

May 1, 1962

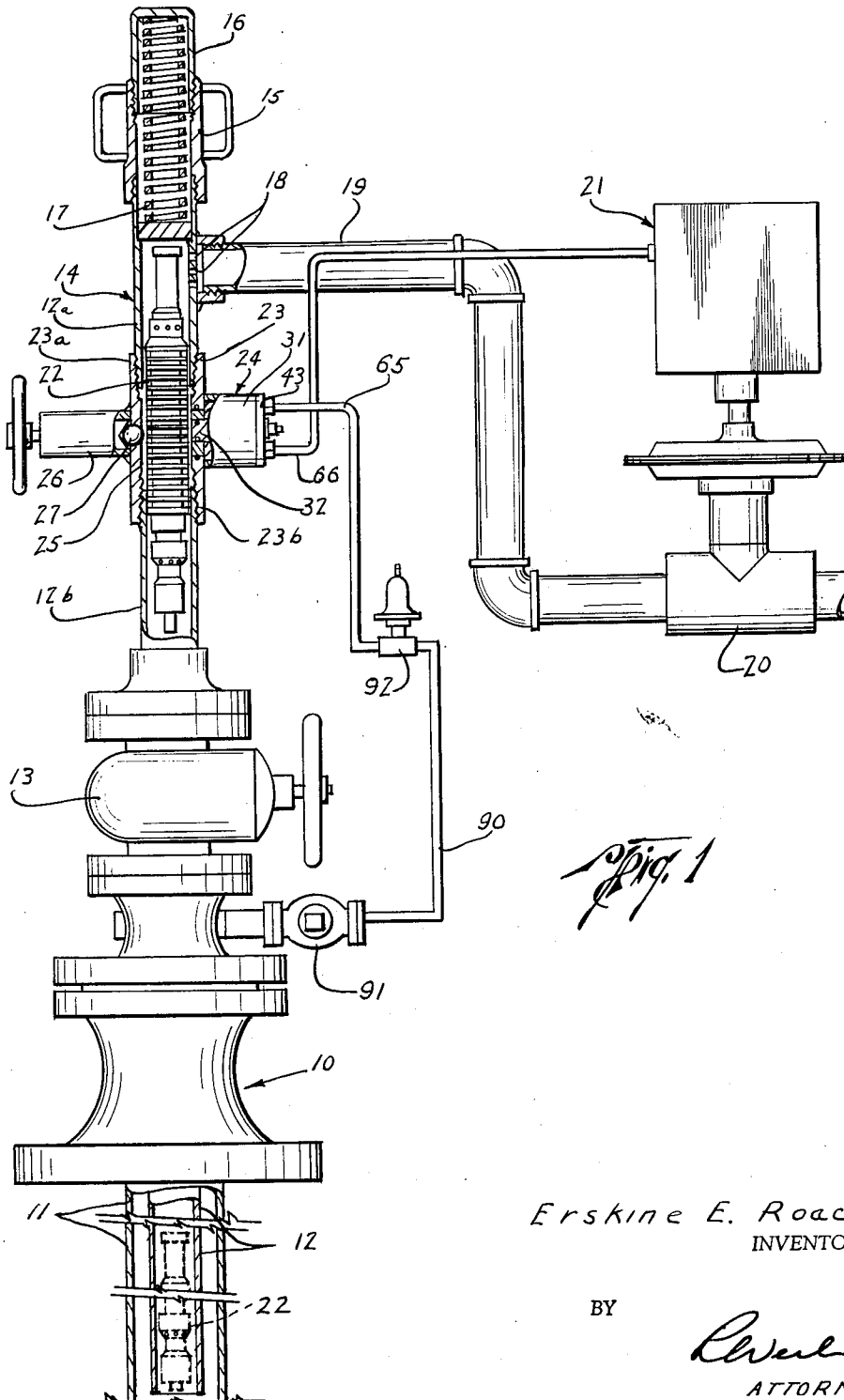
E. E. ROACH

3,031,971

PLUNGER LIFT CONTROL APPARATUS

Filed Aug. 9, 1957

3 Sheets-Sheet 1



May 1, 1962

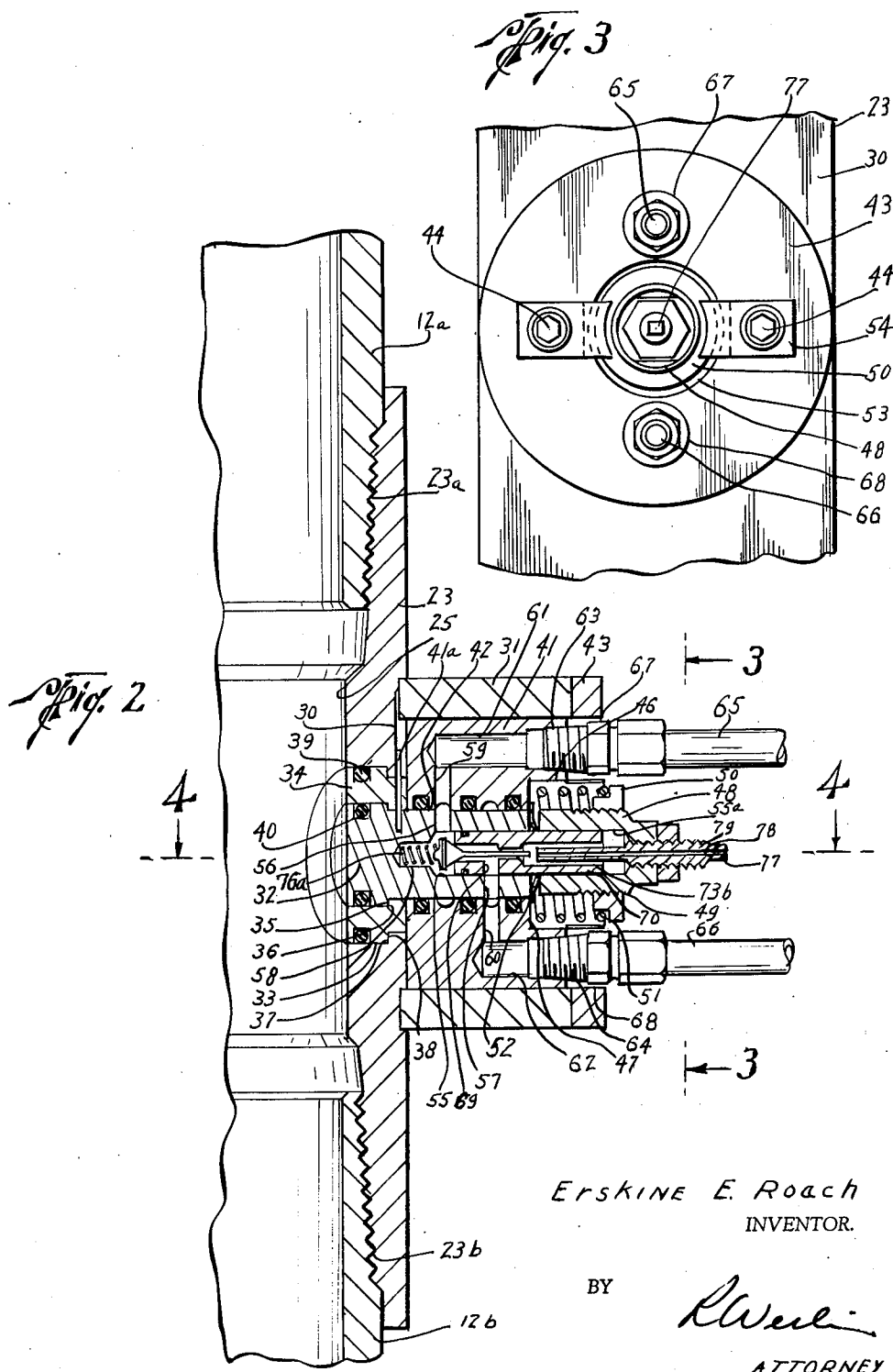
E. E. ROACH

3,031,971

PLUNGER LIFT CONTROL APPARATUS

Filed Aug. 9, 1957

3 Sheets-Sheet 2



May 1, 1962

E. E. ROACH

3,031,971

PLUNGER LIFT CONTROL APPARATUS

Filed Aug. 9, 1957

3 Sheets-Sheet 3

Fig. 4

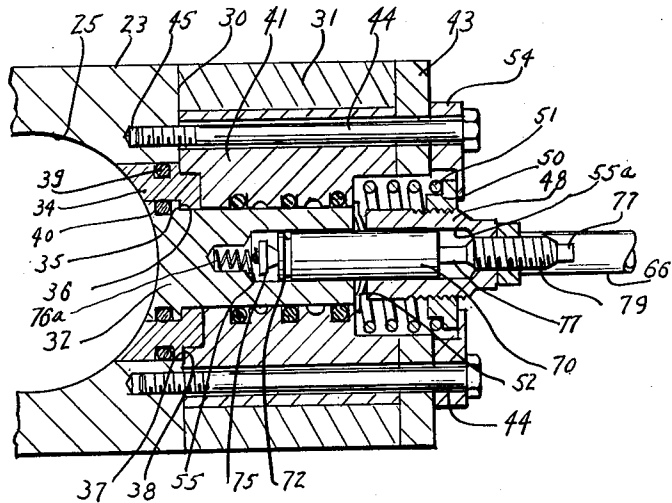
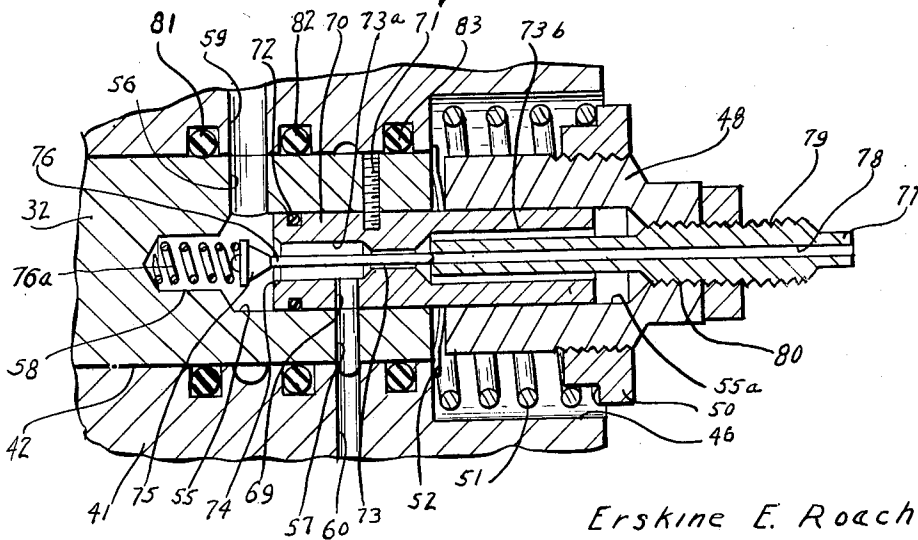


Fig. 5



Erskine E. Roach
INVENTOR.

BY

R. W. ...

ATTORNEY

1

3,031,971

PLUNGER LIFT CONTROL APPARATUS
Erskine E. Roach, Houston, Tex., assignor to Harold
Brown Company, a corporation of Texas
Filed Aug. 9, 1957, Ser. No. 677,281
3 Claims. (Cl. 103—52)

This invention relates to plunger lift apparatus for wells and more particularly to control devices for closing the main valve in the fluid delivery tube leading from a well head when the plunger reaches the upper end of its stroke.

In present and more conventional types of plunger lift apparatus, trip mechanisms are employed which include movable plungers or trigger members movably projecting through the wall of the eductor tube and adapted to be moved upon physical engagement by the lift plunger to cause the movement of the trigger member to actuate the mechanism for controlling the main valve on the eductor tube leading from the well head. Considerable difficulty has been encountered with mechanical devices operating in the described manner, because of their relative complexity and because it is necessary in such conventional apparatus to transmit power through the wall of the lubricator or eductor tube portion which receives the lift plunger, the power being transmitted by movement of the trigger member through an appropriate opening in the wall of the lubricator. Such an arrangement requires a high-pressure seal around the power-transmitting member. Such seals necessarily offer considerable friction, varying with the pressure, to the movements of the trigger member and are also subject to clogging by sand and other detritus commonly carried by the fluid being lifted. These conditions frequently result in malfunctioning of the control unit. Also, malfunction of the production system as a whole will frequently result from the failure or malfunctioning of the trigger mechanism.

It is a primary object of the present invention to overcome the disadvantages inherent in the more conventional systems, such as described above, by providing a magnetic actuating device having no moving parts projecting into the lubricator, nor which require physical engagement by the lift plunger to actuate it, upon arrival of the lift plunger at the upper end of its stroke, in order to effectively operate pilot valve mechanisms positioned exteriorly of the eductor tube for controlling the main valve in the eductor discharge line.

It is a principal object of the present invention to provide a magnetic actuating device in which means are employed to define a normally open magnetic circuit in the wall of the eductor tube near its upper end, which circuit is closable by the arrival of the plunger in the magnetic field to thereby actuate an armature controlling a pilot valve mechanism disposed exteriorly of the eductor tube.

A more specific object, in accordance with this invention, is the provision of a magnetic actuating device operable upon arrival of a lift plunger at the upper end of its travel to actuate a pneumatic pilot valve for controlling a main valve in the eductor discharge pipe of a plunger lift system.

Other and more specific objects and advantages of this invention will become more readily apparent from the following detailed description when read in conjunction with the accompanying drawing which illustrates one useful embodiment in accordance with this invention.

In the drawing:

2

FIG. 1 is an elevational view, partly in section, of the upper end of a well being produced by the plunger lift system, the plunger being shown in its upper position;

FIG. 2 is a longitudinal sectional view of the magnetic actuating device mounted on the eductor pipe of the system, the pilot valve elements being shown in the closed position.

FIG. 3 is an end elevational view taken along line 3—3 of FIG. 2;

FIG. 4 is a transverse sectional view taken along line 4—4 of FIG. 2; and

FIG. 5 is an enlarged sectional view showing the details of the pilot valve mechanism actuated by the magnetic device, the pilot valve elements being shown in the open position.

Referring to the drawing, a well head, generally designated by the numeral 10, is mounted on the upper end of a well casing 11 through which an eductor tubing 12 extends, and is connected to the body of a master valve 13 to which is connected a plunger-receiver or lubricator, designated generally by the numeral 14, having communication with the bore of tubing 12 and forming a part thereof. A bumper spring housing 15, closed at its upper end by cap 16, is mounted on the upper end of lubricator 14 and encloses the bumper spring 17. The lubricator 14 is provided with wall openings 18 near its upper end and communicating with a main fluid discharge pipe 19 in which is mounted a conventional type of diaphragm-motor-operated main control valve 20, the operation of which is controlled through a conventional pneumatic control apparatus, designated generally by the numeral 21. Valve 20 is a normally open type of valve adapted to be closed upon actuation of the diaphragm motor by pneumatic fluid, such as air or gas supplied to the motor through control apparatus 21.

A lift plunger 22, which may be of any well-known or conventional form, adapted to lift quantities of well fluids to the surface under pressure of gas entering the eductor tubing from the well or from the casing, is shown positioned in the eductor tubing and, as illustrated in FIG. 1, is shown in broken lines near the bottom of the tubing and in solid lines in the position of arrival at the surface in lubricator 14.

Lubricator 14 includes a section comprising the body 23 on one side of which is mounted the magnetic actuator, designated generally by the numeral 24, for controlling main valve 20, as will be described hereinafter. Body 23 has a bore 25 forming a part of the bore of the lubricator, which also includes upper and lower tubing sections 12a and 12b, respectively, which are threadedly received in threaded sockets 23a and 23b provided in the upper and lower ends of body 23. The bore of lubricator 14 is adapted to receive plunger 22 which may be held therein by a suitable form of catcher 26 having a spring-pressed ball member 27 adapted to engage the exterior of plunger 22 to temporarily hold the latter in the lubricator in a manner well understood in this art. The catcher 26 does not, of itself, constitute a part of this invention.

Referring now more particularly to FIGS. 2 to 5, the magnetic actuating device is shown in greater detail. Body 23 is of square cross-section, as shown, although it may have only one flat side, indicated at 30, on which the actuator structure is mounted. Body 23 is constructed of ordinary steel or iron so as to be substantially magnetically permeable. An Alnico permanent magnet 31 of generally annular shape is mounted with one end against flat face 30, whereby to incorporate the

enclosed portion of body 23 in the circuit of the magnet. A generally cylindrical pole piece or core 32 of soft iron or other magnetically permeable material is disposed co-axially within magnet 31 and has its inner end (relative to body 23) projecting through an opening 33 provided in the wall of body 23. Opening 33 is substantially larger in diameter than the inner end of core 32 to provide an annular space between the core and the surrounding wall of body 23 which is adapted to receive a ring 34 constructed of non-magnetic material such as brass or suitable non-magnetic stainless steel. The inner end of core 32 is enlarged slightly to form the shoulder 35, which is engageable by an abutting shoulder 36 formed in the bore of ring 34, and the latter is provided on its outer periphery with a shoulder 37 engageable by an inwardly projecting shoulder 38 formed in the bore of opening 33, the engagement of the respective shoulders being such as to prevent core 32 and ring 34 from being displaced outwardly of the body through opening 33. A seal means, such as an O-ring 39, is disposed between the outer periphery of ring 34 and the bore wall of opening 33, and a second O-ring 40 is disposed between the periphery of the enlarged end of core 32 and the bore wall of ring 34 to thereby provide fluid-tight seals between these elements. The inner end faces of core 32 and ring 34 are concaved to be flush with the wall of bore 25 of the body (FIG. 4), so that neither of these elements will form any obstruction to the free passage of the plunger through bore 25. Ring 34 and core 32 are secured against movement inwardly of body 23 by means of a key 41a which extends through registering openings provided in the outer end of ring 34 and in the adjacent portion of core 32 at points exteriorly of body 23.

Slidably mounted in the bore of magnet 30 is a generally cylindrical bushing 41 constructed of a non-magnetic material, such as brass, and which is dimensioned to fit snugly in the bore of magnet 31 and when inserted, to be seated against the inner end of ring 34, as best seen in FIGS. 2 and 4. Bushing 41 has an axial bore 42 adapted to slidably receive core 32. A circular pole plate 43, of magnetically permeable material, is mounted over the outer end of magnet 31 and the magnet assembly, comprising magnet 31, bushing 41, and pole plate 43, is secured to body 23 by means of the screws 44 (FIGS. 3 and 4) which extend through registering openings in these assembly elements and are threadedly received in threaded sockets 45 provided in body 23. The outer end portion of bore 42 is enlarged to form a counterbore 46, thereby providing interiorly thereof the outwardly facing annular shoulder 47 at a point substantially flush with the outer end of core 32. Movable mounted in counterbore 46 and coaxial with core 32 is a generally tubular armature member 48 having a threaded section 49 on its exterior on which is mounted a shouldered adjusting nut 50. A coil spring 51 is mounted in counterbore 46 between nut 50 and shoulder 47 to resiliently bias the armature member outwardly. A leaf spring 52 is mounted between the inner end of armature member 48 and shoulder 47 to likewise additionally bias the armature member outwardly of counterbore 46. Pole plate 43 is provided with an axial opening 53 through which armature member 48 extends and the latter is held against falling outwardly by clips 54 which project over the outer end of nut 50 and are secured to the outer face of pole plate 43 by the screws 44 (FIGS. 3 and 4).

The movements of armature member 48 in response to the opening and closing of the magnetic circuit through the magnet 31 and the pole pieces 32 and 43, as will be described hereinafter, are employed to operate a pilot valve mechanism which, in turn, controls by generally conventional means the supply of a pneumatic fluid to control apparatus 21 by which main valve 20 is closed. In the illustrative embodiment of this inven-

tion, the pilot valve mechanism is mounted inside the magnet assembly as will now be described.

Core 32 is provided with an axial bore 55 which registers with an axial bore 55a in armature member 48. A pair of radial passages 56 and 57 extend through core 32 into communication with bore 55 at longitudinally spaced points, passage 56 being nearer the inner end of bore 55, which is closed at its inner end, being provided with a reduced diameter portion at its inner end forming a recess 58. Bushing 41 is provided with passages 59 and 60 which are adapted to communicate respectively with passages 56 and 57, and passages 59 and 60 communicate respectively with inlet and outlet passages 61 and 62, respectively, extending longitudinally of bushing 41 to the outer end thereof and provided in their outer ends with threaded sockets 63 and 64, respectively, adapted to receive inlet and outlet conduits 65 and 66, respectively, which pass through openings 67 and 68 in pole plate 43. Mounted in bore 55 of the core and projecting therefrom into bore 55a of the armature member is a cylindrical seat nipple 70 which is secured in bore 55 against movement by means of a set screw 71 (FIG. 5), which projects through the wall of core 32 into the body of seat nipple 70. A seal ring 72 encircles nipple 70 near its inner end to seal between the seat nipple and the wall of bore 55. Armature member 48 is, however, free to slide longitudinally over the outer end portion of seat nipple 70. Seat nipple 70 is provided with an axial bore 73 which is counterbored from its inner end to form the enlarged portion 73a which terminates in a tapered annular seat 74, which is adapted to be engaged by a conical pilot valve 75 which is biased toward seat 74 by means of a coil spring 76a seated in recess 58. A radial passage 69 extends through the wall of seat nipple 70 into registration with passage 57 to provide communication between the latter and the enlarged bore portion 73a. The latter and passage 69 provide communication between passages 56 and 57 when valve 75 is in the open position, as illustrated in FIG. 5, and when valve 75 is seated in seat 74, communication between these passages will be cut off. Valve 75 is mounted on an elongate stem 76 which extends through bore portion 73a, and bore 73 and projects into the outer end of bore 73 which is enlarged to form the axial bore 73b. Armature member 48 has mounted axially thereof an armature stem 77, having axial bore 78 therethrough of restricted diameter. Stem 77 has an enlarged externally threaded head 79 threadedly receivable in an internally threaded axial opening 80 in the outer end of armature member 48. Stem 77 projects into enlarged bore 73b and restricted bore 78 is adapted to receive the inner end of pilot valve stem 76 when the armature member is in its innermost position, as illustrated particularly in FIG. 5, the inner end of stem 76 thereby being adapted to form a closure for restricted passage 78, for purposes which will be described more fully hereinafter.

Seal rings, such as the O-rings 81, 82 and 83 (FIG. 5) are positioned in the wall of bore 42 of bushing 41 to seal with the exterior of core 32 at points on opposite sides of passages 59 and 60 and between these passages, as shown.

Inlet conduit 65 is in communication with a source of pneumatic pressure fluid, such as gas, from well casing 11 supplied to conduit 65 through casing head 10 from which a pipe 90, fitted with a valve 91, connects to conduit 65. A pressure reducing valve 92 is mounted in conduit 90 in order to regulate the pressure of the gas going through inlet conduit 65 to the pilot valve structure of the magnetic actuator. Outlet conduit 66 leads to control apparatus 21 where it supplies pneumatic fluid which is employed in apparatus 21 in the wholly conventional manner for operating the motor of valve 20 in order to close main valve 20.

The device operates in the following manner: Before plunger 22 arrives in the bore of body 23, the parts of the

5

magnetic control device will be in the positions as illustrated particularly in FIGS. 2 and 4. The magnetic circuit, which includes permanent magnet 31, the portion of body 23 in contact therewith, and core 32 will be open. Non-magnetic ring 34 will define a magnetic gap in this circuit, there being at most only slight leakage of magnetic flux across this gap between the portion of the wall of body 23 in contact with magnet 31 and core 32. The opposite end of the magnetic circuit formed by pole plate 43 will be spaced from armature member 48 by a narrow air gap formed by the clearance between adjusting nut 50 and the bore of opening 53 in the pole plate, the magnetic circuit being thus open, springs 51 and 52 will be made sufficiently strong to overcome the slight attractive force on armature member 48 resulting from any leakage of magnetic flux and will resiliently hold armature member 48 in its outermost position, as limited by clips 54. In this position, stem 77 in the armature member will be retracted so that coil spring 76a will urge pilot valve 75 to its closed position on seat 74, thereby shutting off communication between inlet and outlet conduits 65 and 66, and also thereby preventing the passage of any pressure fluid through outlet conduit 66 to the control apparatus 21, whereby valve 20, which is a normally open valve, will continue to remain in its open position.

When plunger 22 enters bore 25, as it arrives at the upper end of its stroke, it will enter the field of magnet 31 and as plunger 22 will normally be constructed of magnetically permeable material, such as ordinary steel or iron, it will effectively close the gap in the magnetic circuit between magnet 31 and core 32 and the resulting increase in the magnetic flux passing through core 32 will attract armature member 48 with sufficient force to overcome the resistance of springs 51 and 52 and the inward movement of the armature member will move the end of stem 77 into engagement with the inner end of pilot valve stem 76, the latter entering restricted passage 78 and closing the same while the inward force applied to stem 76 by the inward movement of armature member 48 will force pilot valve 75 rearwardly to the open position against resistance of spring 76. When pilot valve 75 is thus opened, pressure fluid from inlet conduit 65 will flow through passage 61, 59 and 56, thence through bore portion 73a, passages 69, 57, 60 and 62 into outlet conduit 66 and thence to control apparatus 21 where the pressure fluid will be operative to close main valve 20. When the latter closes, then, as is well understood in this art, plunger 22 will be released to fall out of lubricator 14 and drop back through tubing 12 into the well. When this occurs the magnetic circuit again will be broken and the attractive force on armature member 48 reduced to a point such that springs 51 and 52 will be effective to urge armature member 48 away from core 32 to thereby allow pilot valve 75 to be returned to its closed position on seat 74, again shutting off communication for movement of pressure of fluid between conduits 65 and 66. The retraction of armature member 48 will be aided by the pressure fluid temporarily entrapped in bore 56a, restricted bore 78 acting as a choke to delay release of this entrapped gas and thus the fluid pressure in bore 56a will aid the springs in returning the armature member to its inactive position.

From the foregoing, it will be seen that in the described actuating device no moving part or member extends into the bore of the lubricator, and that by means of the described magnetic actuator, power is transmitted through the wall of the lubricator to operate a pilot mechanism positioned exteriorly of the lubricator assembly merely by the entrance into the magnetic circuit interiorly of the lubricator of a magnetically permeable element adapted to form a closure for this circuit.

It will be understood that direct contact between the plunger and the surfaces of the magnetic elements is unnecessary, it being merely sufficient that the magnetically

6

permeable body intersect the normally open magnetic circuit to short-circuit the gap and to close the circuit and produce the desired responsive movement of the armature externally of the lubricator, the latter, of course, being operative to actuate the pilot valve mechanism which controls the main valve.

It will also be evident that this invention necessarily contemplates arrangements in which the permanent magnet member of the magnetic assembly may be mounted on the plunger which will produce the same actuating function as in the illustrative embodiment. Additionally, it will be seen that while, in accordance with the illustrative embodiment, the armature member is actuated by the closing of a normally open magnetic circuit, the same result in the transmission of actuating power to the armature may be attained by opening a normally closed magnetic circuit. Suitable arrangements for such modifications will be evident to those skilled in the art of magnetic circuits.

It will be also evident that numerous types of valve mechanisms, other than that specifically illustrated and described, may be operated by the magnetic actuating structure herein described, the particular form of pilot valve being illustrated and described primarily for purposes of exemplification.

While, as heretofore set forth, this invention is directed more specifically to its application to the operation of plunger lift apparatus, it will be evident that it has various applications wherein it may be desirable to transmit power through the wall of an enclosure to operate external devices in response to actions occurring within the enclosure, the power transmission being effected without employing elements projecting movably into the interior of the enclosure through the wall thereof.

It will be understood that numerous changes and modifications may be made in the illustrative embodiment within the scope of the appended claims but without departing from the spirit of the invention.

What I claim and desire to secure by Letters Patent is:

1. A magnetic device for transmitting power from the interior to the exterior of a body through a wall thereof for actuating a movable element exteriorly of the body, comprising, magnetic means fixedly secured to said wall to define a normally open-magnetic circuit including a portion of said wall, said magnetic means including an annular permanent magnet, a magnetically permeable core disposed axially of the magnet and having one end extending through said wall and concentrically spaced from the magnet, and an annular non-magnetic spacer element disposed between said one end of the core and the surrounding wall of the body to define a magnetic gap therebetween, said circuit being closable by the introduction into the circuit interiorly of the body of a magnetically permeable element, and armature means positioned in said circuit exteriorly of the body and movable in response to the closing of said circuit.

2. A device as described in claim 1 having pneumatically operated means including a pilot valve operable in response to movement of said armature means for closing said control valve.

3. In a device having a valved plunger adapted to travel freely under pressure substantially the full length of an eduction tube in a well, the combination of: a control valve operatively connected to the eduction tube to control flow therefrom, magnetic means for closing the control valve in response to the arrival of the plunger at the upper end of its travel in the eduction tube, said magnetic means being fixedly secured to the wall of the upper end of the eduction tube to define a normally open magnetic circuit including a portion of said wall, said magnetic means including an annular permanent magnet, a magnetically permeable core disposed axially of the magnet and having one end extending through said wall and concentrically spaced from the magnet, and an annular non-magnetic spacer element disposed between said

one end of the core and the surrounding wall of the education tube to define a magnetic gap therebetween, said circuit being closable by the arrival of said plunger adjacent said circuit, and control valve actuating, armature means positioned in said circuit exteriorly of said education tube and movable in response to the closing of said circuit.

5

References Cited in the file of this patent:

UNITED STATES PATENTS

2,001,552	Scott	May 14, 1935
2,472,067	Dickey et al.	June 7, 1949
2,576,168	Allen	Nov. 27, 1951
2,629,401	Miller	Feb. 24, 1953
2,701,331	Holst	Feb. 1, 1955