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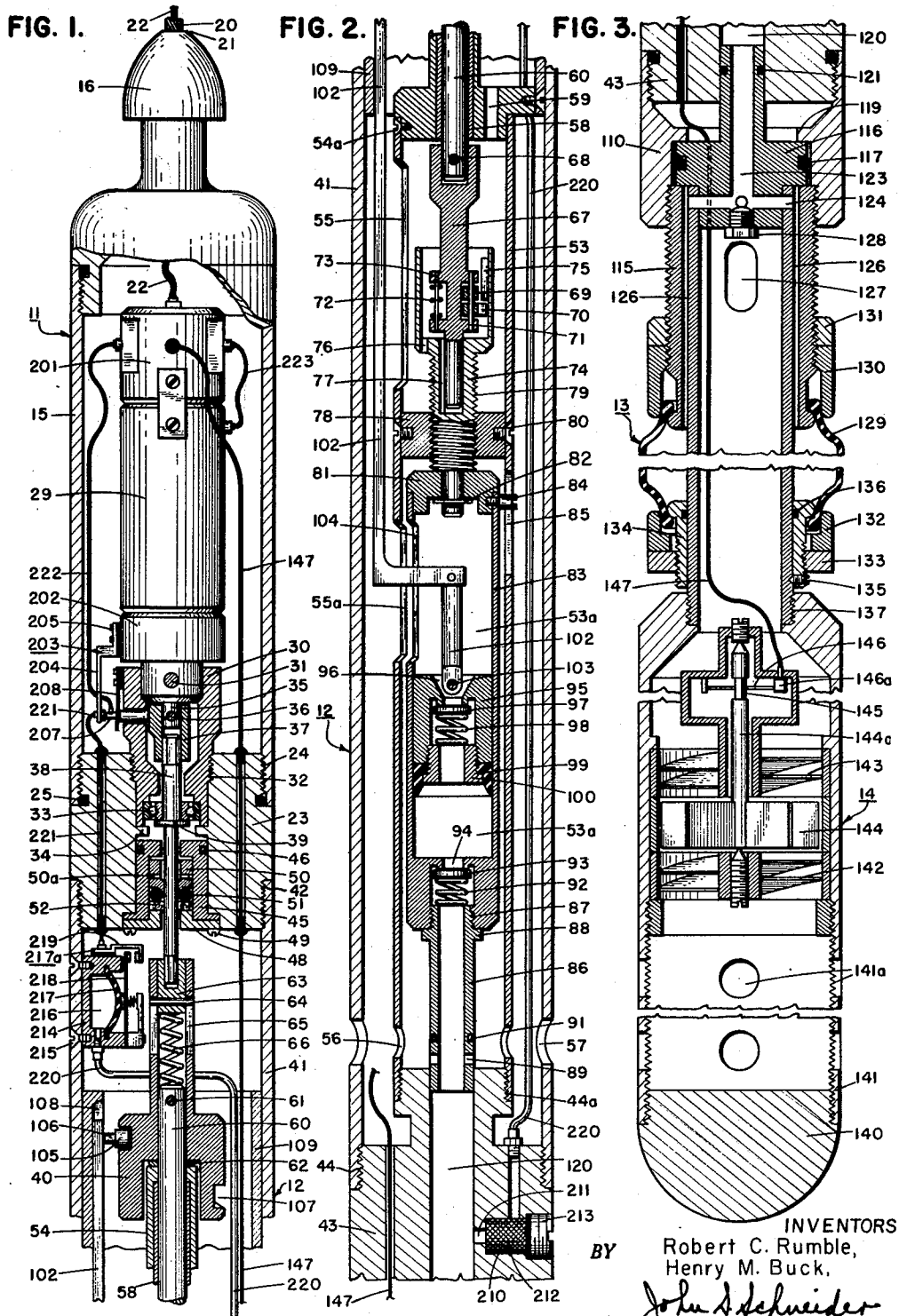
R. C. RUMBLE ET AL

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SOUND MONITOR FOR SUBSURFACE PACKER

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2 Sheets-Sheet 1



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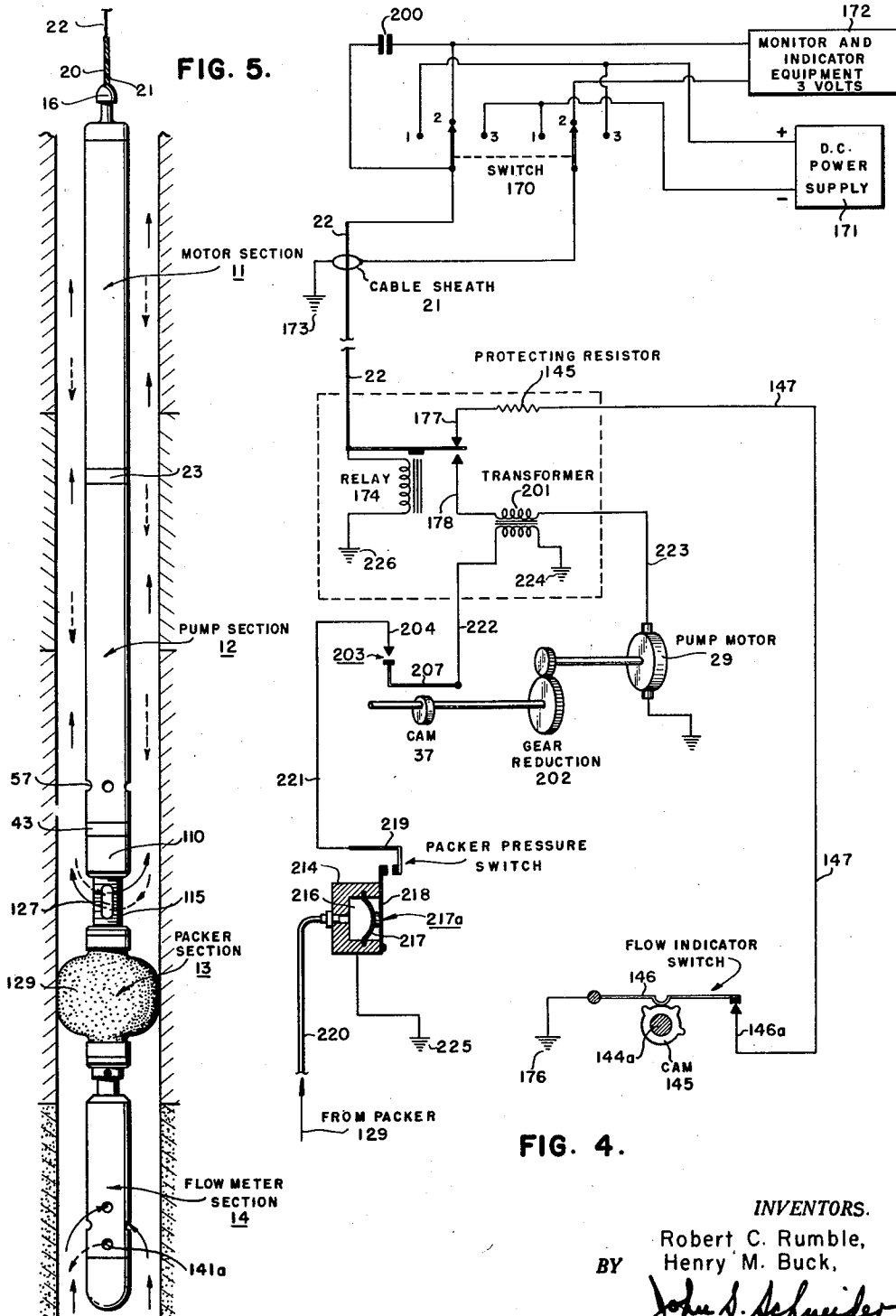
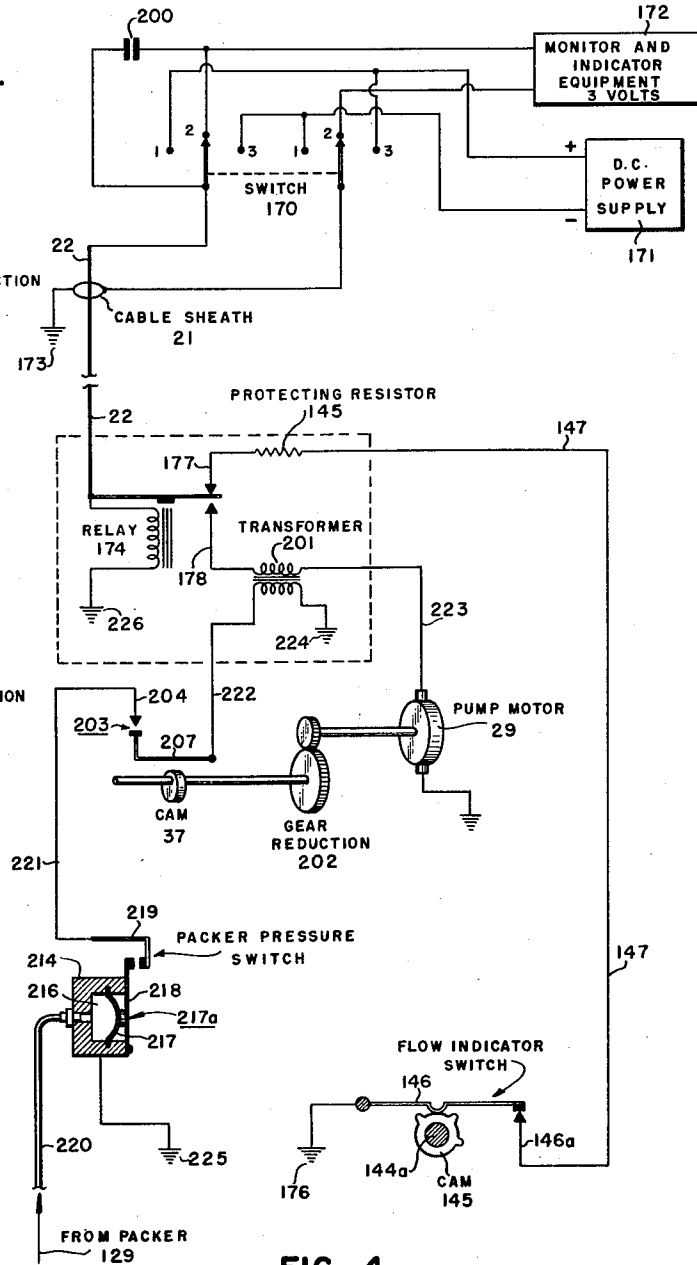
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SOUND MONITOR FOR SUBSURFACE PACKER

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3 Claims. (Cl. 340—18)

This invention is directed to a sound signaling system. More particularly, this invention is directed to a sound signaling system for indicating an amount of internal pressure on an inflatable subsurface packer.

In our copending U.S. patent application Serial No. 602,047, filed August 3, 1956, now U.S. Patent No. 2,856,006, entitled Subsurface Packer, an electrically operated inflatable packer is described in combination with a fluid meter. The signaling system to be described herein is especially adapted for use with the device of the cited U.S. application and will be described in conjunction therewith. However, in its broader aspects, the signaling system may be employed in conjunction with any suitable device.

Hence an object of this invention is to provide a sound monitor whereby an indication of packer pressure after a specified pumping time interval may be obtained. A further object of this invention is to provide a system whereby indication may be obtained of the packer pressure after pumping has ceased; or indication that the packer has drained; or that the packer is leaking and the degree thereof; or that the motor is functioning properly including normal repetitive motor loading in synchronization with pump reciprocation.

Briefly, this invention comprises a signaling system for use in a subsurface fluid inflatable-deflatable packer device provided with rotatable drive means, the inflating and deflating of the packer being dependent upon the direction of rotation of the drive means comprising an electrical circuit connecting a power supply, a transformer, surface indicating means, and first and second switches, the secondary of said transformer being shorted upon closing of said switches, means responsive to fluid pressure in said packer for closing said first switch and means adapted to intermittently close said second switch in response to rotation of said drive means.

Referring to the drawings:

Figs. 1 through 3 are sectional views from top to bottom respectively of the device of the present invention;

Fig. 4 is a schematic diagram including the electrical circuit employed in the operation of the device of the present invention;

Fig. 5 is an elevational schematic view illustrating the device positioned in a borehole.

For a clear understanding of the elements and operation of this device, reference to the figures in greater detail will now be made.

As seen in Figs. 1 through 3, the device consists essentially of four sections. These are a pressure sealed motor section 11, a pump section 12, a packer section 13, and a flowmeter section 14. Section 11 (Fig. 1) consists of a hollow cylinder 15 which has connected to its upper end a fishing neck 16. This connection is pressure sealed by means of an O-ring, as shown. A cable 20, consisting of an outer steel sheath 21 and an inner insulated conductor 22, is shown connected to fishing neck 16. The cable 20 extends to the surface of the earth and forms part of the

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electrical circuit to be described later herein. The lower end of cylinder 15 is connected to a wall member 23 by means of threads 24 and a pressure seal is maintained at this connection by means of O-ring 25. Positioned in section 11 as shown is a reversible motor, such as a permanent magnet motor 29. A transformer unit 201 is positioned adjacent motor 29.

A housing 30 is attached to and shouldered against wall member 23 by means of threads 32. Motor 29 is provided with a gear reduction unit 202 and is mounted in housing 30 and connected thereto by means of set screws 31. The lower end of housing 30 holds the outer race of a thrust bearing 33. A shoulder 34 formed on wall member 23 provides a stop for housing 30. An output shaft 35 of gear reduction unit 202 has mounted thereon for rotation therewith an eccentric cam coupling 37. A pin 36 connects cam 37 to shaft 35. A switch 203 is positioned adjacent housing 30 and includes a switch contact 204 secured to gear reduction housing 202 by means such as screws 205 and a plunger 207 extending through housing 30 and biased by means of spring 208 into engagement with the surface of cam coupling 37. Plunger 207 is electrically connected to the secondary of transformer 201 by a conductor 222. Also, an electrical conductor 223 connects the primary of transformer 201 to motor 29. An opening in the lower end of cam coupling 37 is hexagonal in cross section in order to engage with the upper end of a shaft 38 which is milled to a hexagonal cross section as shown on its upper end. Shaft 38 extends through the inner race of thrust bearing 33 and is prevented from moving upwardly by a flange 39 formed on shaft 38. The lower end of shaft 38 below flange 39 has a reduced diameter and is provided with a milled polygonal cross section for driving a helical cam 40.

The pump section 12 consists of a cylinder 41 which is connected to wall member 23 by means of threads 42 and to a lower wall member 43 by means of threads 44. A fluid seal surrounding the lower end portion of shaft 38 consisting of a bronze bushing 50, an O-ring 51, and felt washers 52, is housed in a removable holder 45 which, in turn, is pressure sealed to wall member 23 by means of an O-ring 46. Grease escape ports 50a are provided in bronze bushing 50 to allow O-ring 51 to form and cause a positive fluid seal between rotating shaft 38 and holder 45 when fluid pressure is exerted below packing 52 and O-ring 51. Holder 45 and the sealing elements 50—52 are maintained in position by a shaft aligning washer 48 which is held by screws 49 threaded into wall member 23.

A cylinder 53 is shown (Fig. 2) screw threadedly attached to wall member 43 as at 44a and attached at its upper end to a cam shaft holder 54 by means of screws 54a. Cylinder 53 has formed intermediate the length thereof longitudinal slits 55 and 55a and has formed adjacent its lower end fluid draining ports 56. Cylinder 41 is provided with fluid entry and draining slits 57 positioned adjacent ports 56.

Cam shaft holder 54 contains a sleeve bearing 58 and is formed to provide a longitudinally extending port 59. A shaft 60, attached at its upper end to helical cam 40 by means of pin 61, may rotate freely in bearing 58. A washer 62 serves as a bearing between rotatable cam 40 and cam shaft holder 54. The upper end of cam 40 is a hollow cylinder which contains an engaging member 63 which latter member is formed with a hole having a polygonal cross section in its upper end which is adapted to engage the lower end of shaft 38. Engaging means 63 is held in cam 40 by a pin 64 which is free to move longitudinally in slot 65 in cam 40 and is biased upwardly by a coil spring 66 supported on the

upper end of shaft 60. The lower end of shaft 60 is connected to a pawl holder 67 by means of a pin 68.

Pawl holder 67 carries two identical but oppositely directed pawls 69 and 70 mounted on a common pin 71. Pawl biasing spring 72 is mounted on a pin 73. The lower end of pawl holder 67 spears into a bearing recess in a pawl follower 74, the bearing recess being provided with a relief slot 77. Pawl follower 74 is provided with a key 75 which projects internally from the pawl follower wall. A plurality of drain holes 76 permits drainage of any fluid or sediment that may enter pawl follower 74. The pawl follower 74 is threadedly engaged to and movable in a wall member 78 by means of threads 79. Wall member 78 is affixed to cylinder 53 by means of screws 80. The lower end of pawl follower 74 is free to rotate in a cylinder head 81 but is constrained from longitudinal movement by means of a washer 82 positioned on the lower end of pawl follower 74.

The cylinder head 81 forms the upper end of a pump cylinder 83 and is connected thereto by means of a screw 84 which is free to move longitudinally in a slot 85 formed in cylinder 53. The lower end of pump cylinder 83 is mounted on shoulder 88 of stinger 86 and is threadedly connected to stinger 86 by means of threads 87. Stinger 86 is provided with a fluid exhaust port 89 and an O-ring 91. The upper end of stinger 86 supports a spring 92 which in turn bears against a check member 93 positioned in a port 94 formed in the lower portion of cylinder 83. This permits only downward flow through port 94 in pump cylinder 83. A piston 95 is slidably arranged in pump cylinder 83. The piston 95 is provided with a fluid entry port 96, check 97, biasing spring 98, cup washer 99 and a retainer 100 which latter is threadedly connected to piston 95. Piston 95 is connected to a piston rod 102 by means of a pin 103. The piston rod 102 extends through a slit 104 formed in pump cylinder 83. Slit 104 in cylinder 83 and slit 55a in cylinder 53 are in alignment.

The upper end of piston rod 102 is attached to a cam follower wheel 105 by means of an axle 106. Cam follower wheel 105 moves in a continuous helical slot 107 in cam 40. Piston rod 102 extends through an opening in cam shaft holder 54 and moves longitudinally in a keyway 108 formed in a cylinder 109 which latter is attached at its lower end to cam shaft holder 54.

The packer section 13 consists of a tubular mandrel 115 which is preferably silver soldered to a packer stinger 116 which is pressure sealed from a packer adapter 110 by means of O-ring 117. Stinger 116 shoulders against a ledge 119 formed in packer adapter 110 and the upper end thereof extends into a passageway 120 in wall member 43 where a fluid seal is maintained by means of an O-ring 121. Stinger 116 is provided with a longitudinally extending passageway 123 communicating with transverse ports 124 formed in tubular mandrel 115 which is thick-walled at its upper end and threadedly connected into the lower end of adapter 110. A plurality of longitudinally extending passageways 126 are provided throughout the length of the thick-walled portion of mandrel 115 and these passageways fluidly communicate with ports 124 as seen in Fig. 3. A series of fluid inlet and outlet ports 127 extend through the upper end of mandrel 115 between the passageways 126. A plug 128 screws into the bottom of stinger 116 in line with passageway 123.

Wall member 43 is provided with a chamber 210 (Fig. 2) fluidly communicating with passageway 120 by means of a port 211. The chamber 210 contains suitable filter material or screen 212. A screw cap 213 is employed to retain the filter material 212 in chamber 210. A housing 214 (Fig. 1) is secured to cylinder 41 by means of screws 215. Housing 214 is formed to provide a chamber 216 in which is positioned a diaphragm 217.

A switch 217a is positioned adjacent diaphragm 217 and includes a movable contact 218 and a stationary contact 219 both attached to housing 214. A conduit 220 fluidly communicates chamber 210 and one side of diaphragm 217. Contact 218 is spring biased against the other side of diaphragm 217 as shown. Thus, sufficient fluid pressure in chamber 216 will force diaphragm 217 against the bias of contact 218 and thereby urge the contacts 218 and 219 into engagement. An electrical conductor 221 connects contact 204 of switch 203 to contact 219 of switch 217a.

A packer 129 is mounted on mandrel 115 with its upper end clamped by clamping ring 130 and threaded nut 131 while its lower end is clamped by clamping ring 132 and threaded nut 133. The latter is threadedly mounted on sleeve 134 which is, in turn, slidable on mandrel 115. A fluid seal is maintained between sleeve 134 and mandrel 115 by O-ring 136. Sleeve 134 may be locked on mandrel 115 in any desired position by set screws 135. As shown in Fig. 3, passageways 126 fluidly communicate with the interior of packer 129. Packer mandrel 115 is threadedly connected to the fluid metering section 14 as at 137.

The packer may consist of a preformed oil resistant rubber element having a maximum diameter approximating the diameter of the borehole wherein the flow measurement is to be made. The oil resistant rubber element may be reinforced with fabric so that it may be inflated to a definite size to form a selected sized baffle which would provide a controlled fluid bypass in the borehole when measuring large rates of flow.

The flowmeter is the same as that disclosed in U.S. patent application Serial No. 526,916 entitled "Flowmeter" filed August 8, 1955, by H. M. Buck. The essential parts of the flowmeter are as follows: a nose plug 140 is connected to a cylindrical member 141 which, in turn, is screw threadedly connected to mandrel 115 at 137. The cylindrical member 141 is provided with fluid inlet and outlet ports 141a. A rotor 144 is mounted on a shaft 144a and stator deflectors 142 and 143 are mounted below and above the rotor 144, respectively. A cam 145 is formed on shaft 144a and a spinner circuit breaker 146 which also acts as a cam follower is positioned so as to bear against the cam 145 and is arranged to move in response to rotation of the cam 145 and to make and break contact with switch contact 146a in response to this movement. Cam 145 is designed to cause cam follower or circuit breaker 146 to make and break contact with switch contact 146a in one sequence when the cam rotates in one direction and in a different sequence when the cam is rotated in an opposite direction. Thus, "coded" signals are generated which are transmitted to the earth's surface as described hereinafter. The difference in the signals indicates direction of flow through the meter and the rate at which the signals are transmitted indicates rate of fluid flow through the meter.

An electrical conductor 147 connects to switch contact 146a and extends throughout the length of the device and into the motor section 11 where connection is made with conductor 22 as shown more clearly in the electrical circuit diagram of Fig. 4. Although conductors 147 and 221 are each shown as individual continuous leads, it is obvious that a number of slip ring connections would be included in order to threadedly assemble the various sections. Also to facilitate assembly of the device, slit 55a should be a continuation of slit 55.

Fig. 4 shows schematically the electric circuit involved in the operation of this device. On the surface is positioned a double-pole three-position switch generally designated 170, a D.C. power supply 171, a condenser 200 and monitor and indicator equipment 172. The switch 170 has three positions designated 1, 2 and 3 which alternatively connect the monitor and indicator equipment 172 and the D.C. power supply 171 in reverse polarities with conductor cable 22. Sheath 21 is grounded as

at 173. Conductor 22 connects to a relay 174 having contacts 177 and 178. Conductor 147 connects in series contact 177, resistor 145 and flow indicator switch elements 146a and 146 grounded as at 176. The secondary of transformer 201 is grounded as at 224; housing 214 is grounded as at 225; and relay 174 is grounded as at 226.

In switch position 2, the conductor 22 is connected directly to the monitor and indicator equipment 172. In the subsurface circuit relay 174 is not energized at this time since the voltage impressed on conductor 22 by the monitor and indicator equipment 172 is of a relatively small amount, for example, three volts. Hence, the spinner breaker 146 is connected through relay contact 177, resistor 145 and lead 147, to conductor 22. In this position the flowmeter functions as the spinner described in the Buck application noted supra. With the switch 170 in position 1 or 3, the D.C. power supply is connected to cable 22. This voltage being higher, for example 65 volts, actuates the relay 174 so that the applied voltage is connected to the pump motor 29 through contact 178 of relay 174. Pump motor 29 rotates shaft 38 clockwise or counterclockwise depending on whether surface switch 170 is in position 1 or 3. Capacitor 200 couples one lead of conductor 22 to the indicator equipment 172 thus "connecting in" the indicator when the switch is in position 1 or 3.

The primary of transformer 201 is positioned in the motor current conductor 223 leading from contact 178 of relay 174 to motor 29. One terminal of the secondary of transformer 201 is grounded as at 224. The other terminal leads through switch 203, which is closed by rotation of eccentric cam 37 moving plunger 207 to engage contact 204 to switch 217a which is closed by movement of diaphragm 217 in response to fluid pressure in chamber 216 moving contact 218 to engage contact 219.

In general operation, the device is lowered in the well with the packer 129 in a deflated condition and with the switch 170 in position 2, as shown in Fig. 13. At a depth at which it is desired to take a reading, vertical travel of the device is arrested. Then switch 170 is thrown to position 1 which actuates pump motor 29 which causes rotation of shaft 38 in one circumferential direction which, in turn, rotates shaft 60 and cam 40. Rotation of cam 40 reciprocates piston rod 102 which forces fluid into the pump chamber 53a via ports 55a and 104 and check 97 and out pump chamber 53a through check 93. Also, pawl follower 74 moves downwardly on screw thread 79 in wall member 78 until pawl 69 moves over the top of key 75. This moves pump cylinder 83 downwardly carrying stinger 86 downwardly into passageway 120. O-ring 91 when positioned in passageway 120 prevents fluid from passing out ports 89 and directs fluid coming from pump chamber 53a through passageways 120, 123, 124 and 126 into packer 129 to inflate the packer.

When a seal is effected by the packer 129 in the wellbore, the switch 170 is thrown back to position 2 so that a reading of the flow rate may be made on the monitor and indicator equipment 172. After the reading has been made and it is desired to retrieve the device or obtain another reading at a different depth, the packer is deflated preparatory to moving the device by positioning the switch at position 3 for a short time, for example 1/2 minute, then it is returned to position 2. This permits the packer to drain and leaves it in a condition to continue draining while raising and lowering the device. It is equally important that the packer be open to permit draining while being raised in the borehole since the decreased pressure at lesser depths in the well causes the gas in the vestige of oil remaining in the packer after deflation to break out of solution. If the packer is not in draining condition when the device is raised, this liberated gas would cause expansion of the packer and thus

cause damage to the packer or prevent its removal from the well. When the packer is sealed against the wellbore, any fluid flow in the well will be diverted through the metering section 14 via ports 141a and 127. When a reading or measurement of the flow reading is made, the D.C. power supply 171 is disconnected from the upper terminus of the cable 22 thereby disconnecting the pump motor 29 from the power supply. When the pump motor ceases to run, the packer remains inflated. The relay 174 when not energized will automatically connect the spinner breaker 146 in the circuit for measurement of the flow direction and rate.

When the direction of rotation of the armature of motor 20 is reversed by reversing the polarity of the D.C. supply voltage 171 by moving the switch from position 1 to position 3, the direction of rotation of pawl holder 67 is also reversed. This causes pawl 70 to engage key 75 of pawl follower 74 which, in turn, causes pawl follower 74 to move upwardly with respect to wall member 78 by means of the threaded connection 79 in wall member 78. This results in pump cylinder 83 being moved upwardly until the ports 89 in stinger 86 are withdrawn from passageway 120. By uncovering ports 89 the flow through the stinger from pump chamber 53a will pass outwardly through ports 89, 56 and 57. The ports 89 are uncovered after the motor 29 has run for approximately 5 seconds in the clockwise direction after which pawl 70 has slipped over the lower end of key 75. Hence, protracted running of the motor 29 in a reverse direction is not necessary to drain the packer.

The operation of the signaling system is as follows: When the pump motor 29 is energized by moving switch 170 to position 1 and the pressure in the packer 129 is equal to or greater than a selected pressure, contact arm 218 grounds conductor 221 which shorts the secondary of the transformer 201 when switch 203 is closed by the rotating eccentric cam 37. The direct current flow to the motor 29 is modulated by motor noise. This noise is loud and readily distinguishable in the surface monitoring equipment which is capacitatively coupled to the line by capacitor 200 when the switch 170 is in either position 1 or 3.

When the secondary of transformer 201 is open (that is, when switches 203 and 217a are open) the inductive reactance of the primary is high which blocks much of the high frequencies of the motor noise. When the secondary of the transformer is shorted the inductive reactance drops sharply, hence the high frequencies in the motor noise pass with little attenuation.

When the motor is running but the packer pressure is insufficient to cause contact arm 218 to ground conductor 221 a rather uniform note is emitted by the surface monitor loud speaker. As the packer pressure moves contact arm 218 to ground conductor 221 a high audio frequency chirp is emitted in synchronization with the closing of switch 203. Shorting of the transformer secondary lowers the inductive reactance of the primary, hence the high notes are not attenuated.

Preferably the secondary of the transformer, having but few turns of large wire, is a low impedance low voltage circuit and thereby not subject to effective shorting by salt water which may ground conductor 221 to the surrounding metal. This type of circuit provides a distinguishable note when the packer is inflated. Other types of circuits may prove impracticable because of grounding of the conductor by saturated salt water.

The sound monitor system described herein will provide indication, among other things, that the packer has pumped to a certain pressure in a specified time interval of pumping.

Also, it can be ascertained what pressure is on the packer after an interval of time after pumping operations have ceased. It also may provide an indication that the packer has drained, and whether or not the packer has developed either a fast or slow leak. The motor noise

itself gives aural indications of proper functioning of the motor and of normal repetitive motor loading in synchronization with pump reciprocation.

Although the insulation is not specifically designated on the drawing, in each instance it is to be understood that insulation will be provided elements requiring such in order to form the circuit shown in Fig. 4.

Having described the apparatus, operation and objects of our invention, we claim:

1. A signaling system for use with a subsurface fluid inflatable-deflatable packer device provided with an electric motor having a rotatable drive, the inflating and deflating of said packer being dependent upon the direction of rotation of said drive comprising an electrical circuit including a D.C. power supply for energizing said system, indicating means adapted to register electrical signals transmitted thereto, a transformer, a first switch and a second switch; said motor being connected to one terminal of the primary of said transformer; coupling means connecting the other terminal of said primary and said indicating means; one terminal of the secondary of said transformer being grounded and the other terminal of said secondary being connected to one terminal of said first switch; the other terminal of said

first switch being connected to one terminal of said second switch, the other terminal of said second switch being grounded whereby said transformer is shorted upon closing of said switches; an inflatable packer; means responsive to fluid pressure in said packer adapted to close said second switch and means adapted to close intermittently said first switch in response to rotation of said drive.

2. A system as recited in claim 1 wherein said pressure responsive means includes a pressure chamber fluidly communicating with the interior of said packer and a diaphragm arranged in said chamber movably responsive to pressure changes within said packer.

3. A system as recited in claim 2 wherein said drive rotation responsive means includes a cam mounted on said drive adapted to close intermittently said first switch upon rotation of said drive.

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