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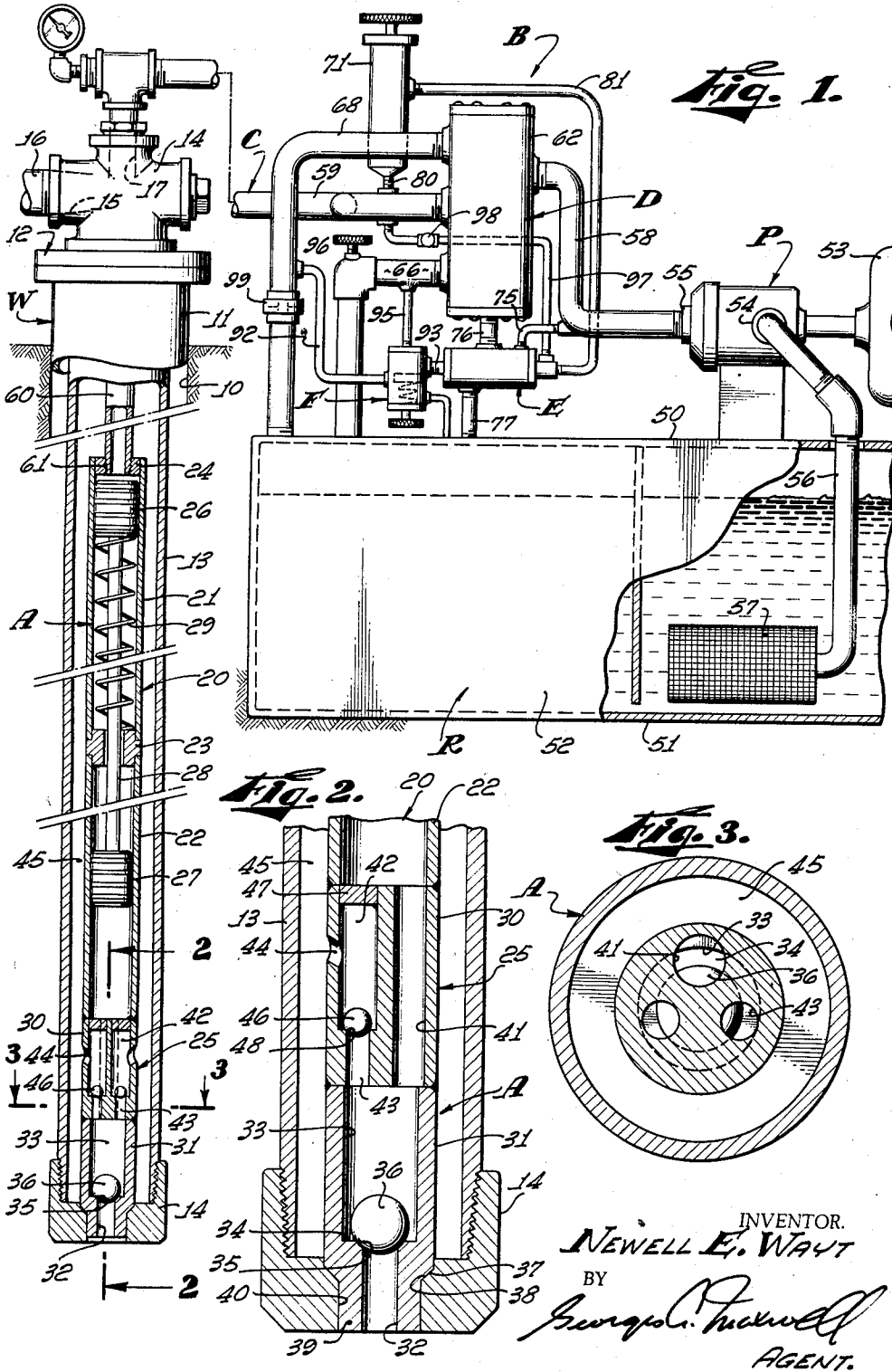
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2,942,552

WELL PUMPING APPARATUS

Filed Aug. 5, 1957

2 Sheets Sheet 1



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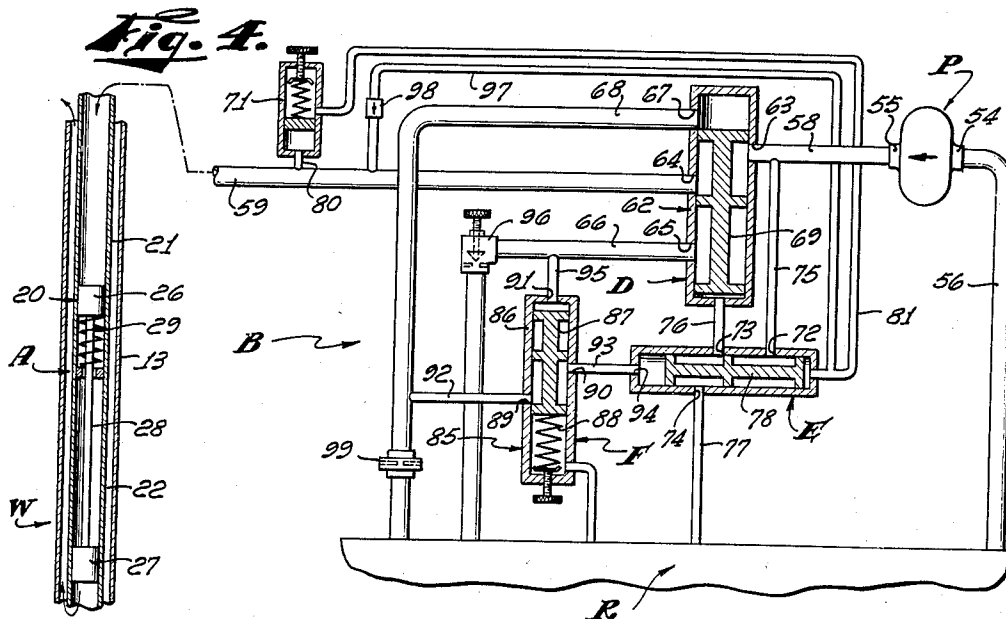
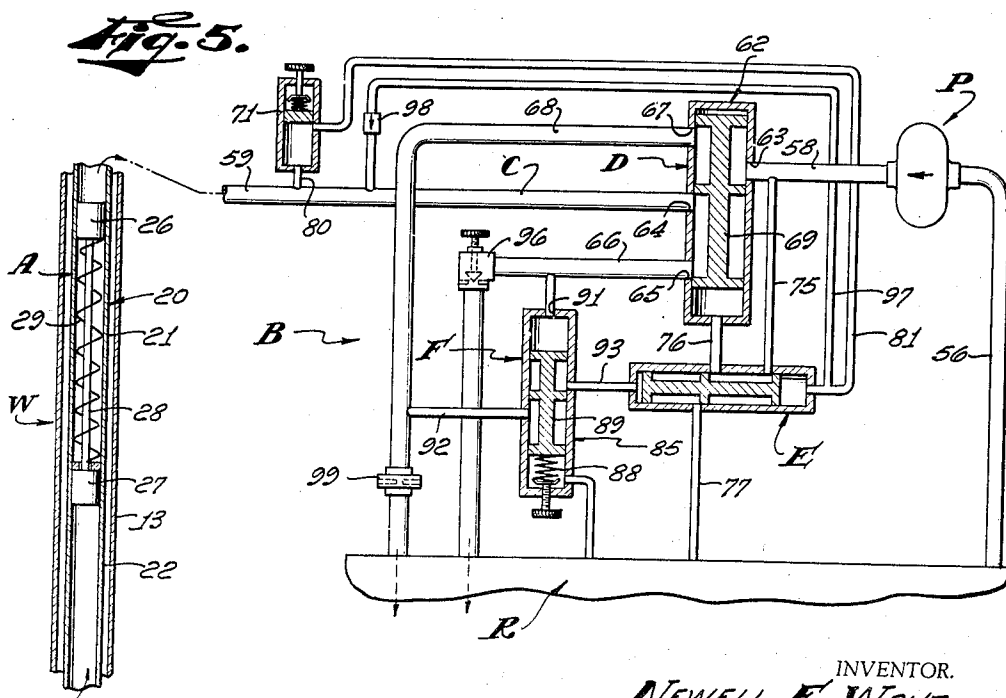
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WELL PUMPING APPARATUS

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2 Sheets-Sheet 2



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2,942,552

WELL PUMPING APPARATUS

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9 Claims. (Cl. 103—45)

This invention relates to a well pumping apparatus and is more particularly concerned with a hydraulically operated pump engageable in the bottom of a well and a fluid supply and control apparatus at the top of the well and operating the pump.

The art of pumping wells with hydraulically operated well pumps and/or hydraulic operating apparatus for well pumps is becoming highly developed and is rapidly replacing the old art of pumping wells with conventional suck rod operated pumps and conventional mechanical pump jacks.

To date several highly effective hydraulic pump jacks have been provided to operate conventional deep well pumps. These jacks are operatively coupled to the pumps by means of a conventional string of sucker rods. While such pump jacks eliminate the old mechanical jacks and the undesirable features associated therewith, they fail to improve, effect or in any way alter the operation of the pumps with which they are related.

Still further, the art has provided several highly effective hydraulically operated deep well pumps. These pumps, however, include a hydraulically-operated motor or drive means which is located in the bottom of the well in direct connection with the pump and which is supplied with operating fluid from supply pumps and the like, at the top or upper ends of the wells in which they are engaged. While such hydraulically operated pumps have proven satisfactory, they are extremely complicated and costly of manufacture and are extremely difficult to service. Still further, such pumps are designed with a set stroke which cannot be varied when the pump is engaged in a well.

In the pumping of wells, it is extremely important or highly advantageous that the rate at which the fluid is withdrawn from the well does not exceed the natural production rate of the well, since overproducing the well frequently results in breaking down of the formation, thereby preventing the proper flow of fluid therethrough, as well packing or sending up the pumping equipment at the bottom of the well. Overproducing a well also frequently allows water to flow into and through the oil producing formation at a much greater rate, with the result that the oil is not allowed to flow properly and the well produces an overabundance of water and is therefore unprofitable to operate.

An object of the present invention is to provide a deep well pumping apparatus which includes an extremely simple and novel hydraulically operated pump adapted to be engaged in the bottom of a well and a novel hydraulic apparatus at the top of the well to operate the pump.

Another object of the present invention is to provide a pump engageable in the bottom of a string of production tubing extending into a well and operated by a reciprocating column of fluid within a delivery pipe engaged through the production tubing and connected with the pump.

A further object of the present invention is to provide a novel, simple and compact hydraulic apparatus at the

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top of the well to move and control the column of fluid operating the pump.

Still another object of this invention is to provide an apparatus of the character referred to which is adjustable to vary and control the length and the rate of the stroke of the pump.

It is another object of the present invention to provide a novel hydraulically operated pump which involves few parts, a pump which is both highly effective and dependable in operation and a pump which is both easy and economical of manufacture and maintenance.

It is a further object of my invention to provide a pump operating apparatus of the character referred to, which apparatus is highly effective and dependable in operation and which is both easy and economical of manufacture and maintenance.

The various objects and features of my invention will be fully understood from the following detailed description of a typical preferred form and application of my invention, throughout which description reference is made to the accompanying drawings, in which:

Fig. 1 is an elevational view of the apparatus that I provide and showing the pump engaged in a well and in section.

Fig. 2 is an enlarged detailed sectional view of a portion of the pump that I provide and taken as indicated by line 2—2 on Fig. 1.

Fig. 3 is an enlarged transverse sectional view of the pump that I provide and taken as indicated by line 3—3 on Fig. 1.

Fig. 4 is a diagrammatic view of the pumping apparatus provided by the present invention in one position.

Fig. 5 is a diagrammatic view similar to Fig. 4 and showing my well pumping apparatus in another position.

The apparatus that I provide and which is illustrated throughout the drawings involves, generally, a hydraulically operated well pump A engageable in the bottom of a well structure W, and a fluid supply and controlling apparatus B at the top of the well structure W and adapted to operate the pump.

The well structure W in which the pump A is engaged is shown as including a well bore 10, a casing 11 depending into and supporting the bore 10, a well head 12 at the upper end of and closing the casing, a production tubing 13 extending through the casing and suspended from the casing head 12, and a pump shoe 14 at the lower end of the tubing and adapted to be engaged by and to support and seal with the pump A. The well head 12 at the upper end of the casing 10 and supporting the tubing 13 is provided with a suitable fitting 14 having a threaded opening 15 at one side thereof to connect with a suitable production pipe 16 adapted to conduct production fluid within the tubing from the well and an opening 17 in the top thereof to cooperatively receive and support a delivery pipe of the apparatus B, as will hereinafter be described, and which depends through the tubing and connects with the pump A.

The well pump A that I provide is shown as including an elongate vertically disposed barrel 20 having top and bottom sections 21 and 22, an apertured partition 23 engaged between and connecting the said top and bottom barrel sections, a head 24 secured to and closing the upper end of the top sections 21 of the barrel, and a valve cage 25 secured to and closing the lower end of the bottom section 22 of the barrel. The pump A further includes an upper piston 26 slidably engaged in the top section 21 of the barrel, a lower piston 27 slidably engaged in the bottom section 22 of the barrel, a connecting rod 28 extending between and fixed to the pistons 26 and 27 and extending freely through the partition 23, and a compression spring 29 engageable in the upper or top section of the barrel and to occur between the upper

piston 26 and the partition 23 and normally yielding urging the pistons 26 and 27 upwardly in their respective sections 21 and 22 of the barrel. In practice, the spring 29 is of considerable strength or weight and is adapted to freely urge or shift the pistons 26 and 27 upwardly in their respective sections of the barrel to urge the column of fluid occurring above the piston 26 upwardly, as will hereinafter be described, and to draw well fluid into and charge the lower section of the barrel.

The valve cage 25 of the pump A is shown as having an upper section 30 fixed to the lower end of the bottom section 22 of the pump barrel 20, and a lower section 31 secured to and depending from the said upper section. The lower section 31 of the valve cage 25 is a substantially tubular member having a central longitudinal flow passage 32 extending longitudinally therethrough, and having an enlarged upwardly opening counterbore entering it from its upper end and defining an intake chamber 33. The counterbore or chamber 33 terminates at a flat bottom 34 and is provided with an annular valve seat 35, which seat is concentric with the flow passage 32 extending through the said section. A suitable check ball or spherical valve element 36 is engaged in the chamber 33 and is adapted to engage on the seat 35 therein and prevent the flow of fluid within the chamber downwardly through the flow passage 32.

The lower end of the lower section 31 of the valve cage 25 is provided with a downwardly inclined sealing face 37 adapted to seat in a downwardly inclined annular seat 38 provided in the pump shoe 14 which is secured to the lower end of the production tubing 13. The said section 31 is further provided with a tubular extension 39 which depends from the bottom end thereof, through a suitable longitudinal opening 40 in the pump shoe, to establish open communication with the interior of the casing 11 or the well bore 10. In practice, the weight of the pump A and the various parts connected directly thereto and occurring within the well structure, urge the lower section 31 of the valve cage 25 into tight sealing engagement with the pump shoe 14.

It is to be understood that the particular pump shoe 14 and the exterior configuration of the valve cage 25 can vary widely in form and construction and that the particular construction and relationship of parts shown in the drawings and described above, is only illustrative of one carrying out of the present invention.

The upper section 30 of the valve cage 25 is a substantially cylindrical member extending between and fixed to the lower end of the pump barrel and the top of the lower section 31 of the cage. The section 30 is shown as having a longitudinally disposed transfer passage 41 extending therethrough and establishing open communication between the intake chamber in the lower section of the cage and the interior of the bottom section 22 of the pump barrel 20, below the piston 27 therein. The said upper section 30 of the pump cage is shown as further including a pair of longitudinally disposed outlet valve chambers 42, inlet ports 43 establishing open communication between the outlet chambers 42 and the intake valve chamber 33 in the lower section and the outlet valve chamber 42, outlet ports 44 establishing open communication with the outlet valve chambers and the annulus 45 occurring between the pump A and the tubing 13, above the pump shoe 14, and ball checks or spherical valve members 46 in the outlet chambers and operable to prevent the fluid in the said annulus 45 to flow downwardly through the outlet valve chambers and into the pump construction.

In practice, and as illustrated in the drawings, the outlet valve chambers 42 are established by longitudinally disposed bores entering the upper end of said section 30 of the cage and closed at their upper ends by means of suitable plugs 47. The bores terminate at flat bottoms and are provided with annular seats 48 adapted to co-operatively receive the valve members 46. The inlet

ports are simple bores of reduced diameter concentric with the seats 48 and continuing downwardly from the bottom of the bores establishing the chambers 42 and establishing open communication with the intake valve chamber 33 in the lower section 31 of the cage. The outlet ports 44 are simple lateral openings established in the side wall of the upper section 30 of the valve cage and establish open communication with the outlet valve chambers 42 at points engaged above the seats 48 therein.

In practice, the various connected elements and parts of the well pump construction A that I provide can be made up or secured together by welding, as illustrated, or can, if desired, be suitably threaded together, without in any way effecting the novelty of the present invention.

It will be apparent from the above, that when the pump A that I provide is engaged in the well structure W in the manner illustrated in the drawings, and the pistons 26 and 27 and the barrel 20 are urged downwardly therein against the resistance of the spring 29 and by means of the apparatus B in a manner that will hereinafter be described, the fluid within the lower or bottom section 22 of the barrel will be forced downwardly through the transfer passage 41 of the valve cage, into the intake valve chamber 33 in the lower section of the valve cage, then upwardly through the inlet ports 43 past the valve members 46 and into the outlet valve chambers 42, and then outwardly through the outlet ports 48 and into and up the annulus 45. When the piston 27 reaches the bottom of the lower section 22 of the barrel and displaces all of the fluid therein, the apparatus B is actuated to allow the spring 29 to urge the pistons 26 and 27 upwardly in the barrel 20. When this takes place, the valve elements 46 in the outlet valve chambers seat, preventing the fluid in the annulus 45 from returning or flowing back into the pump. When the lower or bottom piston shifts upwardly, it draws oil or well fluid occurring in the well, about and below the tubing 13, upwardly through the flow passage 32 past the valve member 36 and into the valve chamber 33. The fluid is then drawn from the valve chamber 33 upwardly, through the transfer passage 41 and into the lower or bottom section 22 of the barrel, thereby recharging the pump and preparing it for discharge again and in the manner set forth above.

The fluid supply and control apparatus B at the top of the well structure W and adapted to operate the pump A is shown as including generally, a reservoir R adapted to carry a column of operating fluid, a pressure pump P adapted to draw fluid from the reservoir, a delivery line C extending into the well structure W and connected with the pump A, a control means D between the pump P and the delivery line L and operable to control the flow of fluid to and from the well pump A. The apparatus B that I provide further includes, an operating means E related to and operating the control means D and timing means F related to and controlling the operating means E.

The reservoir R can be of any desired form and construction and in the particular case illustrated, it is a simple metal box-like unit having top, bottom and side walls 50, 51 and 52.

The pressure pump P is a suitable high pressure positive displacement pump and is shown mounted on the top wall 50 of the reservoir R. The pump P is shown as being driven by a suitable prime mover 53. The prime mover 53 is, in the preferred carrying out of the invention, an electric motor and is fixed to or mounted on the top wall of the reservoir adjacent the pressure pump P.

The pressure pump P is shown as having an inlet fitting 54 and an outlet fitting 55. A suitable intake pipe 56 is connected with the inlet fitting 54 of the pump and depends therefrom through the top wall 50 of the reservoir R and terminates adjacent the bottom wall 51 thereof, where it is provided with a suitable filter 57. A supply 58 is connected with the outlet fitting 55 of the pres-

sure pump P and is connected with the control means D as will hereinafter be described.

The delivery pipe C is made up of a plurality of stands or pipe and has an upper section 59 extending from the control means D to the fitting 14 on the well head 12, and a lower vertically disposed section 60 which depends from the fitting 14 through the string of production tubing and connects with the head 24 of the well pump A, as at 61, and establishes open communication with the upper section 21 of the pump barrel 20, above the upper piston 26 therein.

The control means D is shown as involving a control valve 62 having an inlet port 63 connected to and communicating with the supply pipe 58, a delivery port 54 connected to and communicating with the delivery pipe C, and exhaust port 65 connected with an exhaust pipe 66 which extends to the interior of the reservoir R, and a by-pass port 67 connected with a by-pass pipe 58 which extends to the interior of the reservoir R. The control valve 62 is further provided with a shiftable valve element 69 which is normally positioned in the lower end of the valve and allows for free flow of fluid from the supply pipe 58 through the valve and into the delivery pipe C. The element 69 is shiftable vertically in the valve to allow for free flow of fluid from the supply pipe 58 through the valve and into the by-pass pipe 68 and for free flow from the delivery pipe C through the valve and into the exhaust pipe 66.

With the above relationship of parts, it will be apparent that when the pressure pump P is in operation and the control valve 62 of the means D is in its normal position, fluid is pumped down through the delivery pipe C into the upper section 21 of the well pump barrel, thereby urging the pistons 26 and 27 of the well pump downwardly against the resistance of the spring 29 and in such a manner as to exhaust the charge of well fluid from the lower barrel section of the well pump into and up the annulus 25 in the well structure. It will also be apparent that when the pistons 26 and 27 are fully actuated or in their down position and the well pump A is fully exhausted, the control valve 62 can be unactuated whereupon the fluid issuing from the pump flows through the by-pass pipe 68 and directly into the reservoir R, and the fluid in the upper barrel section 21 of the well pump A and in the delivery pipe C is urged back through the control valve 62 by the piston 26 and the spring 29 of the well pump, through the exhaust pipe 66 and to the reservoir R.

In the case illustrated, the control valve 62 of the means D includes a vertically disposed cylindrical body having closed upper and lower ends. The shiftable valve member 60 therein is in the nature of a spool. When the valve is in its normal position, the spool is positioned in the lower end of the body, as clearly illustrated in Fig. 4 of the drawings. When the valve is in its actuated position, the valve member 69 is positioned in the upper end of the body, as clearly illustrated in Fig. 5 of the drawings.

The operating means E related to and operating the control means D is shown as including an operating valve 70 and a pressure-responsive actuating valve 71. The operating valve 70 is an elongate spool-like valve having closed ends and having inlet, delivery and exhaust ports, 72, 73 and 74, spaced intermediate its ends. The inlet port 72 is connected with the supply pipe 58 by means of an inlet line 75 which extends therebetween. The delivery port 73 is connected with the lower end of the control valve 62 by means of a delivery line 70 which extends therebetween. The exhaust port 74 is connected with an exhaust line 77 which extends from the operating valve to the reservoir R. The valve 70 has a longitudinally shiftable spool-type valve element 78 engaged therein. The valve member 78 has a normal position in the structure where communication between the inlet port 72 and delivery port 73 is shut off and where open communication is established between the delivery port and

the exhaust port 74, as clearly illustrated in Fig. 4 of the drawings. The valve member 78 has a second or actuated position where communication is established between the inlet port 72 and the delivery port 71, and where communication between the delivery port 73 and the exhaust port 74 is shut off, as clearly illustrated in Fig. 5 of the drawings.

With the above relationship of parts, it will be apparent that when the operating valve 70 is in its normal unactuated position, any fluid in the lower end valve 62, below the valve element 69 therein, is free to flow outwardly therefrom, through the valve 70 and into the reservoir R, thereby allowing the valve member 69 of the control valve 62 to remain in its lower unactuated position, or allowing the said valve member 69 to shift downwardly by gravity to its unactuated position. It will be further apparent that when the operating valve 70 is actuated, fluid under pressure from the supply pipe 58 is conducted into the lower end of the control valve 62, thereby shifting the valve member 69 thereof upwardly to its unactuated position and allowing the fluid in the delivery pipe C to flow back into the reservoir R.

The actuating valve 71 of the operating means E is a pressure relief valve connected with the delivery pipe C, downstream from the control valve 62, by means of a nipple 80, or the like. A pressure line 81 extends from the actuating valve 71 to a pressure port 82 in the operating valve 70 to establish open communication therewith. The pressure port 82 in the valve 70 is located in the valve to communicate with the interior thereof at one end of the valve element therein so that when fluid is introduced into the valve, the valve element 78 is shifted from its normal position to its actuated position. The actuating valve 71 controls the flow of fluid from the delivery line to the operating valve and opens in response to the fluid pressure in the delivery pipe C and the resistance of the spring 29 in the well pump A.

With the above relationship of parts, it will be apparent that when the pressure in the delivery pipe C reaches a predetermined point and the spring 29 in the well pump A is compressed to a predetermined extent, the actuating valve 71 opens, with resulting actuation of the operating valve 70 and the control valve 62, thereby shutting off flow into the delivery pipe from the pressure pump P and allowing the spring 29 of the well pump A to extend and urge the pistons 26 and 27 thereof upwardly, thereby drawing a new charge of production fluid into the well pump.

In the preferred carrying out of the invention, the actuating valve 71 is adjustable so that the pressure with which it opens, can be varied. It will be apparent that by suitably adjusting the valve 71, the downward stroke of the well pump A can be advantageously varied, as circumstances require.

The timing means F related to and controlling the operating means E is shown as including a spool-type timer valve 85 having an elongate cylindrical body 86 closed at its opposite ends, a longitudinally shiftable valve element 87 within the body and a suitable spring 88 within the body and normally yielding urging the valve element 87 to an unactuated position therein. The timing valve 85 has inlet and delivery ports 89 and 90 intermediate its ends and a pressure port 91 at one end thereof. When the valve element 87 is in its unactuated position, communication between the inlet and delivery ports 89 and 90 is established and when it is actuated, communication between these ports is shut off. The inlet port 89 is connected to and establishes open communication with the by-pass pipe 68 by means of a suitable inlet duct 92, which extends therebetween. The delivery port 90 is connected with and establishes open communication with the operating valve 70 of the means E by means of a suitable delivery duct 93 which extends therebetween. The delivery duct 92 is engaged in a pressure port 94 provided in the operating valve 70, which port

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is positioned to introduce fluid into the valve element 78 thereof from its actuated position to its unactuated position and to exhaust any fluid from the operating valve 62 when it is actuated. The pressure port 91 is connected to and establishes open communication with the exhaust pipe 66 by means of a pressure duct 95 which extends therebetween. The pressure port 91 and the duct 95 are adapted to allow for the free introduction of fluid into the timing valve 85 in a manner to shift the valve element 89 therein downwardly or against the resistance of the spring 88, and into its actuated position. The timing valve is actuated in the manner set forth above, after the control valve D has been actuated and fluid in the delivery pipe C is free to flow outwardly through the exhaust pipe 66 and under the pressure of the well pump spring 29.

In addition to the above, the timing means F further includes a suitable flow control valve 96 in the exhaust pipe 66, downstream from the pressure duct 95. The flow control valve 96 can be in the nature of an adjustable needle valve, as indicated, and is adapted to control the rate at which the operating fluid can flow from the delivery pipe C, out through the exhaust pipe 66. It will be apparent from the above, that the flow control valve 96 controls the rate at which the well pump A returns to its unactuated position and that rate at which it draws in a new charge of well fluid.

With the above relationship of parts, it will be apparent that when the operating valve 70 is actuated and the control means D is actuated to exhaust the delivery pipe C and allow the well pump A to return to its normal position, the timing valve 85 is actuated by the exhaust fluid and closes communication between the by-pass pipe 68 and the operating valve 62. When the pressure of the exhaust fluid drops to a predetermined point and the spring 29 in the well pump A has expanded and has raised the pistons 26 and 27 of the well pump to a predetermined extent, the timing valve 85 re-establishes open communication between the by-pass port 68 and the operating valve 70, thereby shifting the operating valve to its unactuated position and allowing the control valve 62 of the means D to return to its unactuated position and thereby re-establish open communication between the pressure pump P and the delivery pipe C and causing the well pump A to discharge again.

After the operating and control valves 70 and 62 have been actuated and before the timing valve returns the operating valve to its unactuated position, the actuating valve 71 closes. To exhaust the fluid introduced into the operating valve through the pressure line 61 extending from the actuating valve 70, when the operating valve is returned to its unactuated position, I provide a bleed line 97 having a check valve 98 therein and connected between the pressure line 61 and the delivery pipe C.

When the operating valve 70 is actuated, any fluid that had been introduced therein, through the delivery duct and the timing valve 85, is exhausted therefrom, through the said delivery duct and timing valve before the control valve is fully actuated and before the timing valve has been actuated.

In practice, and to assure sufficient pressure in the by-pass pipe 68 to operate the operating valve 70, I provide a suitable orifice or flow beam fitting 99 in the by-pass pipe 68, downstream of the point where the inlet duct 92 communicates therewith.

In the preferred carrying out of the invention, the spring loaded timing valve 85 is adjustable so that the pressure at which it opens can be varied. Since the pressure in the exhaust pipe 66 is directly related to the spring 29 in the well pump A, and varies in direct proportion with the extent to which the said spring 29 is compressed, it will be apparent that by suitably adjusting the timing valve, the upward travel or upstroke of the pistons 26 and 27 of the well pump A can be varied as desired.

From the foregoing, it will be apparent that by suit-

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ably adjusting and controlling the extent of the downstroke and the upstroke of the well pump A by means of the actuating valve 71 and the timing valve 85, and by controlling the time or rate of the upstroke of the well pump A by means of the flow control valve 96 in the exhaust pipe 66, complete control of the operation of the well pump A and resulting control of the production of the well to which the apparatus of the present invention is related, can be obtained, all without the necessity of pulling the pump or rebuilding, modifying or otherwise working on the operating apparatus therefor.

It is to be understood that the several valves illustrated throughout the drawings, and described above, are only illustrative of one preferred type of valve construction that could be advantageously employed in the apparatus that I provide. It is recognized that other especially constructed valves or specially assembled valving mechanisms could be employed.

It will be further apparent that the apparatus that I provide is simple, practical, highly effective and dependable, and that once it is put into operation and suitably adjusted for the particular well to which it is related, it will continue to operate as desired and in such a manner as little or no maintenance is required.

In practice, and in accordance with the broader principles of the present invention, the operating means E and timing means F for the control means D can vary widely in form and construction. If desired, the operating means E could be a suitable mechanically operating means, rather than a hydraulic means as illustrated and the timing means F, likewise, could be a mechanical mechanism rather than a hydraulic means, without departing from the broader aspects of the present invention.

Having described only a typical preferred form and application of my invention, I do not wish to be limited or restricted to the specific details herein set forth, but wish to reserve to myself any variations or modifications that may appear to those skilled in the art and fall within the scope of the following claims.

Having described my invention, I claim:

1. A well pumping apparatus of the character referred to including, a string of production tubing extending into a well, a well pump having an elongate vertically disposed barrel and a valve cage at the lower end thereof and sealed with the tubing, said cage having an inlet valve communicating with the well and allowing for flow of well fluid into the pump only, and an outlet valve communicating with the interior of the tubing and allowing for flow of well fluid from the pump only, a piston slidably engaged in the barrel, a spring in the barrel and normally yieldingly urging the piston upwardly therein to draw well fluid into the barrel through the inlet valve, a fluid delivery pipe extending through the tubing and communicating with the well pump barrel above the piston therein, a pressure pump at the top of the well, and flow controlling means including a flow directing valve between the pressure pump and the fluid delivery pipe and operable to intermittently direct fluid from the pressure pump downwardly through the fluid delivery pipe to urge the piston downwardly in the well pump barrel and force the well fluid in the barrel outwardly through the outlet valve and up the tubing, an exhaust pipe connected with said directional valve to conduct fluid therefrom when said valve is actuated to allow the well pump to exhaust, a flow control valve in the exhaust pipe and operable to control the rate of the upstroke of the well pump, an operating means related to the directional valve to shift said valve to and from its actuated position and responsive to the fluid pressure in the delivery and exhaust pipes.

2. A well pumping apparatus of the character referred to including, a string of production tubing extending into a well, a well pump having an elongate vertically disposed barrel and a valve cage at the lower end thereof and engaged in the tubing and sealing therewith at the lower

end thereof, said cage having an inlet check valve communicating with the well and an outlet check valve communicating with the interior of the tubing, a piston slidably engaged in the barrel, a spring in the barrel and normally urging the piston upwardly therein to draw well fluid into the barrel from the well and through the inlet valve, and operating apparatus adapted to intermittently urge the piston downwardly in the barrel against the spring to force the well fluid therein out through the outlet valve and up the tubing and including, a pressure pump at the top of the well, a supply pipe extending from the pressure pump, a delivery pipe connected with the barrel of the well pump above the piston therein and extending to the top of the well and a control valve between the supply pipe and the delivery pipe and adapted to normally establish open communication therebetween and direct operating fluid down through the delivery pipe and operable to shut off communication between the supply pipe and the delivery pipe and allow for free flow of operating fluid up through and out of the delivery pipe.

3. A well pumping apparatus of the character referred to including, a string of production tubing extending into a well, a pump having an elongate vertically disposed barrel and a valve cage at the lower end thereof and engaged in the tubing to seal therewith at the lower end thereof, said cage having an inlet valve communicating with the well and an outlet valve communicating with the interior of the tubing, a piston slidably engaged in the barrel, a spring in the barrel and normally urging the piston upwardly therein to draw well fluid into the barrel from the well and through the inlet valve, and operating apparatus adapted to intermittently urge the piston downwardly in the barrel to force the well fluid therein out through the outlet valve and up the tubing and including, a reservoir at the top of the well to carry a body of operating fluid, a pressure pump related to the reservoir and having a supply pipe extending therefrom, a delivery pipe connected with the barrel of the well pump above the piston therein and extending to the top of the well, a control valve between the supply pipe and the delivery pipe and adapted to normally establish open communication therebetween and direct operating fluid down through the delivery pipe and operable to shut off communication between the supply pipe and the delivery pipe and allow for free flow of operating fluid up through and out of the delivery pipe, operating means related to the control valve and adapted to shift the control valve from one position to the other, and timing means related to the operating means to intermittently operate the operating means.

4. A well pumping apparatus as set forth in claim 3 in which, said control valve has an inlet port connected with the supply pipe, an outlet port connected with the delivery pipe, a by-pass port connected with a by-pass pipe extending to the reservoir, an exhaust port connected with an exhaust pipe extending to the reservoir and a shiftable valve element controlling the flow of fluid through the ports, said valve element having a normal position where open communication is established between the inlet port and the outlet ports and the supply and delivery pipes connected therewith and having an actuated position where open communication is established between the inlet port and the exhaust port and the supply and by-pass pipes connected therewith and where open communication is established between the outlet and exhaust ports and outlet and exhaust pipes connected therewith.

5. A well pumping apparatus as set forth in claim 3 in which, said operating means is responsive to the pressure in the delivery pipe and includes a pressure release valve connected with the delivery pipe, and a pressure line extending from the pressure release valve to said means and adapted to conduct fluid to and to actuate

the said means when the pressure in the delivery pipe reaches a predetermined amount.

6. A well pumping apparatus as set forth in claim 3 in which, said control valve has an inlet port connected with the supply pipe, an outlet port connected with the delivery pipe, a by-pass port connected with a by-pass pipe extending to the reservoir, an exhaust port connected with an exhaust pipe extending to the reservoir and a shiftable valve element controlling the flow of fluid through the ports, said valve element is established between the inlet and outlet ports and the supply and delivery pipes connected therewith and having an actuated position where open communication is established between the inlet port and the exhaust port and the supply and by-pass pipes connected therewith and where open communication is established between the outlet and exhaust ports and the outlet and exhaust pipes connected therewith, said operating means being responsive to the pressure in the delivery pipe and including a pressure release valve connected with the delivery pipe, and a pressure line extending from the pressure release valve to said operating means and adapted to conduct fluid to and to actuate said means when the pressure in the delivery pipe reaches a predetermined amount.

7. A well pumping apparatus as set forth in claim 6 in which, said timing means is adapted to return the operating means to its unactuated position and to permit the control valve to return to its unactuated position and includes a hydraulically actuated valve, a delivery duct from said valve to the said operating means, an inlet duct from said valve to the by-pass pipe, a spring loaded valve element in the valve and normally establishing open communication between the inlet and delivery ducts, and a pressure duct between said valve and the exhaust pipe and adapted to conduct fluid into the valve to shift the valve element thereof to shut off flow between the inlet and delivery ducts, after the control valve is open and until the pressure in the delivery duct drops to a predetermined amount.

8. A well pumping apparatus of the character referred to including, a string of production tubing extending into a well, a reciprocating well pump at the bottom of the tubing and sealed therewith, a delivery pipe extending from the well pump to the top of the tubing and adapted to carry a column of operating fluid, means at the top of the well to intermittently and alternately urge the column of operating fluid downwardly through the delivery pipe and allow the fluid to move freely upwardly through the delivery pipe, the well pump including, an elongate vertically disposed barrel having top and bottom sections, a partition between and connecting the sections, a head at the upper end of the top section and connected with the delivery pipe, a valve cage at the lower end of the bottom sections and establishing sealing engagement with the tubing, upper and lower pistons in the top and bottom sections of the barrel and connected by a tie rod extending freely through the partition and a compression spring between the upper piston and the partition and normally yieldingly urging the pistons upwardly to draw well fluid into the bottom section of the barrel and to urge the column of operating fluid upwardly through the delivery pipe, said valve cage having an inlet passage communicating with the well, a check valve in the passage and allowing for free flow of well fluid into the pump, an outlet port communicating with the interior of the tubing, and an outlet valve related to the port and allowing for the flow of fluid from the pump through the outlet port.

9. A well pumping apparatus of the character referred to including, a string of production tubing extending into a well, a reciprocating well pump at the bottom of the tubing and sealed therewith, a delivery pipe extending from the well pump to the top of the tubing and adapted to carry a column of operating fluid, control means at the top of the well to intermittently and alternately urge the column of operating fluid downwardly through the

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delivery pipe and allow the fluid to move freely upwardly through the delivery pipe, the well pump including, an elongate vertically disposed barrel having top and bottom sections, a partition between and connecting the sections, a head at the upper end of the top section and connected with the delivery pipe, a valve cage at the lower end of the bottom sections and establishing sealing engagement with the tubing, upper and lower pistons in the top and bottom sections of the barrel and connected by a tie rod extending freely through the partition and a compression spring between the upper piston and the partition and normally yieldingly urging the pistons upwardly to draw well fluid into the bottom section of the barrel and to urge the column of operating fluid upwardly through the delivery pipe, said valve cage having an inlet valve passage communicating with the well, a check valve in the passage and allowing for free flow of well fluid into the pump, an outlet port communicating with the interior of the tubing, and an outlet valve related to the port and allowing for the flow of fluid from the pump through the outlet port, said control means including, a reservoir, a pressure pump communicating with the reservoir, a control valve having an inlet port connected with the supply pipe extending from the pressure port, an outlet port connected with the delivery pipe, an exhaust port connected with an exhaust pipe communicating with the reservoir, a by-pass port connected with a by-pass pipe connected with the reservoir, a vertically shiftable valve element in the valve and normally establishing open communication between the inlet and outlet ports, and operable to establish open communication between the inlet and by-pass ports and between the outlet and exhaust ports, a port in the bottom of the valve to pass actuating fluid into and out of the valve below the element to shift it to and from its normal position, operating means adapted to conduct actuating fluid into and out of the control valve and responsive to fluid pressure in the delivery pipe and including a horizontally disposed operating valve having an inlet port connected with the supply pipe by an inlet line, a delivery port connected with the port in the bottom of the control

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valve by a delivery line, an exhaust port connected with the reservoir by an exhaust line, a shiftable valve element in the operating valve and normally establishing open communication between the delivery and exhaust ports and operable to establish open communication between the inlet and delivery ports, the operating means further includes a pressure port at one end of the valve to conduct fluid into the valve to shift the element to its actuated position, a pressure line extending from the pressure port to the delivery pipe, an adjustable pressure responsive valve in the pressure line and adapted to open when the pressure in the delivery line reaches a predetermined amount and a port at the other end of the operating valve adapted to conduct operating fluid into the operating valve to shift the element to its unactuated position, fluid actuating timing means adapted to conduct actuating fluid into and out of the operating valve through said port in the other end thereof and to shift the operating valve to its unactuated position and including a vertically disposed adjustable timing valve having a port in its upper end and connected with the exhaust pipe by a pressure duct, an inlet port connected with the by-pass pipe by an inlet duct, a delivery port connected with the operating valve by a delivery duct, and a spring loaded valve element normally establishing open communication between the inlet and delivery ports and adapted to be shifted downwardly by the introduction of fluid from the exhaust pipe through the pressure port and to a position where communication between the inlet and delivery ports is shut off, and an adjustable flow control valve in the exhaust pipe downstream from the pressure duct to control the rate of operating fluid outwardly therethrough.

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