

Jan. 17, 1961

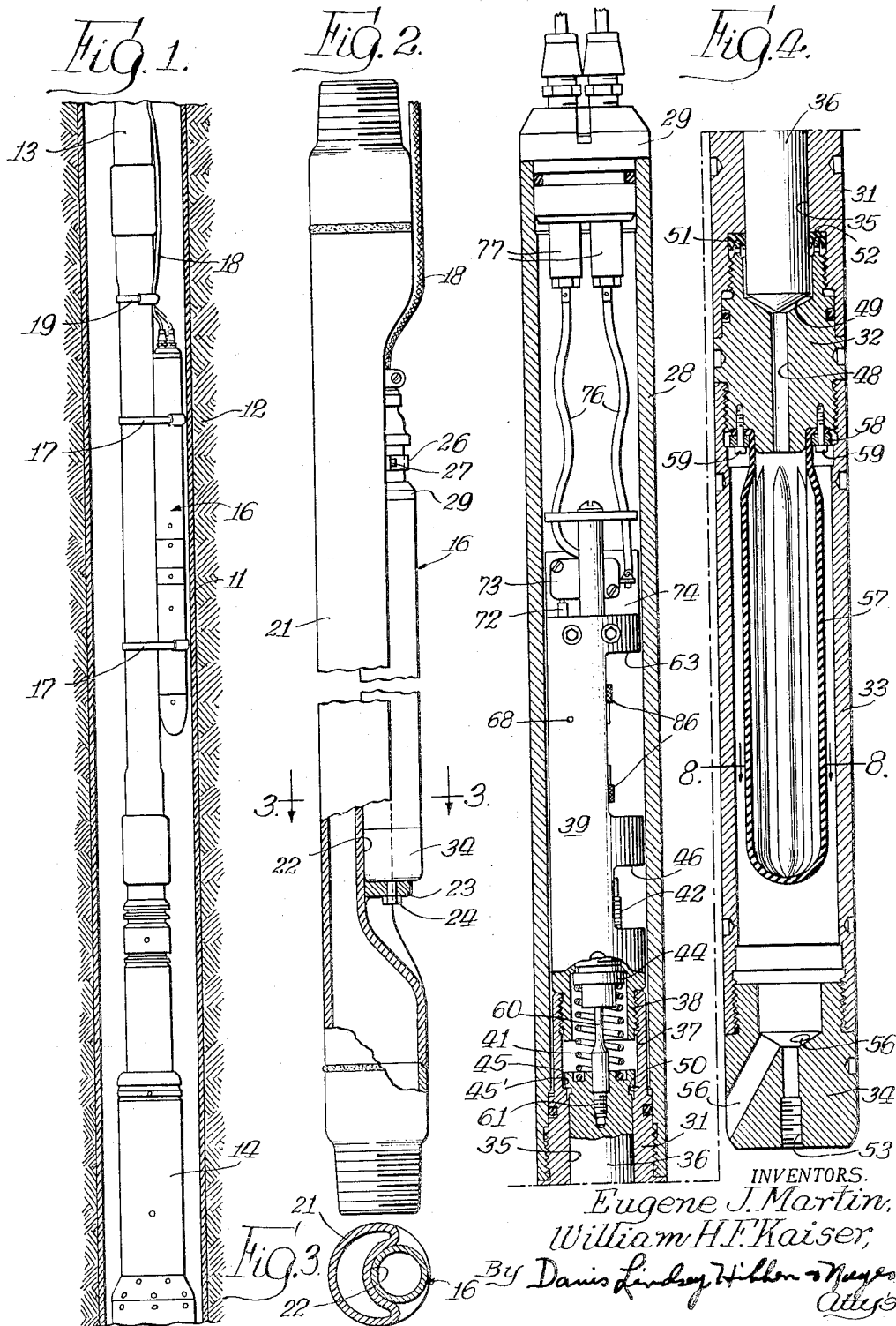
E. J. MARTIN ET AL

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CONTROL MEANS FOR OIL WELL PUMPS

Filed Nov. 20, 1956

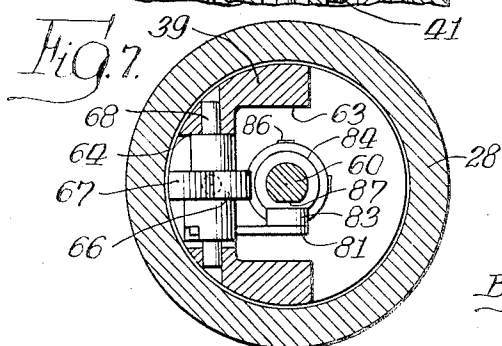
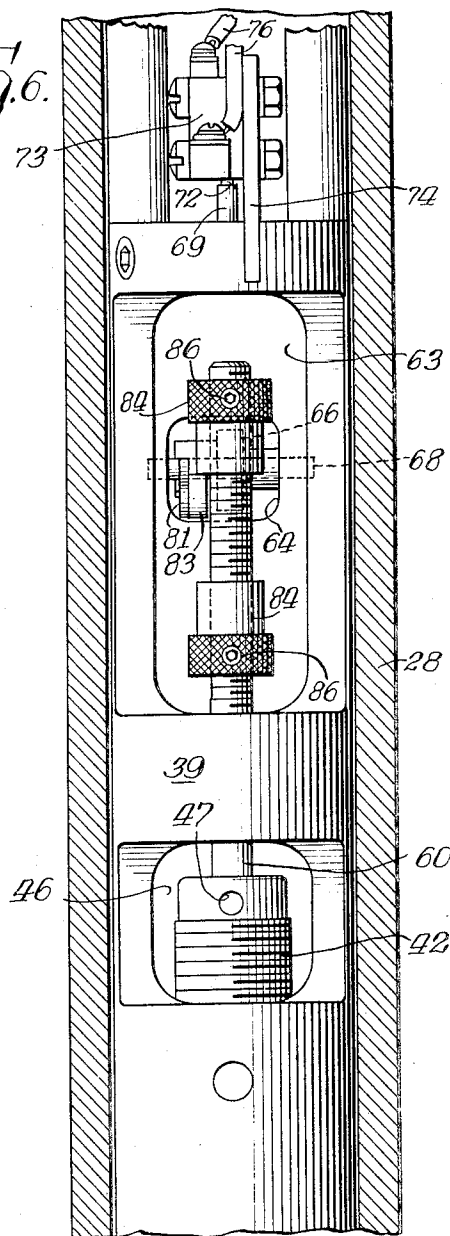
3 Sheets-Sheet 1



E. J. MARTIN ET AL

CONTROL MEANS FOR OIL WELL PUMPS

3 Sheets-Sheet 2



INVENTORS.

Eugene J. Martin

William H. F. Kaiser,

By Davis Lindsey Hicken + Noyes
Attys.

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E. J. MARTIN ET AL

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3 Sheets-Sheet 3

Fig. 8.

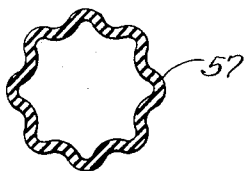
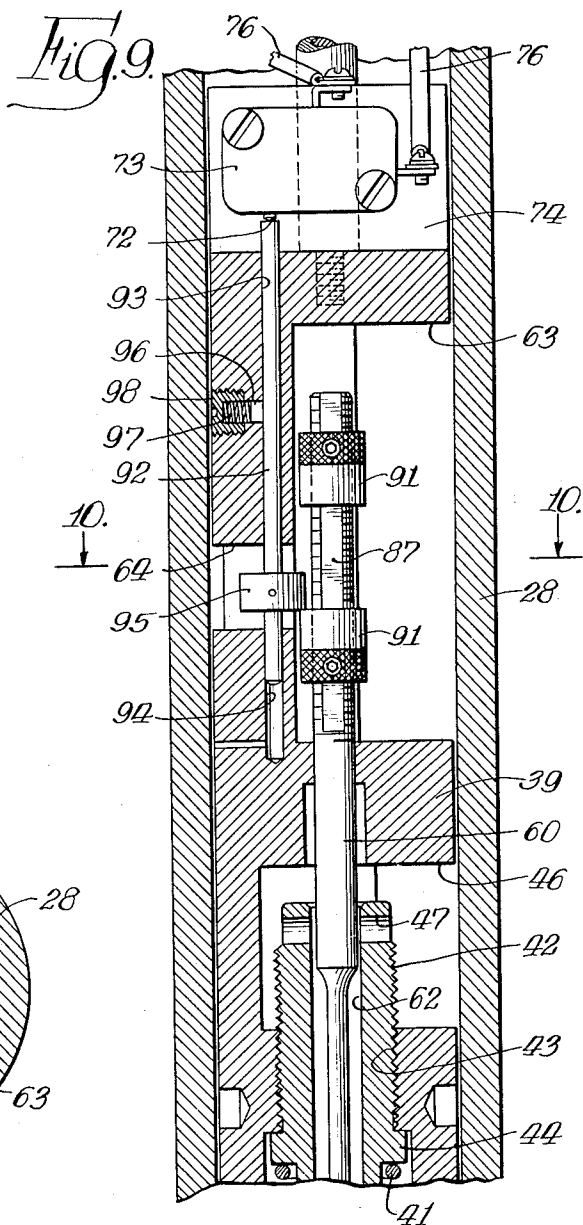
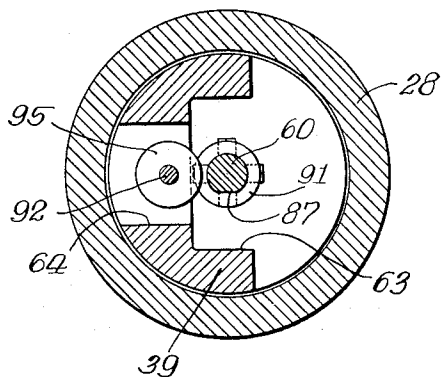


Fig. 10.



INVENTORS,
Eugene J. Martin,
William H. F. Kaiser,
By Davis Lindsey Hilken & Noyes
Attys.

1

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CONTROL MEANS FOR OIL WELL PUMPS

Eugene J. Martin and William H. F. Kaiser, Fort Wayne, Ind., assignors to Perfect Circle Corporation, Hagerstown, Ind., a corporation of Indiana

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4 Claims. (Cl. 200—83)

This invention relates to improvements in pumping apparatus for oil wells or the like and more particularly to novel control means for such apparatus.

In the case of non-flowing oil wells, it is well known to those skilled in the art that in order to obtain optimum and most economical production from a given well great care must be taken in regulating the pumping schedule. Up to the present time, the general practice has been for a skilled operator to determine the proper pumping schedule based on his experience and judgement. In some cases a well may be pumped at irregular intervals determined by the operator and in other cases a time control mechanism may be employed for automatically starting and stopping the pump on a cyclic schedule again determined by the operator. However, prior to our invention there has been no convenient and inexpensive device available for regulating the production of an individual oil well in accordance with the actual requirements or flow characteristics of the well.

It is known that the fluid level or head of oil in the well is a highly important factor in determining the optimum pumping schedule for a non-flowing well, but ordinarily no readily obtainable and reliable information as to the fluid level in the well is available to the operator. For many types of submersible motor-pump units it is quite important that a certain minimum fluid level be maintained in the well in order to avoid damage to the unit. Furthermore, if operation of the pump is continued after the hole is pumped dry there is an obvious waste of power in addition to various disadvantages which may result from over-pumping, e.g. excessive inflow of water or gas, cave-ins or heaving, etc. In the other hand, it is also known that under many conditions there is a certain maximum fluid level which should not be exceeded in order to avoid interference with proper inflow of oil into the well from the surrounding producing formation. Our invention is predicated on the principle of continuously measuring the fluid pressure at or near the bottom of the well as an indication of the fluid level in the well, and as a result the operation of the pump can readily be controlled, either manually or automatically, to maintain the fluid level in the well within the maximum and minimum limits peculiar to each individual well for optimum and most economical production. In other words, by means of geological and production information known for a given well, the optimum fluid levels at which the pump should be started and stopped can be determined by the operator, and by adjusting the novel control device of the present invention in accordance with these selected maximum and minimum fluid levels the well can thereafter be cycled for optimum production consistent with the overall pumping plan. Thus, the invention makes it possible to eliminate both over-pumping and under-pumping so that the fluid level within the well is maintained within the desired limits irrespective of time.

Accordingly, a primary object of the invention is to provide a novel and improved control device for oil well pumps or the like.

2

A further object of the invention is to provide novel means for operating an oil well pump or the like in accordance with predetermined changes in fluid level.

Another object of the invention is to provide a novel and improved fluid level controller for use with an oil well pump or the like.

An additional object of the invention is to provide a novel and improved arrangement for automatically controlling the pumping of an oil well or the like so as to obtain optimum production from the well.

Other objects and advantages of the invention will become apparent from the subsequent detailed description taken in conjunction with the accompanying drawings, wherein:

Fig. 1 is a small scale fragmentary view at the bottom of a well showing one manner of installing the control device of the present invention;

Fig. 2 is a small scale view showing another manner of installing the device;

Fig. 3 is a transverse sectional view taken along the line 3—3 of Fig. 2;

Fig. 4 is a longitudinal sectional view on an enlarged scale of the control device per se;

Fig. 5 is a fragmentary longitudinal sectional view on a still further enlarged scale of a portion of the mechanism shown in Fig. 4;

Fig. 6 is a view in side elevation of the internal mechanism as it would be seen from the right-hand side of Fig. 5;

Fig. 7 is a transverse sectional view substantially as taken along the line 7—7 of Fig. 5;

Fig. 8 is a transverse sectional view as seen along the line 8—8 of Fig. 4;

Fig. 9 is a view similar to Fig. 5 showing a modification of the invention; and

Fig. 10 is a sectional view along the line 10—10 of Fig. 9.

Referring first to Fig. 1, the invention is illustrated in connection with an oil well having a casing 11 extending into the underground formation indicated at 12. The customary production tubing 13 extends to the ground level from a pump unit 14 which may be of any conventional type but in this instance is shown as a submersible motor-pump unit disposed adjacent the bottom of the well. The control unit comprising the principal feature of the present invention is designated at 16 and, in this instance, is securely fastened to the production tubing 13 above the motor-pump unit 14 by means of straps 17. An electrical cable connection 18 extends from the unit 16 to the ground level for a purpose hereinafter described in detail, and the cable 18 is anchored to the production tubing at suitable intervals by means of clamps or straps 19.

In Figs. 2 and 3 a different and preferred manner of installing the control device 16 is illustrated. In this instance, a nipple 21 having a longitudinally extending inwardly depressed recess 22 is secured by conventional pipe connections below the pump unit (not shown). The control unit 16 is fitted within the recess 22 so that the overall diameter does not exceed the normal diameter of the nipple (see Fig. 3). A lowermost support plate 23 is secured adjacent the lower end of the recess 22 for supporting the lower end of the unit 16, and a screw 24 extends upwardly through the plate 23 into the end of the unit 16. A strap 26 secured to the nipple 21 by screws 27 holds the upper end of the unit 16 in place. The cable connection 18 extending from the unit 16 may be clamped at intervals to the tubing by suitable cable clamps as in Fig. 1. Although the choice of manner of installation of the control device 16 will depend upon space limitations and other considerations peculiar to each individual well, it will be recognized that in either

case the control unit is disposed closely adjacent the pump at the bottom of the well so as to respond to fluid pressure in the well as determined by the fluid head or fluid level above the control unit. In either case, the control device 16 constitutes a permanent installation capable of sensing or responding to fluid pressure and fluid level in the well at all times and thereby affording an accurate and reliable basis for either manual or automatic operation of the pumping equipment in accordance with the principle heretofore described.

Referring now to Figs. 4 to 8, the details of the control unit 16 will be described. For ease of installation in an oil well or the like where space considerations are important, the housing of the unit preferably comprises an elongated cylindrical structure of relatively small diameter so as to permit installation of the unit in the manner shown in either Fig. 1 or Fig. 2. In this instance, the housing consists of a plurality of threadedly interconnected sections including an upper housing section 28 having a top cap or closure 29, an intermediate cylinder section 31, a coupling section 32, a lower housing section 33, and a bottom cap or closure section 34. By making the housing of the control device in a plurality of detachable sections, it will be understood that assembly and adjustment of the device is facilitated as well as maintenance and repair.

The intermediate cylinder section 31 of the control unit is provided with an accurately machined internal bore 35 of restricted diameter having an elongated solid piston or plunger 36 reciprocally mounted therein. It is a highly important feature of the present invention that the cylinder 35 and the piston 36 are fitted to an extremely close tolerance on the order of a 30 millionth or a 40 millionth of an inch. A clearance of this magnitude eliminates the necessity of a positive fluid seal and at the same time permits the presence of a lubricating film between the piston and cylinder. For best results, it is preferred that molybdenum disulfide or similar high pressure lubricant be employed. For oil well use or the like, the pressure actuated piston and cylinder arrangement must be capable of accommodating a wide pressure range, e.g. from a low of around 5 pounds per square inch to as high as 5000 pounds per square inch or even higher in some instances. We have found that the close fitting piston and cylinder arrangement described above is adequate to seal against the passage of fluid even at the very high pressures encountered in an oil well and yet is sensitive enough to detect and measure very low pressures when necessary.

The cylinder section 31 is formed with an upper tubular extension 37 (Fig. 4) which fits within the lower end of the housing section 28 and has threadedly secured thereto a depending tubular end or extension 38 of an elongated cam support structure designated at 39 and hereinafter described in detail. A spring 41 engages the upper end of the piston 36 and is loaded to any desired degree of compression by means of an adjusting screw 42 (Fig. 5) threadedly mounted in an opening 43 in the cam support 39 and having a flange or shoulder portion 44 in engagement with the upper end of the spring 41. The upper end of the piston 36 has a head or flange portion 45 of slightly enlarged diameter which seats against a shoulder 45' in the cylinder for determining the lowermost position of the piston. Preferably, the cylinder wall is notched or relieved slightly at this point, as at 50, in order to minimize any tendency for the piston to stick in its lowermost position. The upper end of the adjusting screw 42 projects into a lateral opening or recess 46 provided in one side of the cam support 39 so that the spring 41 can be adjusted (upon removal of the upper housing section 28) by insertion of a suitable tool through the recess 46 into a radial aperture 47 in the upper end of the adjusting screw. As will readily be understood, by proper selection of the spring 41 and by adjustment of the loading screw 42, the piston 36 may

be adapted for use in measuring any desired range of pressure to accommodate the conditions in a given well.

For urging the piston 36 upwardly against the force of the spring 41, fluid pressure is imposed against the lower end of the piston 36 through a central bore 48 (Fig. 4) in the coupling 32, the bore 48 communicating at its upper end with an enlarged annular clearance or space 49 at the lower end of the piston and cylinder means. An inverted U-shaped cup or packing 51 of flexible material is mounted in a recess 52 adjacent the lower end of the cylinder wall in snug engagement with the piston 36 and in fluid communication with the annular space 49. By reason of the inverted U-shaped configuration of the packing 51 it will be understood that the pressure of the fluid in the space 49 tends to force the innermost wall of the packing tightly against the piston thereby providing an auxiliary fluid seal at high pressures. However, at low fluid pressures there is no appreciable auxiliary sealing effect and the packing 51 functions merely as a scraper under these conditions. Thus, a desirable auxiliary sealing effect is obtained at high fluid pressures but the sealing effect is appreciably diminished at low pressures so as to obtain the desired sensitivity of the piston at low pressures.

The bottom cap 34 has a central threaded opening 53 adapted to receive the screw 24 (Fig. 2) for securing the cap 34 to the support plate 23. The bottom cap 34 is also provided with a plurality of openings or fluid passages 56 through which the external well fluid can pass into the interior of the lower housing section 33 for imposing fluid pressure in the well against the lower end of the piston 36. In order to protect the accurately machined piston and cylinder surfaces from the detrimental effects of corrosive or abrasive materials commonly found in oil well fluids and the like, we prefer to interpose a flexible or collapsible fluid-impervious (i.e. impervious to both liquids and gases) seal between the piston 36 and the fluid inlet 56. In the illustrated embodiment of the invention this seal is in the form of an elongated sack or bladder 57 made of synthetic rubber or similar oil resistant material. In order to facilitate expansion and contraction of the bladder 57, it is preferably formed with a plurality of longitudinal pleats or convolutions as best seen in Fig. 8. The lower end of the bladder is, of course, closed and the upper open end of the bladder is secured to the coupling 32 by means of an annular seal ring 58 and a plurality of screws 59 interposed between the bladder convolutions and thereby effectively sealing the lower end of the bore 48 from direct contact with external well fluid. For transmitting the pressure of the external well fluid to the piston 36, the bladder 57 is filled with a moisture-free highly purified non-corrosive fluid such as transformer oil. As will readily be understood, the external well fluid has access to the interior of the lower housing section 33 through the passages 56 and the pressure of this fluid is transmitted directly through the flexible bladder 57 and its internal supply of protective fluid and through the bore 48 and the space 49 to the lower end of the piston 36 thereby moving the latter upwardly against the action of the spring 41 to an extent determined by the magnitude of the fluid pressure in the well which is in turn determined by the fluid head or level in the well.

Referring more particularly to Figs. 5 to 7, an elongated stem 60 having a threaded connection 61 with the upper end of the piston 36 extends upwardly through a central bore 62 in the spring adjusting screw 42 and terminates at its upper end in another enlarged lateral recess 63 in the cam support 39. In a smaller connecting recess 64 in the cam support 39 a rotary cam element 66 having a flat part 67 is journaled for rotary movement by means of a cam shaft 68 (Fig. 7) extending transversely into the adjacent cam support structure 39. An elongated reciprocally mounted plunger

69 has its lower end in contact with the periphery of the cam element 66 and extends upwardly through the cam support 39 into engagement with a depressible spring-pressed operating element or button 72 on a two-position electrical switch 73 which is in this instance a normally open switch. The switch 73 is rigidly secured on an upright bracket plate 74 which is in turn fastened in a slot in the upper end of the cam support 39. A pair of electrical conductors 76 extend from the switch 73 to a detachable connector mechanism 77 (Fig. 4) comprising part of the upper closure or cap 29. These conductors 76, of course, extend from the control unit through the cable 18 to the ground level for connecting the switch 73 in a suitable circuit, as hereinafter described.

As will be seen from Fig. 5, rotary movement of the cam element 66 will effect raising or lowering of the plunger 69 dependent upon whether the curved periphery of the element 66 or the flat part 67 is in engagement with the lower end of the plunger. This movement of the plunger 69 in turn effects movements of the switch operating element 72 for actuating the switch 73 between its "on" and "off" positions. Of course, it will be understood that the switch 73 may also comprise a normally closed switch in which case the flat portion 67 of the cam 66 would be disposed to the left of the plunger 69 as seen in Fig. 5. As another alternative, the switch 73 may be a normally closed switch with the same cam arrangement of Fig. 5 but with a holding relay in the switch circuit for holding the motor circuit open when the switch is closed. For exerting a frictional braking or retarding effect on the rotary cam element 66 so as to resist inadvertent rotary movement thereof, a movable detent 78 is urged against the periphery of the cam element 66 by means of a spring 79, the detent 78 being mounted in the cam support 39 at a point remote from the point of engagement of the plunger 69 with the cam element.

For effecting rotary movement of the cam element 66 in response to movement of the piston 36, a connection is provided by a lever arm 81 fitted at one end thereof in a groove 82 at one side of the cam element 66. The opposite end of the lever arm 81 extends laterally toward the uppermost end of the stem 60 and carries a contact roller 83 disposed closely adjacent the stem 60 (Fig. 7). For engaging the roller 83, the upper end of the stem 60 has threadedly secured thereon in spaced relation at opposite sides of the roller 83 a pair of knurled stop collars or abutment members 84. Each of the members 84 is adjustable along the threaded upper end portion of the stem 60 and each member 84 is provided with a plurality of circumferentially spaced set screws 86, four being provided in this instance. At any adjusted position of a member 84, one of the set screws 86 is tightened to engage an elongated flat 87 at one side of the stem 60 for locking the abutment member 84 in fixed relation on the stem 60. Upon removal of the upper housing section 28 the adjustable stops 84 are readily accessible through the recess 63.

In the operation of the control device, the upper and lower stop members 84 are adjusted on the stem 60 in relation to the pressure of the spring 41 and the rotation of the cam element 66 so as to cause the switch 73 to be actuated at its "on" and "off" positions corresponding to the desired maximum and minimum fluid levels, respectively, in the well. In the position of the device shown in Fig. 5, for example, it will be understood that the fluid level in the well has reached the selected minimum as indicated by the fact that the fluid pressure in the well has been reduced and the piston 36 has been moved downwardly by the action of the spring 41 and the upper abutment member 84 has been moved into contact with the roller 83 on the lever arm 81 thereby rotating the cam element 66 in a clockwise direction as viewed in Fig. 5. This rotary movement of the cam

element 66 has brought the flat cam portion 67 into contacting position with the plunger 69 thereby allowing the latter to move downwardly under the influence of the spring-pressed switch operating button 72. In the case of an automatic control system, the switch 73 is connected in the electric control circuit for the pump motivating power source, such as the motor of the unit 14, and the position of the mechanism shown in Fig. 5 corresponds to the "off" position of the normally open switch 73 so that the control circuit is disrupted and the pump is shut down inasmuch as the fluid level in the well has reached the selected minimum. Obviously, as the fluid level in the well later builds up, the increase in fluid pressure will gradually move the piston 36 upwardly until the lower abutment member 84 engages the roller 83 on the lever arm 81 and effects counterclockwise rotary movement of the cam element 66. Movement of the cam element in this direction finally brings the circular periphery of the element 66 into contact with the lower end of the plunger 69 thereby raising the latter slightly and depressing the switch operating button 72 so that the switch 73 is actuated to its "on" position and operation of the pump unit is resumed at a point corresponding to the selected maximum fluid pressure and fluid level in the well. In order to protect the switch actuating mechanism, including the stem 60, from damage due to overtravel, the upward movement of the piston 36 is limited by engagement of the flange 45 with the lower end 38 of the cam support 39.

Referring now to Figs. 9 and 10, a modification of the motion transmitting mechanism is shown which eliminates the use of the rotary cam previously described. Similar parts or elements of the structure have been given the same reference numerals heretofore used. The upper threaded end portion of the stem 60 has a pair of spaced stop collars 91 adjustably mounted thereon in the same general manner as the abutment members 84 described above. An elongated shiftable rod or plunger 92 is movably supported in parallel relation adjacent the stem 60 by means of a pair of aligned bores 93 and 94 in the cam support 39 at opposite sides of the recess 64. A cooperating abutment 95 is rigidly carried on the plunger 92 and is disposed within the recess 64. The diameter of the abutment 95 is sufficiently large so that the abutment extends laterally beyond the recess 64 in between the collars 91 on the stem 60. A laterally disposed frictional detent 96 mounted in an opening in the cam support structure 39 is urged by a spring 97 seated in a screw plug 98 into engagement with the stem 92 for yieldably retaining the latter in any given position. As before, the upper end of the plunger 92 engages the spring-pressed depressible operating element 72 of the switch 73.

In the position of the device shown in Fig. 9, the piston and its stem 60 are moving upwardly so that the lower collar 91 has contacted the cooperating abutment 95 on the plunger 92. Continued upward movement of the stem 60 will result in depression of the switch button 72 by the action of the plunger 92 thereby closing the normally open switch 73 and starting the pump. As the fluid level and fluid pressure in the well subsequently decrease, the stem 60 will move downwardly. However, in spite of the normal tendency of the spring-pressed operating element 72 to urge the rod 92 downwardly, the plunger 92 and the abutment 95 carried thereon will remain in their uppermost switch actuating position because of the frictional retaining action of the spring-pressed detent 96 on the plunger 92. Thus, as the stem 60 continues its downward movement, the lower collar 91 disengages itself from the abutment 95 and ultimately the uppermost collar 91 on the stem 60 will contact the abutment 95 and positively retract the plunger 92 thereby allowing the switch button 72 to project outwardly and restore the switch 73 to its normally open position whereby to shut off the pump.

From the foregoing, it will be seen that our invention provides a relatively simple, inexpensive, and reliable pressure measuring device which can be installed more or less permanently in each well so as to provide a continuous measure of fluid pressure which is, of course, a direct measure of the fluid level or head in the well. The pressure actuated piston means of the control device reacts to the pressure changes in the well as the fluid level in the well varies and movement of the piston operates an electric switch comprising an integral part of the control unit. However, the switch is connected in a control circuit or the like by a suitable cable running from the control unit in the well to the control box at the ground level. In the case of an automatic control scheme, the switch of the control unit is simply connected by suitable circuitry with the electric motor for the pump so that the pump is turned on and off automatically as the fluid level in the well reaches the selected maximum and minimum levels. If the pump is operated by a gasoline engine or the like, the switch may be connected in the ignition circuit of the engine so as to stop the engine when the fluid level reaches a selected minimum. If the engine is equipped with power actuated starting equipment, the switch of the control unit can be connected in circuit with the starting device so as to restart the engine when the fluid level in the well reaches the selected maximum. If no automatic starting device is available, a signal light or sound unit may be actuated to notify the operator to restart the engine.

It will also be apparent that the device of the present invention can be used to good advantage in various other situations encountered in oil well operation. For example, preset controlled cycling by means of the control device herein described may be quite valuable in areas where keeping fluid on the sand face is an important factor. The control device is also especially useful in low pressure reservoir areas in which a well is capable of reaching a certain static level and will not produce until it is pumped down again. Production areas in which water flooding is involved provide another important application of the invention since the pumping cycle is automatically adjusted to the fluid level in the well. The device also lends itself to modified operation without removal from the well. For example, if for any reason it is desired to deactivate the control unit without removing the same from the well, the electrical cable connections from the switch may be by-passed at the control box. Also, if for any reason it is found in a particular well that automatic operation strictly in accordance with predetermined control settings is undesirable, a sequence timer can be incorporated in the circuit to extend the pumping time cycle to any desired degree. Also, instead of automatic operation it will be understood that the electrical connections from the switch may be used to energize a pilot light or an audible signal device at the ground level for manual starting and stopping of the pump. In addition to use in wells, the level control unit can also be used in other circumstances. For example, in tank batteries for the purpose of switching fluid inlet lines from one tank to another.

Although it might be expected that other types of pressure sensitive devices could be used for level control purposes of the general character here involved, it has been found that such devices as flexible diaphragms or bellows members are not practical for use over wide pressure ranges such as may be encountered in oil well operation. Even if heavy duty diaphragms or bellows are resorted to so as to withstand high pressure operation, such devices generally have insufficient stroke or movement for control purposes at the lower pressure ranges. However, the close clearance piston and cylinder means utilized in our invention affords a highly satisfactory and inexpensive device for control purposes and is capable of operation over a wide pressure range with the re-

quired sensitivity for control purposes at both high and low pressures.

Although the invention has been described with respect to a particular structural embodiment thereof, it is to be understood that various modifications and equivalents may be resorted to without departing from the scope of the invention as defined in the appended claims.

We claim:

1. A device for measuring fluid pressure in an oil well or the like, comprising an elongated housing, close clearance piston and cylinder means intermediate the ends of said housing, spring means yieldably urging the piston toward one end of said housing, fluid inlet means adjacent said one end of the housing for admitting external fluid under pressure into the housing, flexible sealing means interposed between said fluid inlet means and the piston for sealing the piston from contact with external fluid but providing fluid pressure communication from the external fluid to the piston for urging the latter toward the opposite end of said housing, switch means mounted in said housing between said piston and cylinder means and the opposite end of said housing, means including a rotary cam element journaled in said housing at one side thereof for actuating said switch means for opening and closing a circuit, an elongated member rigidly coacting at one end thereof with said piston for movement in unison with the latter and extending at its opposite end to a point adjacent said cam element, lever means cooperable at one end thereof with said cam element for rotating the latter and extending at its opposite end into operating relation with the opposite end of said elongated member, and a pair of spaced abutments on said elongated member for engaging the opposite end of said lever and thereby effecting rotary movement of said cam element in opposite positions of the piston corresponding to selected maximum and minimum fluid pressures.

2. The device of claim 1 further characterized in that said abutments are independently adjustable on said elongated member for varying the switch actuating pressures.

3. A device for indicating fluid pressure in an oil well or the like, comprising an elongated housing, close clearance piston and cylinder means intermediate the ends of said housing, spring means yieldably urging the piston toward one end of said housing, fluid inlet means adjacent said one end of the housing for admitting external fluid under pressure into the housing, flexible sealing means interposed between said fluid inlet means and the piston for sealing the piston from contact with external fluid but providing fluid pressure communication with the piston for urging the latter in the opposite direction, switch means mounted in said housing between said piston and cylinder means and said opposite end of the housing and including a spring-pressed depressible operating element, switch actuating means including a rotatable cam element journaled in said housing in spaced relation from said switch means, a reciprocally mounted plunger extending between said operating element and said cam element for actuating the switch in different rotary positions of the cam element, means for rotating the cam element in response to movement of the piston to oppositely disposed positions corresponding to selected maximum and minimum fluid pressures, and a spring-pressed detent frictionally engaging the cam element remote from the point of engagement of said plunger with the cam element for restraining the latter against inadvertent rotary movement.

4. A device for measuring fluid pressure in an oil well or the like, comprising an elongated housing, close clearance piston and cylinder means intermediate the ends of said housing, spring means yieldably urging the piston toward one end of said housing, fluid inlet means adjacent said one end of the housing for admitting external fluid under pressure into the housing, an elongated,

flexible, fluid-impervious enclosure sealingly mounted between said piston and cylinder means and said fluid inlet means, said enclosure being filled with a protective fluid in contact with said piston whereby to seal the piston from contact with external fluid but providing fluid pressure communication from the external fluid to the piston for urging the latter toward the opposite end of said housing, switch means mounted in said housing between said piston and cylinder means and the opposite end of said housing for opening and closing a circuit, 5 switch actuating means including a rotary cam element journaled in said housing, means operatively interconnecting said cam element with said switch means for actuating the latter in different positions of the cam element, 10 an elongated member rigidly coacting at one end thereof with the piston for movement in unison with the piston and extending at its opposite end to a point adjacent said cam element, lever means connected to said cam element for rotating the latter, and independently adjustable spaced abutment means adjacent said opposite end of said 15 elongated member for engaging said lever means and thereby shifting said cam element in response to move-

ment of the piston between opposite positions corresponding to selected maximum and minimum fluid pressures.

References Cited in the file of this patent

UNITED STATES PATENTS

1,940,516	Tennant -----	Dec. 19, 1933
2,297,678	Allen -----	Oct. 6, 1942
2,302,923	Zimarik -----	Nov. 24, 1942
2,328,266	Durbin -----	Aug. 31, 1943
2,435,143	Knauth -----	Jan. 27, 1948
2,482,443	Tornros -----	Sept. 20, 1949
2,529,688	Grupp -----	Nov. 14, 1950
2,548,878	Dillman -----	Apr. 17, 1951
2,606,442	Raines -----	Aug. 12, 1952
2,677,393	Cornelius -----	May 4, 1954
2,680,168	Murphy -----	June 1, 1954
2,690,713	Urmann et al. -----	Oct. 5, 1954
2,716,395	Pettigrew et al. -----	Aug. 30, 1955
2,770,309	Whitehill -----	Nov. 13, 1956
2,790,043	Clason -----	Apr. 23, 1957
2,829,597	Patterson -----	Apr. 8, 1958