Sept. 14, 1943. H. J. PANKRATZ 2,329,359

WELL PUMP

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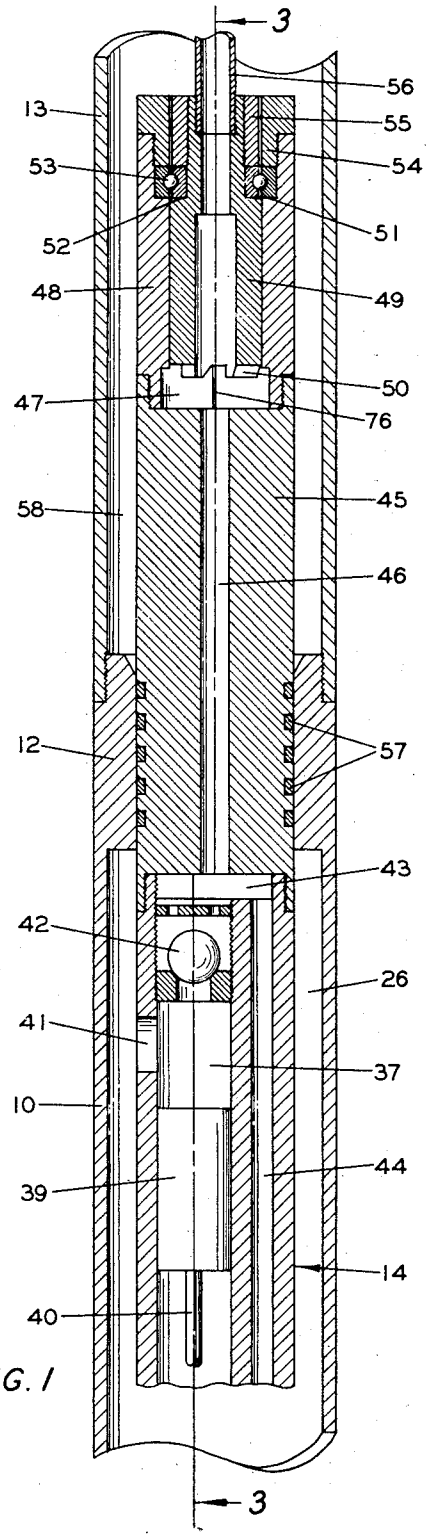


FIG. 1

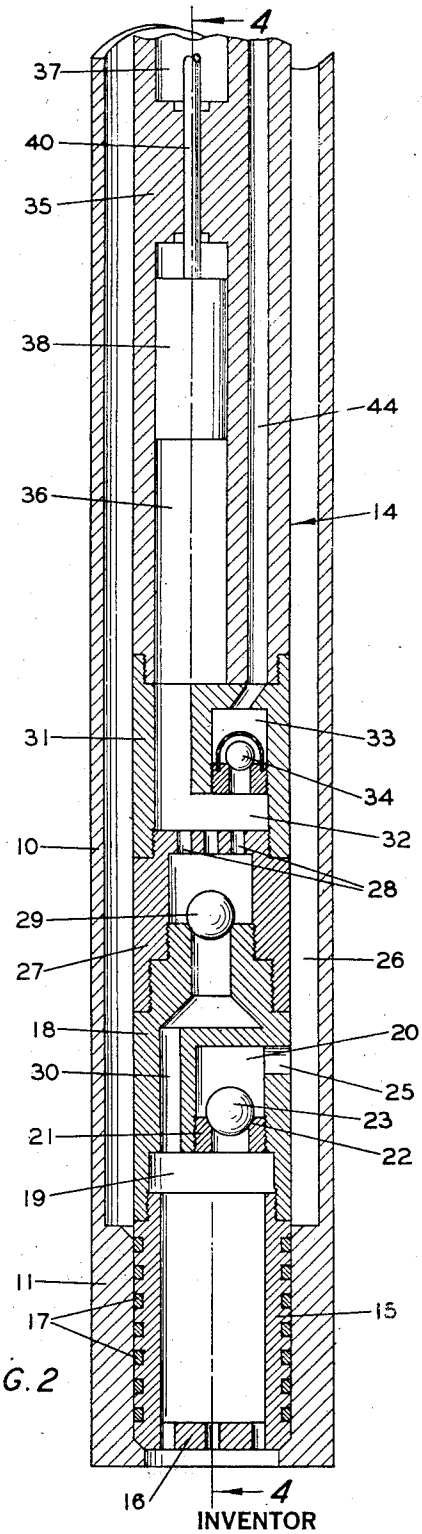


FIG. 2

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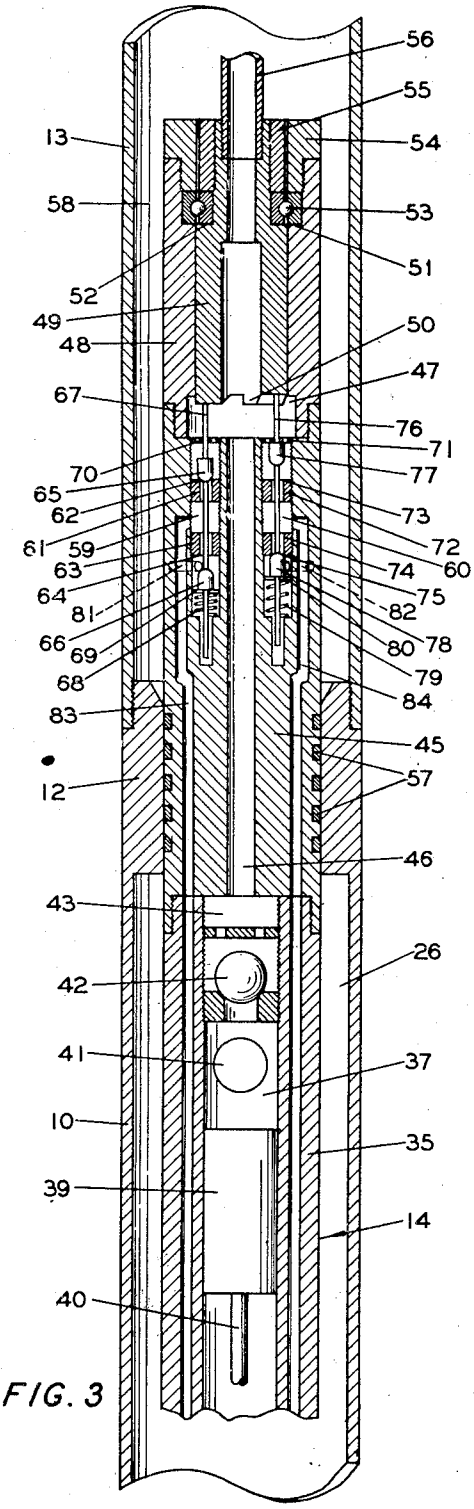


FIG. 3

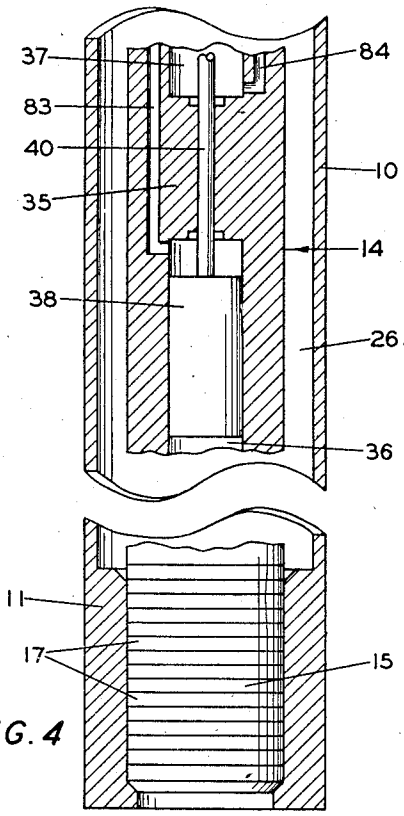


FIG. 4

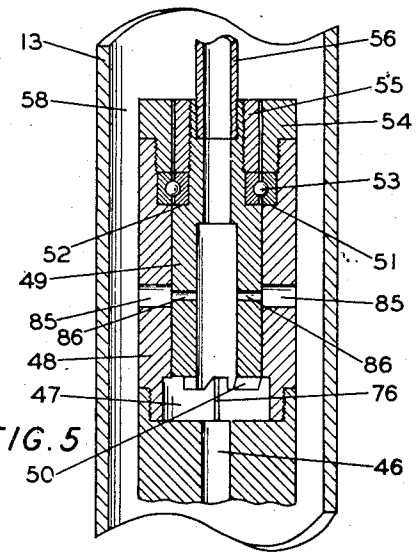


FIG. 5

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UNITED STATES PATENT OFFICE

2,329,359

WELL PUMP

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Application November 13, 1941, Serial No. 418,963

8 Claims. (Cl. 103—46)

This invention relates to well pumps, and more particularly it relates to well pumps which utilize fluid under pressure to lift well fluid to the surface of the ground.

When a well bore is drilled into a virgin hydrocarbon-bearing formation it is common to find that there is sufficient energy stored in the hydrocarbon fluid to flow that fluid out of the well bore at the surface of the ground. However, as additional wells are drilled into the formation and hydrocarbon fluids are removed therefrom, the energy originally in the formation, unless sustained by a natural water drive or by pressure maintenance methods, becomes depleted and the hydrocarbon oil no longer flows to the surface of the ground. As a great percentage of the hydrocarbon oil still remains in the formation, other means of recovering the oil are employed, such as the utilization of compressed air or gas for gas-lifting the hydrocarbon oil from the lower portion of the well bore to the surface of the ground, or the employment of various mechanical pumping devices. In actual practice in the industry, many wells are equipped with mechanical pumping devices as soon as the wells cease to flow, and many wells, which do not flow naturally when drilled and completed for the production of hydrocarbon oil, are provided with mechanical pumping equipment. This type of equipment may include pumping devices, such as reciprocating pumps which are actuated by a string of sucker rods; submersible, electrically-driven centrifugal pumps; or hydraulic pumps.

Present-day types of bottom-hole hydraulic pumps, which depend upon a fluid of high pressure for actuation, commonly have a relatively short stroke, which is controlled by a valve mechanism. It has been found that the pressure fluid, which actuates the pump and aids in actuating the valve mechanism, is greatly reduced in pressure while operating the valve mechanism. This lowers the operating efficiency of the pump. By the practice of my instant invention I obtain several advantages and economies which are not obtainable with present-day pumps: First, I am able to fully utilize the available reservoir energy; next, I employ a positive control means with which I am able to adapt my pumping apparatus to any type of reservoir pumping condition; third, I overcome the loss of fluid pressure now inherent in present-day types of bottom-hole fluid-operated pumping apparatus by mechanically controlling my instant pumping apparatus from the surface of the ground; also, I may effect a greater volumetric efficiency by constructing my pumping apparatus with a long stroke; and further, my instant invention will operate as satisfactorily by utilizing high pressure gas or air for a source of energy as by utilizing high pressure liquid.

The primary object of my invention is to provide a well pumping apparatus which utilizes fluid under pressure to lift well fluid to the surface of the ground.

Another object of my invention is to provide a fluid actuated bottom hole pump which utilizes either a liquid or a gas as pressure fluid and which is positively controlled from the surface of the ground.

This invention has for a further object the provision of apparatus of the character indicated wherein the pump is controlled by an arrangement of apparatus that is mechanically actuated from the surface of the ground.

A still further object of my invention is to provide a reciprocating fluid driven pump which utilizes available energy in the reservoir and which operates efficiently and economically.

These and additional objects and advantages will be apparent to persons skilled in the art by reference to the following description and annexed drawings, wherein;

Figure 1 is an elevation view of my invention, partly in cross-section, illustrating the upper portion of the pumping apparatus;

Figure 2 is an elevation view, partly in cross-section, illustrating the lower portion of my invention;

Figure 3 is a vertical section taken along line 3—3 of Figure 1;

Figure 4 is a vertical section taken along line 4—4 of Figure 2; and

Figure 5 is a fragmentary elevation view, partly in cross-section, illustrating a modification of my instant invention.

Referring to the drawings and more particularly to Figures 1 and 2, I have denoted therein an outer pump barrel by reference numeral 10. The outer pump barrel is provided with a lower seating adapter 11 and with an upper adapter 12 which is secured at the top to an oil well tubing 13 that is supported in a well bore from the surface of the ground in a known manner. It is to be understood that the term "tubing" as applied to tubing 13 may be construed to mean an oil well casing or other desired tubular member, which is positioned in a well bore. The outer pump barrel 10 contains an inner pump barrel 14, which is positioned concentrically therein by seating adapters 11 and 12. The lower end por-

tion of the inner barrel is provided with a hollow seating nipple 15, preferably having a perforate end member 16. A plurality of seating rings 71, which are provided on the periphery of nipple 15, serve to anchor the inner barrel within adapter 11, forming a seal between the barrel and the adapter. A valve casting 18 which is threadedly attached to the upper end of seating nipple 15, is bored in the lower end to form a chamber 19. A valve chamber 20, which is formed in the lower right hand portion of casting 18, is preferably adapted to receive a threaded ring 21, which is provided with centrally located valve seat 22 which supports a ball 23. Ball 23 cooperates with seat 22 to allow the flow of well fluid upwardly from chamber 19 through ring 21. A port 25, which is provided in casting 18, allows communication between valve chamber 20 and an annulus 26 which is formed by the inner surface of outer pump barrel 10 and the outer surface of inner pump barrel 14 between lower adapter 11 and upper adapter 12. The upper end of casting 18, which is threadedly connected to a cage member 27, having perforations 28, supports a ball check valve 29. Valve 29 permits the flow of fluid upwardly through a passage 30 which extends upwardly through casting 18 from chamber 19. A valve containing member 31, having an opening 32 extending therethrough, is provided with a valve chamber 33, which contains a check valve 34, that permits the flow of a fluid upwardly from opening 32. The top of member 31 is threadedly attached to a cylinder 35 having a lower bore 36 and an upper bore 37 which contain a lower piston 38 and an upper piston 39, respectively. The pistons, which reciprocate simultaneously, are connected by a common rod 40 which is in tension during the reciprocation of the pistons. It is to be noted that the lower end of bore 36 connects with opening 32 and that bore 37 communicates with annulus 26 by way of a port 41, which is provided in cylinder 35 near the upper end of bore 37. The upper end of bore 37 is adapted to receive a ball check valve 42 which permits the flow of fluid upwardly from the bore into a fluid chamber 43 which is provided in the upper end of cylinder 35. Cylinder 35 is also provided with a passage 44 which allows communication between fluid chamber 43 and valve chamber 33. The lower end of a cylindrical valve body 45, which has a central passage 46, is threadedly connected to the upper cylinder 35. Passage 46 provides communication between chamber 43 and an enlarged centrally located opening 47 that is formed in the lower end portion of a cylindrical sleeve 48, which is threadedly secured to the upper end of body 45. Sleeve 48 contains a hollow rotatable shaft 49 having a cam 50 which is formed on its lower end. Sleeve 48 and hollow shaft 49 are provided with a pair of flush shoulders 51 and 52, respectively, which support a suitable bearing 53. The bearing is held in position on shoulders 51 and 52 by an externally threaded ring 54, which is threadedly positioned in the upper end of sleeve 48 and by an internally threaded ring 55, which is threadedly connected to the upper end of shaft 49. The upper end portion of shaft 49 is also secured to the lower end of an inner string of well tubing 56. Tubing 56, which is provided with a slip joint (not shown), is also preferably supported and rotated at the surface of the ground in a manner disclosed in United States Patent No. 2,202,970. It will be noted in Figure 1 that a plurality of rings 57 are provided on the lower peripheral surface of body 45. These rings, which may be identical in composition to rings 17, form a seal between body 45 and adapter 12, thus closing annulus 26 at the top. An upper annular space 58, which is formed on the interior of tubing 13, extends upwardly from adapter 12 to the surface of the ground.

Referring next to Figures 3 and 4, it will be noted that body 45 is provided with a pair of bores 59 and 60. Bore 59 contains an upper ported member 61 having a valve seat 62 formed on its upper face and a lower ported member 63 having a valve seat 64 formed on its lower face. An upper valve head 65 and a lower valve head 66 are spaced on a common valve stem 67, which is in sliding engagement with cam 50 at all times. A compression spring 68 of any desired strength is contained concentric with stem 67 in the lower portion of bore 59 beneath a perforate guide ring 69 which is preferably secured to valve head 66 and which makes sliding contact with the wall of bore 59. A spider 70 is positioned in the upper part of the bore to guide stem 67, during its substantially vertical movement and to allow communication between bore 59 and opening 47. Bore 60 contains parts which are shown as being identical to those contained in bore 59. This bore contains a spider 71, an upper ported member 72 having a valve seat 73, and a lower ported member 74 having a valve seat 75. A common stem 76 is in sliding engagement with cam 50 and carries a pair of spaced valve heads 77 and 78. A compression spring 79 is positioned concentrically with stem 76 in the lower portion of bore 60 beneath a perforate guide ring 80, which is preferably secured to valve head 78. It is to be noted that when valve stem 67 is fully depressed by cam 50, valve stem 76 is fully raised by the action of spring 79. Thus, the upper valve head on one stem and the lower valve head on the other stem engage their seats at the same time. Valve body 45 is provided with a pair of conduits 81 and 82 which allow communication between annular space 58 and bores 59 and 60, respectively. A duct 83, which extends downwardly through body 45 and cylinder 35, places bore 59 in communication with bore 36. A second duct 84, which also extends downwardly through member 45 and cylinder 35, places bore 60 in communication with bore 37.

In operation, the apparatus of my instant invention is assembled as shown in the drawings and positioned in a well bore. Well fluid in the well bore enters the apparatus through seating nipple 15, from which it flows upwardly into chamber 19. Part of the fluid in the chamber may then flow upwardly through passage 30, check valve 29, perforations 28, and opening 32, entering the lower portion of bore 36; or it may flow upwardly from chamber 19 through ring 21, lifting ball 23 off seat 22 and thence flowing into valve chamber 20, from which the fluid passes through port 25 to annulus 26 where the fluid fills to the top of the annulus. Let us assume that pistons 38 and 39 are just beginning their downward stroke, and that tubing 56 is rotating at a constant rate of speed, rotating hollow shaft 49. Cam 50 on the lower end of the hollow shaft, which is in sliding engagement with valve stems 67 and 76, depresses stem 67 against the action of spring 68, causing valve head 65 to engage with seat 62 and causing valve head 66 to move off its seat 64. At the same time, cam 50 allows spring 79 to urge stem 76 upwardly, seating valve head 78 upon seat 75 and unseating valve head 77 from

its seat 73. Thus, a pressure fluid, which is supplied through annular space 58 from the surface of the ground, is permitted to flow through conduit 81 into bore 59, and thence through duct 83 to the upper portion of bore 36. At the same time exhaust fluid in the lower portion of bore 37 is permitted to flow upwardly through duct 84, bore 60, and spider 71 into opening 47. As the pressure fluid acts upon the upper end of piston 38, moving pistons 38 and 39 downwardly, well fluid in bore 36 is displaced by piston 38. The pressure exerted on the well fluid by piston 38 closes check valve 29 and opens check valve 34, allowing fluid from bore 36 to flow downwardly through opening 32 and thence upwardly through chamber 33, passage 44, chamber 43, passage 46, thence to opening 47 where the well fluid mixes with exhaust fluid from bore 37. From opening 47, the mixture of well fluid and exhaust fluid flows upwardly through hollow shaft 49 to tubing 56 which conveys the fluid to the surface of the ground. As the pistons move downwardly, fluid in annulus 26 flows through port 41, filling bore 37 above piston 39.

When the pistons have completed their downward stroke, tubing 56 has rotated hollow shaft 49 to a position whereby cam 50 depresses valve stem 76, seating valve head 77 and unseating valve head 78, permitting pressure fluid from annular space 58 to flow through duct 82, bore 60, duct 84 and thence into the lower portion of bore 37, where the fluid acting upon the lower end of piston 39 urges pistons 38 and 39 upwardly. At the same time the cam allows spring 68 to raise valve stem 67, unseating valve head 65 and seating valve head 66, whereby fluid which is exhausted from within bore 36 by upward movement of piston 38 flows upwardly through duct 83, bore 59, spider 70 and thence into opening 47. As the pistons move upwardly, piston 39 displaces fluid from within bore 37. The pressure exerted on the well fluid by piston 39 causes the fluid to seat ball 23 on seat 22 and to open check valve 42, allowing the fluid from bore 37 to flow into chamber 43, and thence upwardly through passage 46 into opening 47 where the well fluid mixes with the exhaust fluid from bore 36. The mixture of exhaust fluid and well fluid thence flows upwardly through hollow shaft 49 and tubing 56 to the surface of the ground. As piston 38 moves upwardly, well fluid in passage 30 unseats check valve 29 and flows through perforations 28, opening 32, and into bore 36. When the upward stroke of the pistons is completed, cam 50, through the rotation of tubing 56, is again in a position causing valve stem 67 to be depressed and valve stem 76 to be raised. Thus, pressure fluid is again admitted to the upper portion of bore 36 where the fluid acts upon piston 38 urging pistons 38 and 39 downwardly and the cycle of operation repeated.

It will be noted from Figures 1 and 2 that well fluid may flow upwardly from the lower portion of a well bore to the surface of the ground by completely by-passing pistons 38 and 39, provided there is sufficient energy in well fluid. This is accomplished by the fluid flowing upwardly by way of nipple 15, chamber 19, ring 21, chamber 20, port 25, annulus 26, port 41, bore 37, and chamber 43, and thence through passage 46, chamber 47, hollow shaft 49, and tubing 56 to the surface of the ground; or by the fluid flowing upwardly through nipple 15, chamber 19, passage 30, perforations 28, chamber 33, passage 44, chamber 43, and thence upwardly to tubing 56, through which the fluid is conveyed to the surface of the ground.

Turning next to Figure 5 for a description of a modification of my invention, it is to be noted that like parts shown in the drawings, which is a fragmentary view of the upper portion of my apparatus, and in the other drawings heretofore described carry the same reference numerals. In this embodiment, which may be used advantageously especially when the fluid utilized for actuating pistons 38 and 39 is a gas, I have provided sleeve 48 with a plurality of ports 85. During the rotation of tubing 56, ports 85 are brought into alignment with a second plurality of ports 86 which are provided in hollow shaft 49. When ports 85 and 86 are in alignment, annular space 58 is brought into communication with the interior of the hollow shaft. The operation of this modification of my invention relative to the lifting of well fluid upwardly from the lower portion of a well bore to the interior of hollow shaft 49 is identical to that of my first embodiment. In this embodiment, however, the rotation of tubing 56 and the hollow shaft, in addition to controlling the admission of pressure fluid to bores 36 and 37 and the exhaust of pressure fluid therefrom, aligns ports 86 with ports 85 for a short interval of time. When the ports are in alignment, gas which is utilized as a pressure fluid flows from annular space 58 through ports 85 and 86 to the interior of hollow shaft 49, where the gas enters the stream of well fluid which is being pumped to the surface of the ground and assists in lifting it thereto. It is to be noted that the gas entering the well fluid is at a superior pressure and that the well fluid is prevented from flowing downwardly through the apparatus by check valves 42 and 34.

Although the invention has been herein shown and described in simple and practicable form, it is recognized that certain parts or elements thereof are representative of other parts or elements which may be used in substantially the same manner to accomplish substantially the same results. Therefore, it is to be understood that the invention is not to be limited to the exact details described herein, but is to be accorded the full scope and protection of the following claims.

I claim:

1. In well pumping apparatus of the character described, the combination comprising a fluid actuated pump mechanism adapted to be lowered into a well bore and including actuating fluid inlet means and outlet means, an outer conduit for supplying actuating fluid to the inlet means, an inner conduit rotatably disposed within the outer conduit for transmitting well fluid and actuating fluid that is discharged from the pump mechanism to the surface of the ground, and means responsive to rotational movement of the inner conduit for controlling the admission and discharge of actuating fluid into and from the pump mechanism.

2. In well pumping apparatus of the character described, the combination comprising a fluid actuated pump mechanism adapted to be disposed in a well bore and including valved inlet and outlet means, means for supplying actuating fluid to the pump mechanism, means for transmitting well fluid and actuating fluid that is discharged from the pump mechanism to the surface of the ground, means including cam means for controlling the admission and discharge of actuating

fluid into and from the valved inlet and outlet means, respectively.

3. In well pumping apparatus of the character described, the combination comprising a fluid actuated pump mechanism adapted to be disposed in a well bore and including valved inlet and outlet means, means for supplying actuating fluid to the pump mechanism, means for transmitting well fluid and actuating fluid that is discharged from the pump mechanism to the surface of the ground, means including cam means for controlling the admission and discharge of actuating fluid into and from the valved inlet and outlet means, respectively, the last mentioned means being positively operated from the surface of the ground.

4. In well pumping apparatus of the character described, the combination comprising a fluid actuated pump mechanism adapted to be disposed in a well bore and including valved inlet and outlet means, an outer conduit for supplying actuating fluid to the inlet means, an inner conduit rotatably disposed within the outer conduit for transmitting well fluid and actuating fluid that is discharged from the pump mechanism to the surface of the ground, and caming means responsive to rotational movement of the inner conduit for cooperating with the valved inlet and outlet means to control the admission and discharge of actuating fluid into and from the pump mechanism.

5. In well pumping apparatus of the character described, the combination comprising a fluid actuated pump mechanism including fluid inlet and outlet means and valve means associated with the inlet and outlet means, said valve means being movable along a substantially lineal path, an outer conduit for supplying actuating fluid to the inlet means, an inner conduit rotatably disposed within the outer conduit for transmitting well fluid and actuating fluid that is discharged from the pump mechanism to the surface of the ground, and means responsive to rotational movement of the inner conduit for imparting lineal movement to the valve means to control the admission and discharge of actuating fluid into and from the pump mechanism.

6. In well pumping apparatus of the character described, the combination comprising a fluid actuated pump mechanism including fluid inlet and outlet means and valve means associated with the inlet and outlet means, said valve means being movable along a substantially lineal path, an outer conduit for supplying actuating fluid to the inlet means, an inner conduit rotatably disposed within the outer conduit for transmitting well fluid and actuating fluid that is discharged from the pump mechanism to the surface of the ground, and means including caming means for converting rotational movement of the inner conduit into reciprocating movement of the valve means to control the flow of actuating fluid through the inlet and outlet means.

7. In well-pumping apparatus of the character described, the combination comprising a well bore, an inner and an outer conduit defined in the well bore, a fluid-actuated pump positioned in the well bore and including a pump body, an inlet to the pump body in communication with the producing formation of the well, an outlet from the pump body in communication with the inner conduit of the well bore, conduits in the pump body provided for alternate admission and exhaust of actuating fluid supplied thereto, and means operated by movement of said inner conduit adapted to established communication of the actuating fluid conduits alternately with the said inner and outer well bore conduits.

8. In a well pump apparatus of the character described, the combination comprising a fluid-actuated piston pump adapted to be positioned in a well bore, an outer conduit in the well bore for supplying actuating fluid to the pump, a central conduit in the well bore for conveying fluids discharged from the pump to the surface of the ground, pistons disposed within the pump, each having a well-fluid displacing side and a fluid pressure actuated side, a channel associated with the displacing side of each piston for admission and discharge of well fluid, a channel associated with the actuated side of each piston for admission and discharge of actuating fluid, valve means disposed in each of last said channels for controlling admission and discharge of actuating fluid therethrough, and cam means operable by said central conduit to actuate said valve means.

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