. 2.

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6 Sheets-Sheet 3

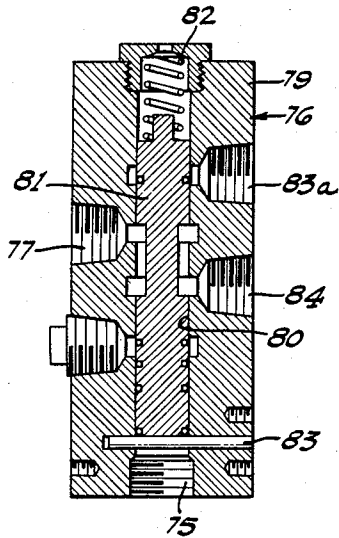


FIG. 4

FIG. 3.

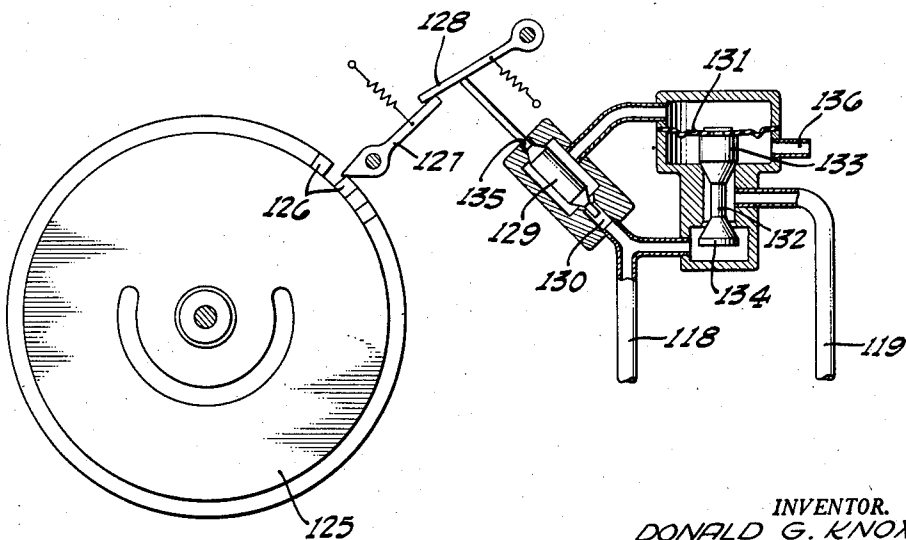
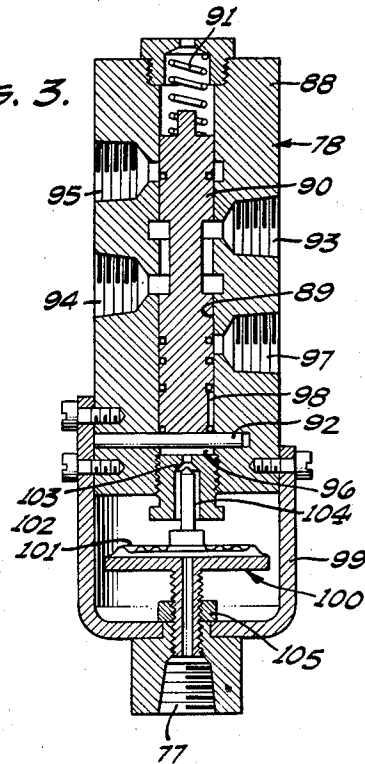


FIG. 9.

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6 Sheets-Sheet 4

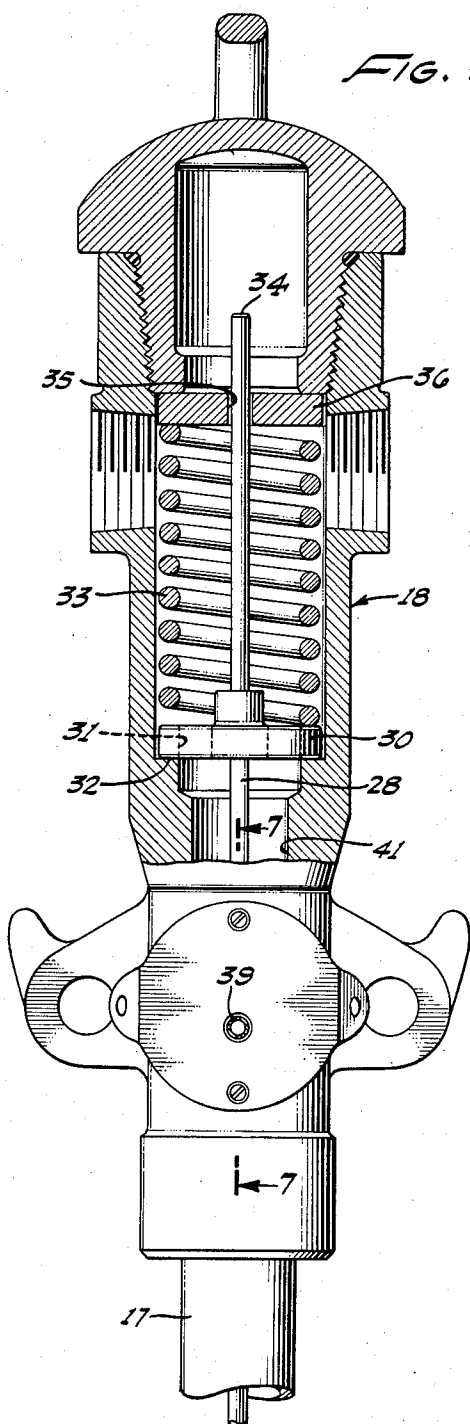
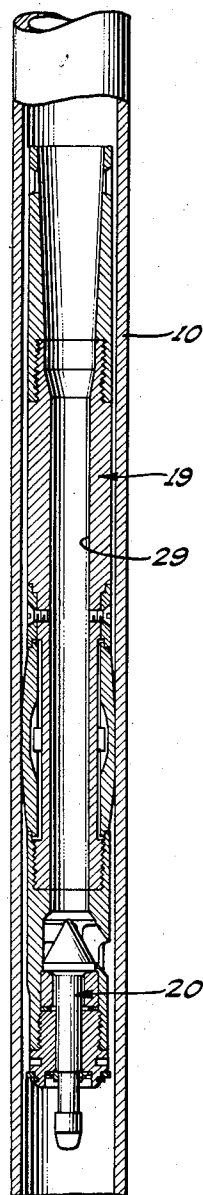


FIG. 6.



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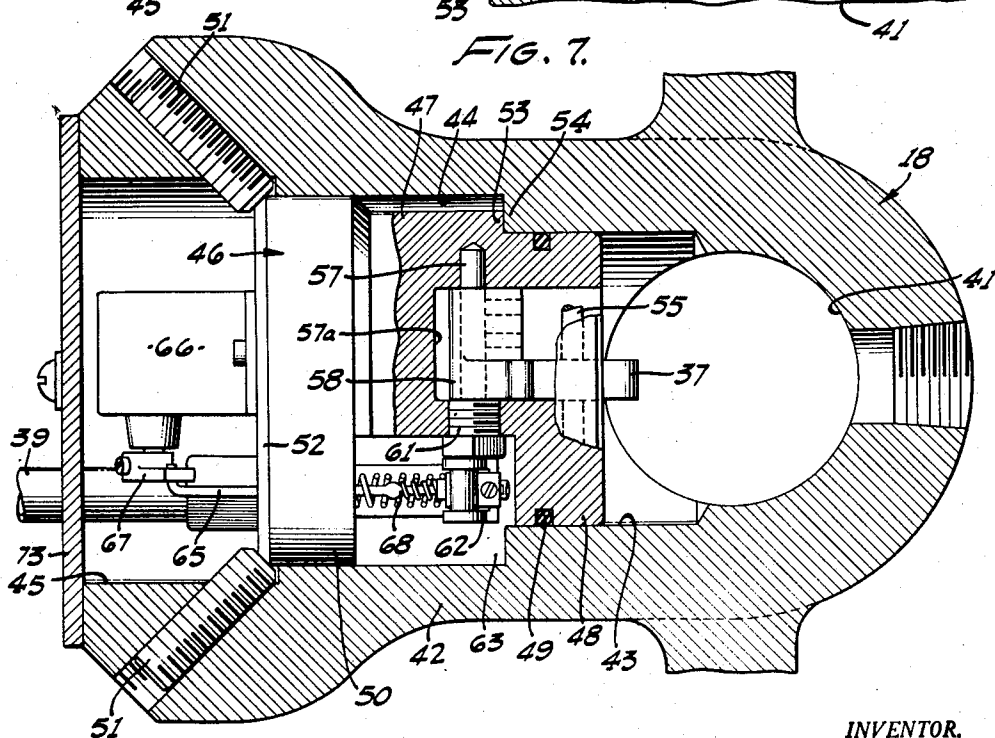
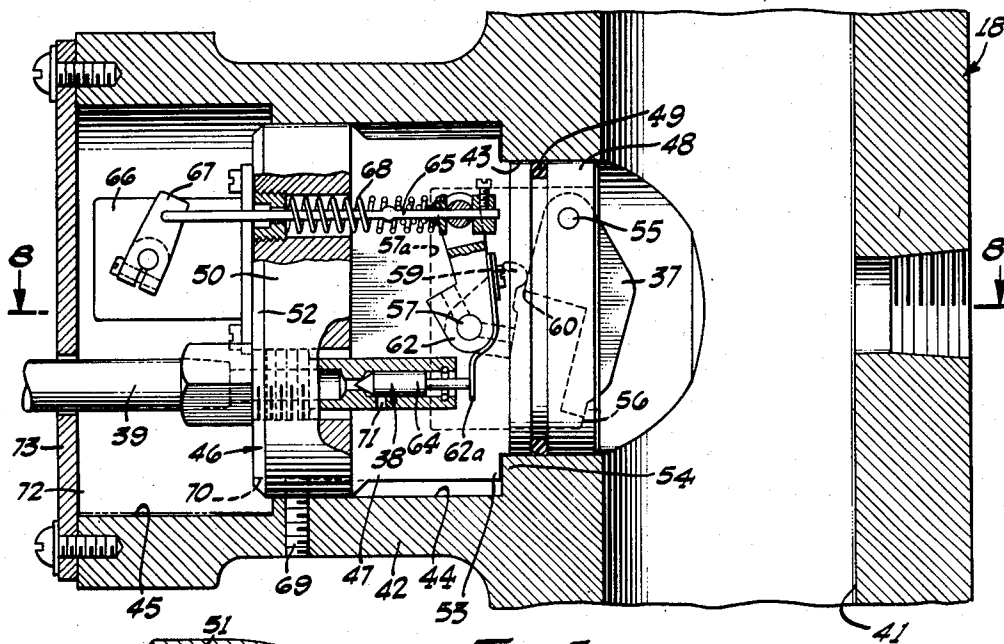
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6 Sheets-Sheet 5



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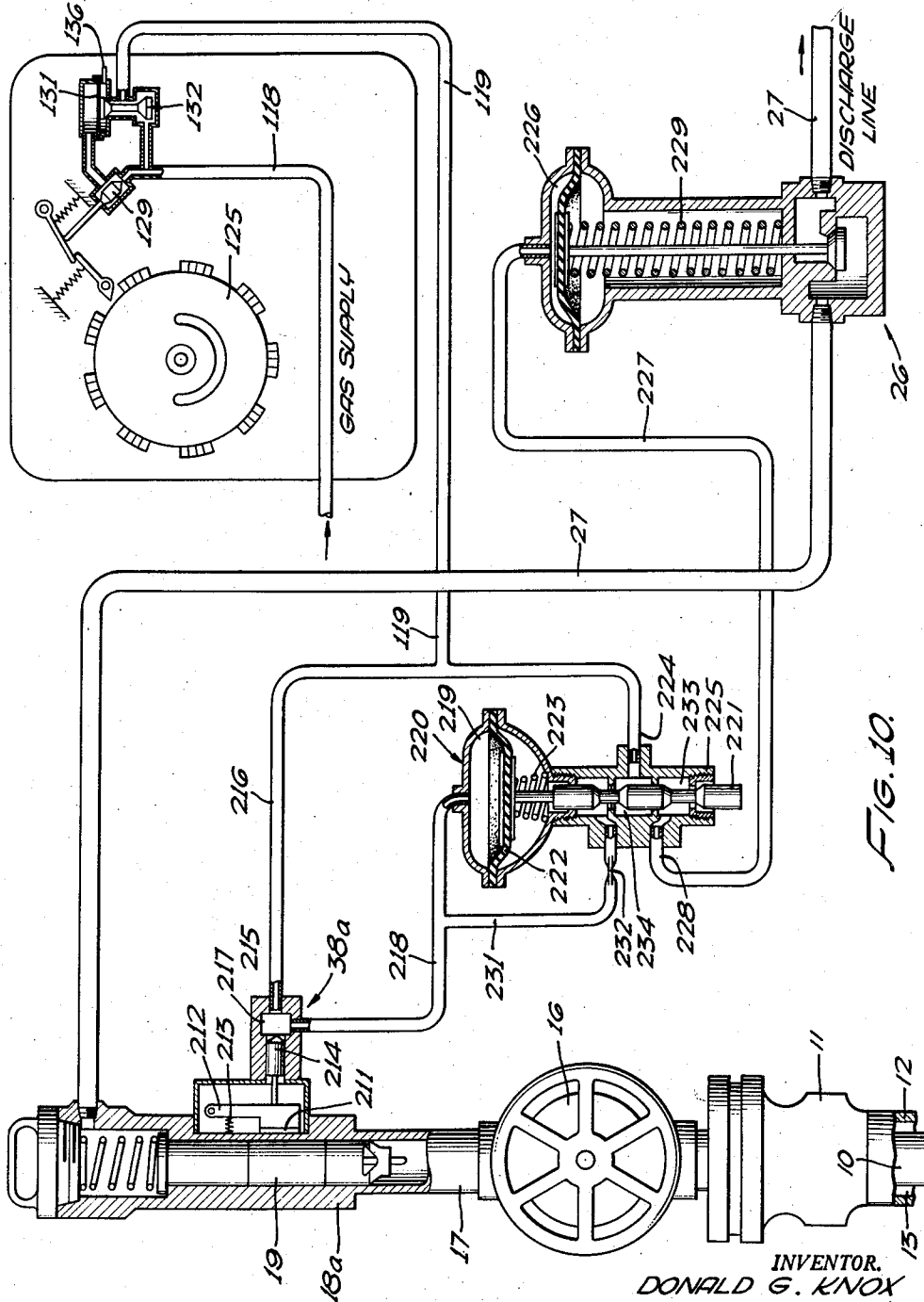
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6 Sheets-Sheet 6



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1

2,918,015

FREE PISTON PUMPING DEVICE FOR GAS WELLS AND OIL WELLS

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Application September 2, 1958, Serial No. 758,211

18 Claims. (Cl. 103—52)

This invention relates to free piston pumping devices of the general type shown in my prior Patents No. 2,699,121; 2,661,024; 2,642,002. In such devices, a plunger travels for a substantial distance in an eduction tube in a well under pressure of gas below the plunger to raise a load of well fluid to the surface. Devices of this type have commonly been used for many years to raise oil to the surface and more recently such devices have been used to remove salt water as it accumulates in gas wells, to prevent "drowning" of the well.

It is the principal object of this invention to provide an improved form of free piston pumping device which may be used to raise oil from oil wells or to remove unwanted salt water from gas wells, and in which the cycle of operation is controlled from the surface by means of a timer. Another object is to provide such a device which operates satisfactorily when the time cycles are unusually long and when the fluid is lifted at infrequent intervals. Another object is to provide a device of this type in which the plunger is held at the well head during the major portion of the cycle when the well fluid produced includes sand in objectionable quantities.

Another object is to provide a control device for free piston pumping apparatus employing a mechanical timer at the surface and provided with three-way pilot valves so that the motor valve in the discharge line may be actuated when the plunger reaches the well head. Another object is to provide a device of this type in which the control valve in the discharge line may be actuated after a lapse of a few minutes even though the plunger may fail to enter the well head at the end of its upward stroke. A related object is to provide a single pilot valve for operating the motor control valve in the discharge line, together with a timer-operated valve and a plunger-operated valve on the well head for actuating said pilot valve. Other objects and advantages will appear hereinafter.

This application is a continuation-in-part of my prior application, Serial No. 591,144 filed June 13, 1956 now abandoned.

In the drawings:

Figure 1 is a diagram partly in section, showing surface controls constituting a preferred embodiment of my invention.

Figure 2 is a view similar to Figure 1 showing a modification.

Figure 3 is a sectional detail of one of the pilot valves.

Figure 4 is a sectional detail of another of the pilot valves.

Figure 5 is a side elevation partly in section showing the bumper housing at the upper end of the eduction tube.

Figure 6 is a sectional elevation showing the plunger in the eduction tube.

Figure 7 is a sectional elevation partly broken away, taken substantially on the line 7—7 as shown in Figure 5.

Figure 8 is a transverse sectional view taken substantially on the lines 8—8 as shown in Figure 7.

2

Figure 9 shows details of operation of the mechanical timer in diagrammatic form.

Figure 10 is a diagram showing a modified form of my invention.

Referring to the drawings, the eduction tube generally designated 10 comprises a string of tubing which extends down into the well from the well head 11. The well casing 12 also extends into the well and defines an annulus 13 between the casing 12 and the eduction tube 10. A side outlet 14 in the well head communicates with this annulus 13 and is connected to a shut-off valve 15 which is normally open.

The eduction tube 10 passes through the well head 11 and is connected to the master gate valve 16. A nipple 17 connects the upper end of the valve 16 to the bumper housing 18. The plunger generally designated 19 (see Figure 6) travels in the eduction tube 10 and passes upwardly through the well head 11, valve 16, nipple 17 and comes to rest within the bumper housing 18. A valve assembly 20 on the plunger 19 is closed during the upward travel of the plunger 19 within the eduction tube 10 and well fluid carried to the surface by the plunger 19 passes outward from the bumper housing 18 through a discharge conduit generally designated 21. This conduit includes the shut-off valve 22, adjustable flow bean 23, piping 24, 25, control valve 26 and flow line 27. If desired, a by-pass line 28a may be provided around the control valve 26 and furnished with a shut-off valve 29a.

The lower portion of the eduction tube 10 is conventional and may be similar to that shown in my Patent No. 2,642,002.

As the plunger 19 enters the bumper housing 18 at the upper end of its path of travel, the rod 28 is received within the central opening 29 of the plunger 19 and mechanically contacts the valve 20 in the plunger to move it to open position. Gas under pressure below the plunger 19 then passes through the open valve and through the central passage 29 and outward through the discharge conduit 21 as shown in Figure 5. The rod 28 is mounted on a collar 30 which is provided with central openings 31 through which fluid and gas may pass. This collar 30 normally rests on the shoulder 32 under force of the coil spring 33. This spring acts as a shock absorber when the upper end of the plunger 19 strikes the lower surface of the collar 30. A guide bar 34 fixed to the collar 30 passes loosely through a central opening 35 in the washer 36 at the upper end of the spring 33.

A mechanically operated trigger 37 is mounted on the bumper housing 18 and this trigger is operated by contact with the plunger 19 when the latter enters the bumper housing 18. When the trigger 37 is contacted by the plunger 19 it acts to open a valve assembly 38 and thereby vent line 39 to atmosphere, thereby causing the control valve 26 to move to closed position in the manner described below. When the control valve 26 closes the path of escape of fluid and gas through pipe 27 from the eduction tube 10 is shut off. The plunger 19 then drops by gravity down through the eduction tube 10. It remains on bottom until the control valve 26 is opened by the timer 40, as described below.

The bumper housing 18 is provided with a cylindrical opening 41 which slidably receives the plunger 19. The bumper housing 18 is also provided with an integral lateral extension 42 which includes a transverse bore 43 intersecting the opening 41. The lateral extension 42 also includes a counterbore 44 and a clearance opening 45.

The trigger 37 is carried on a trigger insert plug assembly generally designated 46. This plug assembly 46 includes a body 47 having a forward cylindrical portion 48 having a snug fit within the bore 43. A seal-

ing ring 49 on this cylindrical portion prevents leakage. A second cylindrical portion 50 on the body 46 is slidably received within the counterbore 44. The body 46 is held in position against pressure within the opening 41 by means of compression screws 51 which are threaded in the lateral extension 42 and which engage the surface 52. These set screws 51 hold the body shoulder 53 against abutment 54 provided on the lateral extension 42.

The trigger 37 is mounted on a pivot shaft 55 carried on the forward end of the cylindrical portion 48 of the body 46. Pivotal movement of the trigger 37 about the shaft 55 is limited by the stationary stop element 56 provided on the cylindrical portion 48. A rock shaft 57 is mounted on the body 46 and this rock shaft extends across the cavity 57a containing the trigger 37. A follower element 58 is fixed to this shaft and has a nose portion 59 which is contacted by a surface 60 on the trigger 37. The shaft 57 extends through a seal element 61 and has a lever 62 fixed to its projecting end, and positioned within the recess 63. A projection 62a fixed on this lever 62 engages one end of the movable valve element 64 on the vent valve assembly 38. The lever 62 also serves to operate a push rod 65 for actuation of a counter mechanism 66 through bell crank 67. A spring 68 acts on the lever 62 to maintain the valve element 64 in closed position. The body 46 is prevented from turning in the counterbore 44 by means of a set screw 69 which engages a key way 70.

When the plunger 19 engages the trigger 37 it causes the lever 62 to be swung in a counterclockwise direction as viewed in Figure 7 thereby allowing the movable valve element 64 to move to the right under the force of gas pressure in the line 39. This action serves to bleed the line 39 to atmosphere through the lateral port 71 and through clearance spaces communicating with the cavity 72. The cavity 72 is not sealed with respect to the atmosphere but communicates therewith through clearance openings in the window 73. When the plunger 19 drops out of the bumper housing 18 after the control valve 26 closes, the spring 68 returns the lever 62 to its initial position, thereby causing the extension 62a to contact the movable valve element 64 and thereby closes the vent valve assembly 38.

The line 39 is connected by T fitting 74 to line 75 leading to the pilot valve assembly 76. The line 77 connects the non-adjustable pilot valve assembly 76 with the adjustable pilot valve assembly 78. The pilot valve assembly 76 includes a ported housing 79 having a central bore 80 which receives a sliding valve element 81. A spring 82 at one end of the element 81 tends to move the other end into contact with the cross pin 83 which acts as a stop. When pressure from line 75 moves the element 81 in a direction to compress the spring 82, line 77 is vented to atmosphere through vent port 83a. When the line 75 is vented, the spring moves the element 81 downward to contact the stop pin 83, thereby connecting line 77 with line 84. Line 84 is connected through tube fitting 85 to pipe 86. A fitting having a small diameter orifice 87 is positioned between pipe 86 and T fitting 74.

The pilot valve assembly 78 is provided with a housing 88 having a central bore 89. A movable valve element 90 is slidably mounted within the bore 89. A spring 91 acts on one end of the element to move it against a stationary stop pin 92 at the other end. In the position shown in Figure 3, the line 93 is placed in communication with the line 94. When the valve element 90 moves upward under the application of pressure at the lower end thereof, the line 93 is vented through the vent port 95. Pressure reaches the chamber 96 at the lower end of the bore 89 via line 97 and groove 98 formed in the valve element 90. A bracket 99 is fixed to one end of the housing 88 and provides a support for the adjustable member 100. This member carries a bellows element 101 which supports a movable valve element 102 adapted to close against a sta-

tionary seat 103. When pressure is applied from line 77, the diaphragm 101 causes the valve element 102 to close against the seat 103. When pressure in line 77 is relaxed, the diaphragm 101 returns to its normal free position thereby separating the valve parts 103 and 102 to bleed the lower chamber 96 to atmosphere through the passage 104. The nut 105 permits the member 100 to be fixed in axially adjusted position.

A flow bean 106 receives gas under pressure from nipple 107 and this gas passes through piping 108 and valve 109 to the sales line 110. The sales line 110 together with parts which connect it to the interior of the casing 12 constitutes a gas line through which gas constantly flows, under normal conditions, regardless of the position of the control valve 26. A supply line 111 carries gas from the flow bean 106 through shut-off cock 112 and delivers it to the filter 113. Gas from the filter passes through piping 114 and through the reducing regulators 115 and 116. The gas delivered to the T fitting 117 is regulated to a predetermined operating pressure, for example 20 p.s.i. The T fitting 117 is connected to the T fitting 85 and is also connected to the timer inlet at 118. The timer outlet 119 is connected to the T fitting 120 and the latter is connected to the lines 94 and 97.

The control valve 26 is normally closed by means of a spring. When line 93 is pressurized, a diaphragm within the diaphragm chamber 121 moves the valve stem 122 downward to open the motor valve 26. Conversely, venting of the line 93 relaxes pressure within the diaphragm chamber 121 and permits the spring to close the valve 26.

The timer mechanism generally designated 40 serves to connect the inlet 118 to the outlet 119 at predetermined time intervals. Any suitable or desirable form of timer may be used. In the particular form of timer illustrated in Figure 9, a clock driven disk 125 is provided with detachable clips 126 which may be secured to its periphery. When the point of the trigger 127 falls into the slot left by the displaced clip, the other end of the trigger exerts a force on the leaf spring 128. This in turn allows a primary three-way valve 129 to open the supply port 130. The supply of gas then flows from the inlet 118 through the valve 129, loading the diaphragm 131 of the secondary three-way valve 132. Force exerted on this diaphragm closes this exhaust valve 133 and opens the supply valve 134 to supply pressure to the outlet 119. As the timing disk turns counter-clockwise, the timing clip engages trigger 127 forcing the trigger to relieve its pressure on the leaf spring 128. This allows the three-way valve 129 to close the supply port 130 and to open the exhaust port 135, bleeding pressure off chamber above the diaphragm 131. The gas then closes supply valve 134 and opens the exhaust valve 133. The pressure in the main diaphragm then bleeds out exhaust port 136.

The pilot bleeds gas only when the primary three-way valve 129 is moving through the intermediate position. Secondary three-way valve 132 acts quickly and allows only a small amount of supply gas to be lost on the exhaust stroke of control valve 26. This pressure reduces the possibility of regulator freeze-ups by avoiding any steady flow of supply gas, and also reduces the total amount of gas used for operation.

In the operation of the form of the invention shown in Figure 1, the plunger 19 stays at the bottom of the well with gas flowing from the casing 12 through bean 106 to the sales line 110. At the end of a desired time interval, the control valve 26 is opened, causing a rush of gas through the flow bean 23 and through piping 24 and 25 to the flow line 27. This brings the plunger 19 to the surface, raising a fluid load above it. Fluid discharges through flow bean 23 and through control valve 26 to the flow line 27. This flow line 27 ordinarily is connected to a gas separator or sump (not shown).

After the fluid is discharged, the plunger 29 enters the

5

bumper housing 18 and engages the trigger 37. This action serves to close the control valve 26 in the manner described below and the plunger 29 thereupon returns to the lower end of eduction tube 10 until the beginning of the next time cycle.

The corresponding operation of the control mechanism for causing the plunger to cycle in the manner described is set forth as follows: operating pressure, for example, 20 p.s.i. in line 86 passes through orifice 87 to pressurize the trigger line 39. This pressure in line 75 raises the plunger 81 of the pilot valve 76 venting line 77 to atmosphere through port 83a and closing off line 84. When the timer 40 operates to pressurize the outlet 119 from the inlet 118 by-pass line 97 is pressurized. The valve element 90 in the pilot valve 78 is in the position shown in Figure 3. This pressurizes the diaphragm chamber 121 and moves the valve stem 122 downwardly to open the control valve 26.

When the plunger 29 reaches the surface, it actuates the trigger 37 and thereby permits the valve assembly 38 to vent the line 39 to atmosphere through the vent port 71. The reduction in pressure in line 39 causes the valve element 81 in the pilot valve 76 to move downward under force of the spring 82 to connect the pressure line 84 with the line 77. This in turn pressurizes the diaphragm 101 of the pilot valve 78 causing the valve port 102 to close against the seat 103. The valve element 90 is raised by pressure in the chamber 96 supplied via line 97 and groove 98. A pressure line 94 is shut off and line 93 is vented through port 95. Venting of the line 93 results in upward movement of the valve stem 122 to close the control valve 26.

When the control valve 26 closes, the plunger 19 drops away from the well head thereby closing the trigger valve assembly 38, and permitting pressure in line 39 to build up by gas supplied through orifice 87. Pressure in the line 75 then raises the valve element 81 in the pilot valve 76 to close off pressure line 84 and to vent the line 77 through the vent port 83a. Line 93 remains vented through port 95 and the control valve 26 remains closed. The timer 40 trips again and shuts off the supply of gas to the outlet 119. This action releases pressure in the by-pass line 97, thus permitting the spring 91 to move the valve element 90 in the pilot valve 78 thereby connecting line 94 with line 93. The cycle is then ready to repeat.

Should the plunger 19 fail to enter the bumper housing 18, the control valve 26 is closed by the timer 40 shortly after the plunger 19 is scheduled to arrive at the well head. This is accomplished by setting of the timer mechanism. This feature avoids the possibility of loss of gas through the line 27 in the event the plunger should fail to reach the upper end of its stroke within the bumper housing 18.

In the modified form of my invention shown in Figure 2, the eduction tube 10, well head 11, casing 12, valve 16, nipple 17 and bumper housing 18 are substantially the same as previously described. The same plunger 19 is used. The bumper housing 18 and its associated mechanism including the vent valve 38 is substantially the same as previously described. The mechanism opener rod 28 is provided with an enlargement 130a which restricts the flow passage area within the opening 29 of the plunger 19 when the latter is positioned within the bumper housing 18. This restriction produces a pressure drop from the bottom to the top of the plunger 19 with the result that the plunger may be maintained within the bumper housing until the intensity of pressure is substantially reduced in the eduction tube below the plunger. The result is that the plunger is held within the bumper housing for a substantial period of time before dropping back down the eduction tube 10. This form of my invention is used when sanding or other conditions are present which would interfere with the operation of the plunger if it were maintained on bottom for substantial periods of time.

6

In this form of control mechanism as shown in Figure 2, a normally closed control valve 135 is connected to piping 24 by means of T fitting 136. Pipe 137 leading from the control valve 135 connects to a sump (not shown). A normally open control valve 138 is connected to the sales line 139 through the check valve 140. The sales line 139 together with the parts which connect it to the interior of the bumper housing 18 constitutes a gas line through which gas may flow from the well regardless of the position of the control valve 135. Spring loaded check valve 140 serves to prevent any reverse flow from sales line through valve 138 when valve 135 is open to the sump. Gas passes from the casing 12 through nipple 14, valve 15 and supply line 141 to the strainer 142, and to the reducing regulator 143. Gas from the regulator passes through line 144 to the T fitting 145 and thence to the pilot valves 146 and 147 and to the timer 148. The pilot valves 146 and 147 are substantially duplicates and are the same as pilot valve 76 shown in Figure 4. Timer mechanism 148 is substantially the same as timer 40 previously described. The line 149 connects with the pilot valve 146 and with the diaphragm chamber 150 of the control valve 135 via branch pipe 151. Line 152 connects the pilot valve 146 with the timer 148 and the line 153 connects the timer 148 with the pilot valve 146 via T fitting 154, and with pilot valve 147 via branch pipe 155. The line 156 connects the pilot valve 147 with the diaphragm chamber 157 of the normally open control valve 138.

In the operation of this form of my invention, the plunger 19 remains in the bumper housing 18 while gas passes outward through flow bean 23 and through normally open valve 138 to the sales line 139. Plunger 19 in contact with trigger 37 releases pressure in line 149. Pilot valve 146 connects line 149 with the pressure line 152 and pilot valve 147 vents line 156 through vent port 158. Control valve 135 remains closed because pressure in the branch pipe 151 is released through pilot valve 38. This is because port in pilot valve 38 is larger than restricting orifice 160.

When the timer 148 trips to interrupt the supply of gas to the line 153, the pilot valve 147 connects line 144 to line 156, pressurizing the diaphragm chamber 157 and thereby closing the valve 138. Thus motor valve 135 remains closed permitting plunger to descend.

When the timer 148 again trips to pressurize line 153, pilot valve 147 connects line 156 to the vent port 158 thereby opening valve 138. Pilot valve 146 connects line 152 through orifice 160 to line 149 thereby causing valve 135 to open slowly to sump as pressure builds up in pressure line 149. The plunger 19 begins to rise in the eduction tube 10. When the plunger 19 strikes the trigger 37 the vent valve 38 opens to bleed the line 149. The valve 135 closes gradually as the pressure in the diaphragm chamber 150 is bled to atmosphere. The plunger 19 remains in the bumper housing 18 because of the restriction imposed by the enlargement 130a. The cycle is then ready to repeat.

Although I have described certain embodiments of my invention in connection with removal of unwanted salt water from gas wells, my invention is not limited to such use but can be applied to advantage for the production of oil from oil wells.

In the modified form of my invention shown in Figure 10, the eduction tube 10, well head 11, casing 12, valve 16 and nipple 17 are substantially the same as described in connection with Figure 1. The same plunger 19 is used and the bumper housing 18a is similar to the bumper housing 18 but is constructed of non-magnetic material, for example 18-8 austenitic stainless steel. The vent valve assembly 38a replaces the vent valve 38 and a magnetically operated trigger device 210 replaces the mechanical trigger 37. This device 210 includes a permanent magnet 211 mounted on a pivoted arm 212 and adapted to swing in a counterclockwise direction, as

viewed in Figure 10, whenever the plunger 19 enters the bumper housing 18. The construction and operation of this magnetic trip device 210 is contained in the copending application of William A. Shaw, Serial No. 640,365, filed February 15, 1957. A spring 213 normally holds the arm 212 in its retracted position and contact between the arm and sliding valve element 214 holds the latter in closed position against the seat 215. Line 216 communicates with the seat and with line 119 extending from the timer operated valve.

A chamber 217 encloses a portion of the moving valve element 214 and is connected by means of a line 218 to the diaphragm chamber 219 in the pilot valve assembly 220. A valve spool 221 is fixed at one end to the diaphragm 222 and the other end is open to atmosphere. A spring 223 acts to move the spool 221 in the direction to reduce the volume of the diaphragm chamber 219. A port 224 in the housing 225 connects with the gas line 119 from the timer valve. The control valve 26 in the discharge line is substantially the same as that described in connection with Figure 1, and the diaphragm chamber 226 thereof is connected by line 227 to the port 228 in the housing 225 of pilot valve assembly 220.

Gas under pressure delivered to line 119 from the timer valves pressurizes line 216 leading to the trigger valve assembly 38a, and also pressurizes line 227 through open port in valve 220 leading to the diaphragm chamber of the control valve 26 in the discharge line 27. The plunger valves 129 and 132 open when the clock driven timer wheel 125 reaches a predetermined position, as described above. The plunger 19 is at the bottom of the well at that time. Opening of the control valve 26 in the discharge line 27 reduces the pressure within the eduction tube 10, and the plunger 19 begins its upward trip, carrying a load of well fluid above it. When the plunger 19 enters the interior of the bumper housing 18, the magnetic attraction between the magnet 211 and the metal of the plunger causes the pivoted arm 212 to swing in a counterclockwise direction against the action of the spring 213. The moving valve element 214 then moves away from the seat 215 to allow gas in the line 216 to pressurize the chamber 217 and deliver gas under pressure through line 218 to the diaphragm chamber 219 of the pilot valve assembly 220. The diaphragm 222 moves downward against the action of the spring 223 to move the spool 221 and change the porting. This serves to vent the line 227 to atmosphere and allow the internal spring 229 in the control valve 26 to raise the valve stem and close the valve, thereby shutting in the well. The parts are then in the position shown in Figure 10.

The plunger 19 then drops back down the eduction tube 10, and the pivoted arm 212 is swung in a clockwise direction by the spring 213, and this serves to move the valve element 214 into closed position against the seat 215.

It should be noted that the timer clock continues to drive the timer wheel 125 and if, through some circumstance, the plunger 19 fails to arrive at the surface and enter the bumper housing 18, the timer wheel 125 will act after a predetermined interval to close the valve 129 and thereby close the valve 132. Closing of the valves 129 and 132 shuts off the supply of gas to the diaphragm chamber 226, at the same time venting port 136 to atmosphere, permitting the spring 229 to close the control valve 26 in the discharge line 27. Thus, the well is shut in after a predetermined time interval even though the plunger 19 should fail to arrive at the surface.

Closing of the timer valves 129 and 132 in the normal sequence of operation occurs after the plunger 19 has dropped downward out of the bumper housing 18 and after the valve element 214 is closed against the seat 215. Gas in lines 119 and 216 is vented to atmosphere through the vent port 136 (see Figure 9) and gas in the

lines 218, 231 vents through a restriction 232 into the space 234 within the valve housing 225. The space 233 communicates through line 119 with atmospheric vent port 136 so long as the valve spool 221 is in this position. When escape of gas from the chamber 219 permits the spring 223 to raise the diaphragm 222, the line 231 is vented through restriction 232 to atmosphere through the ported chamber 234. The parts are then in the initial position and the cycle repeats as soon as the timer plate 125 moves to bring the next gap in the clips 126 into position opposite the point of the trigger 127.

Having fully described my invention, it is to be understood that I do not wish to be limited to the details herein set forth, but my invention is of the full scope of the appended claims.

I claim:

1. In a gas well installation having an eduction tube connected to a well head, the improvement comprising, in combination: a valve plunger adapted to travel freely under pressure substantially the full length of the eduction tube to remove accumulations of liquid in the well, a discharge conduit connected to the well head, a first control valve operatively connected to the discharge conduit, a second control valve operatively connected to the discharge conduit, a movable trigger element positioned adjacent the well head and adapted to be mechanically actuated by physical contact with said plunger, means for closing the first said control valve upon actuation of said trigger, a timer device operatively connected to close the second control valve at predetermined time intervals.

2. In a gas well installation having an eduction tube connected to a well head, the improvement comprising, in combination: a valved plunger adapted to travel freely under pressure substantially the full length of the eduction tube to remove accumulations of liquid in the well, a discharge conduit connected to the well head, a first control valve operatively connected to the discharge conduit, a movable trigger element positioned adjacent the well head and adapted to be mechanically actuated by physical contact with said plunger, means for closing the first said control valve upon actuation of said trigger, a second control valve operatively connected to the discharge conduit, gas actuated means including a pilot valve for closing the second control valve, and a timer device operatively connected to supply a gas under pressure to said pilot valve at predetermined time intervals.

3. In a gas well installation having an eduction tube connected to a well head, the improvement comprising, in combination: a valved plunger adapted to travel freely under pressure substantially the full length of the eduction tube to remove accumulations of liquid in the well, a discharge conduit connected to the well head, a first control valve operatively connected to the discharge conduit, a movable trigger element positioned adjacent the well head and adapted to be mechanically actuated by physical contact with said plunger, pneumatic means for closing the first said control valve upon actuation of said trigger, a second control valve operatively connected to the discharge conduit, pneumatic means for closing the second control valve at predetermined time intervals, and means adjacent the well head for maintaining the plunger at the upper end of its stroke so long as either of said control valves is open.

4. In a device for use with a valved plunger adapted to travel freely under pressure substantially the full length of an eduction tube in a well, the combination of: a bumper housing having a longitudinal opening to receive the plunger, the bumper housing having an integral lateral extension provided with a bore intersecting said longitudinal opening, a body removably secured within the bore and having a movable trigger mounted thereon for contact with the plunger, the body having a recess, seal means preventing leakage between said longitudinal bore

and said recess, and a vent valve assembly in said recess adapted to be actuated by the trigger.

5. In a device for use with a valved plunger adapted to travel freely under pressure substantially the full length of an eduction tube in a well, the combination of: a bumper housing having a longitudinal opening to receive the plunger, the bumper housing having an integral lateral extension provided with a bore intersecting said longitudinal opening, a shoulder in said bore, a body removably mounted within the bore in sealing relationship, at least one threaded element on the bumper housing extension engaging the body to maintain the body in contact with said shoulder, a movable trigger mounted on the body for contact with the plunger, and a vent valve assembly on the body adapted to be actuated by the trigger.

6. In a device for use with a valved plunger adapted to travel freely under pressure substantially the full length of an eduction tube in a well, the combination of: a bumper housing having a longitudinal opening to receive the plunger, the bumper housing having an integral lateral extension provided with a bore intersecting said longitudinal opening, a shoulder in said bore, a body removably mounted within the bore in sealing relationship, at least one threaded element on the bumper housing extension engaging the body to maintain the body in contact with said shoulder, a movable trigger for contact with the plunger and a counter to be actuated by the trigger.

7. In a well pump device having a plunger adapted to travel in an eduction tube to deliver well fluid into a discharge line, the discharge line being connected to a well head at the upper end of the eduction tube, and a pressure operated control valve in the discharge line, the improvement comprising in combination: a timer device, a fluid pressure supply conduit, means including valve means in said fluid pressure supply conduit operated by the timer device for opening the control valve and subsequently closing it after a predetermined time interval, and means including a valve assembly on the well head acting to close the control valve in response to entry of the plunger into the well head during said time interval.

8. In a well pump device having a plunger adapted to travel in an eduction tube to deliver well fluid into a discharge line, the discharge line being connected to a well head at the upper end of the eduction tube, and a pressure operated control valve in the discharge line, the improvement comprising in combination: a timer device, a fluid pressure supply conduit, a pilot valve connected to operate the control valve, valve means in said fluid pressure supply conduit operated by the timer device for delivering gas under pressure to the pilot valve and subsequently closing off such delivery after a predetermined time interval, and means including a valve assembly on the well head connected to the pilot valve and acting to close the control valve in response to entry of the plunger into the well head during said time interval.

9. In a well pump device having a plunger adapted to travel in an eduction tube to deliver well fluid into a discharge line, the discharge line being connected to a well head at the upper end of the eduction tube, and a pressure operated control valve in the discharge line, the improvement comprising in combination: a fluid pressure supply conduit, means including valve means in the fluid pressure supply conduit for operating the control valve, timer means controlling the operation of said valve means whereby the control valve is opened and then subsequently closed after a predetermined time interval, and means including a valve assembly on the well head acting to close the control valve in response to entry of the plunger into the well head during said time interval.

10. In a free piston well pump device having an eduction tube connected to a well head, a plunger adapted to travel freely under pressure within the eduction tube

to remove accumulations of liquid in the well, a discharge conduit connected to the well head and communicating with the tubing to carry away said liquid, and a pressure operated control valve in said discharge conduit, the improvement comprising, in combination: a pilot valve assembly connected to operate the control valve, a timer mechanism, a pressure fluid conduit connected to the pilot valve assembly, valve means operated by the timer mechanism for delivering fluid under pressure to the pilot valve assembly to cause opening of the control valve, said timer mechanism also acting to shut off the supply of gas after a predetermined time interval and thereby close said control valve and means including a valve assembly on the well head acting on the pilot valve to close the control valve in response to entry of the plunger into the well head during said time interval.

11. In a free piston well pump device having an eduction tube connected to a well head, a plunger adapted to travel freely under pressure within the eduction tube to remove accumulations of liquid in the well, a discharge conduit connected to the well head and communicating with the tubing to carry away said liquid, and a pressure operated control valve in said discharge conduit, the improvement comprising, in combination: a pilot valve assembly connected to operate the control valve, a timer mechanism, a pressure fluid conduit connected to the pilot valve assembly, valve means operated by the timer mechanism for delivering fluid under pressure to the pilot valve assembly to cause opening of the control valve and means including a valve assembly on the well head connected to the pilot valve and acting to close the control valve in response to entry of the plunger into the well head, said timer mechanism also acting to close said valve means after a predetermined time interval in the event that the plunger should fail to enter the well head.

12. In a well installation having an eduction tube connected to a well head, an improvement comprising, in combination: a plunger adapted to travel freely under pressure substantially the full length of the eduction tube to remove accumulations of liquid within the well, a discharge conduit connected to the well head, a first control valve operatively connected to the discharge conduit, a second control valve operatively connected to the discharge conduit, a movable element positioned adjacent the well head, means for moving said element in response to entry of the plunger into the well head, means for closing the first said control valve upon movement of said movable element, and a timer device operatively connected to close the second control valve at predetermined time intervals.

13. In a well installation having an eduction tube connected to a well head, an improvement comprising, in combination: a plunger adapted to travel freely under pressure substantially the full length of the eduction tube to remove accumulations of liquid in the well, a discharge conduit connected to the well head, a first control valve operatively connected to the discharge conduit, a movable element positioned adjacent the well head, means for moving said element in response to entry of the plunger into the well head, means for closing the first said control valve upon movement of said movable element, a second control valve operatively connected to discharge conduit, means including a pilot valve for closing the second control valve, and a timer device operatively connected to supply fluid under pressure to said pilot valve at predetermined time intervals.

14. In a well pump device having a plunger adapted to travel in an eduction tube to deliver well fluid into a discharge line, the discharge line being connected to a well head at the upper end of the eduction tube, and a pressure operated control valve in the discharge line, the improvement comprising, in combination: a timer device, a fluid pressure supply conduit, means including valve means in said fluid pressure supply conduit operated by the timer device for opening the control valve

and subsequently closing it after a predetermined time interval, means including a valve assembly on the well head operable to close the control valve, the valve assembly including a movable valve element, and magnetic means on the well head operable to actuate said valve element in response to entry of the plunger into the well head during the said time interval.

15. In a well pump device having a plunger adapted to travel in an eduction tube to deliver well fluid into a discharge line, the discharge line being connected to a well head at the upper end of the eduction tube, and a pressure operated control valve in the discharge line, the improvement comprising in combination: a timer device, a fluid pressure supply conduit, a pilot valve connected to operate the control valve, valve means in said fluid pressure supply conduit operated by the timer device for delivering gas under pressure to the pilot valve and subsequently closing off such delivery after a predetermined time interval, means including a valve assembly on the well head connected to the pilot valve and operable to close the control valve, the valve assembly including a movable valve element, and magnetic means on the valve head adapted to actuate the valve element in response to entry of the plunger into the well head during said time interval.

16. In a well pump device having a plunger adapted to travel in an eduction tube to deliver well fluid into a discharge line, the discharge line being connected to a well head at the upper end of the eduction tube, and a pressure operated control valve in the discharge line, the improvement comprising in combination: a fluid pressure supply conduit, means including valve means in the fluid pressure supply conduit for operating the control valve, timer means controlling the operation of said valve means whereby the control valve is opened and then subsequently closed after a predetermined time interval, means including a valve assembly on the well head operable to close the control valve, the valve assembly including a movable valve element, and magnetic means on the well head adapted to actuate the valve assembly in response to entry of the plunger into the well head during said time interval.

17. In a free piston well pump device having an eduction tube connected to a well head, a plunger adapted to travel freely under pressure within the eduction tube to remove accumulations of liquid in the well, a discharge

conduit connected to the well head and communicating with the tubing to carry away said liquid, and a pressure operated control valve in said discharge conduit, the improvement comprising, in combination: a pilot valve assembly connected to operate the control valve, a timer mechanism, a pressure fluid conduit connected to the pilot valve assembly, valve means operated by the timer mechanism for delivering fluid under pressure to the pilot valve assembly to cause opening of the control valve, said timer mechanism also acting to shut off the supply of gas after a predetermined time interval and thereby close said control valve, the valve assembly including a movable valve element, and magnetic means on the well head adapted to actuate the valve element in response to entry of the plunger into the well head during said time interval.

18. In a free piston well pump device having an eduction tube connected to a well head, a plunger adapted to travel freely under pressure within the eduction tube to remove accumulations of liquid in the well, a discharge conduit connected to the well head and communicating with the tubing to carry away said liquid, and a pressure operated control valve in said discharge conduit, the improvement comprising, in combination: a pilot valve assembly connected to operate the control valve, a timer mechanism, a pressure fluid conduit connected to the pilot valve assembly, valve means operated by the timer mechanism for delivering fluid under pressure to the pilot valve assembly to cause opening of the control valve, means including a valve assembly on the well head connected to the pilot valve and operable to close the control valve, the valve assembly including a movable valve element, and magnetic means on the well head adapted to actuate said valve element in response to entry of the plunger into the well head during said time interval.

References Cited in the file of this patent

UNITED STATES PATENTS

40	2,001,552	Scott	May 14, 1935
	2,642,002	Knox et al.	June 16, 1953
	2,649,738	Tait	Aug. 25, 1953
	2,661,024	Knox	Dec. 1, 1953
	2,699,121	Knox	Jan. 11, 1955
45	2,714,855	Brown	Aug. 9, 1955
	2,762,309	Knox	Sept. 11, 1956