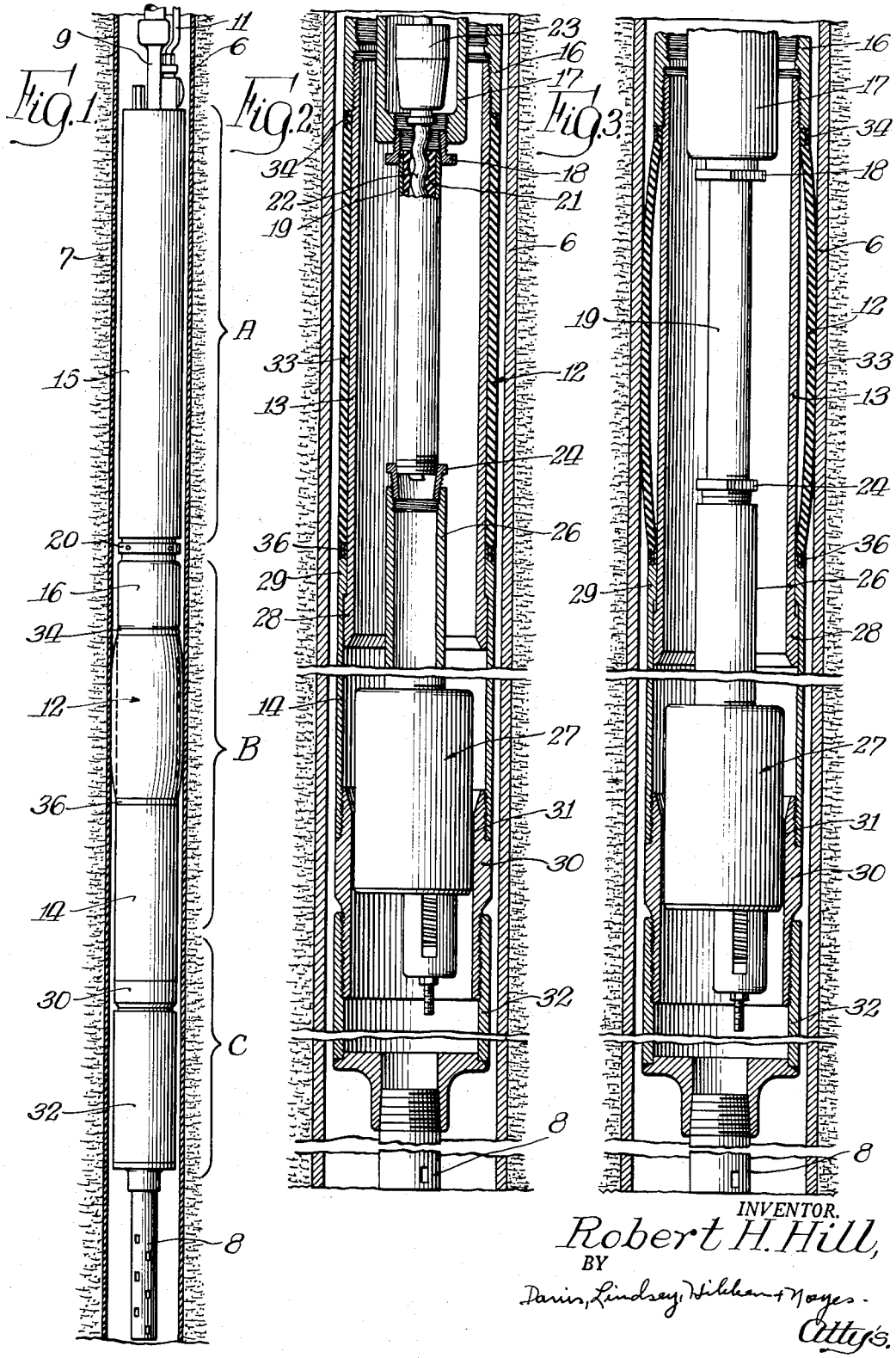
June 12, 1956 R. H. HILL 2,749,992

PUMPING APPARATUS

Filed Sept. 20, 1951 2 Sheets-Sheet 1




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Fig. 4.

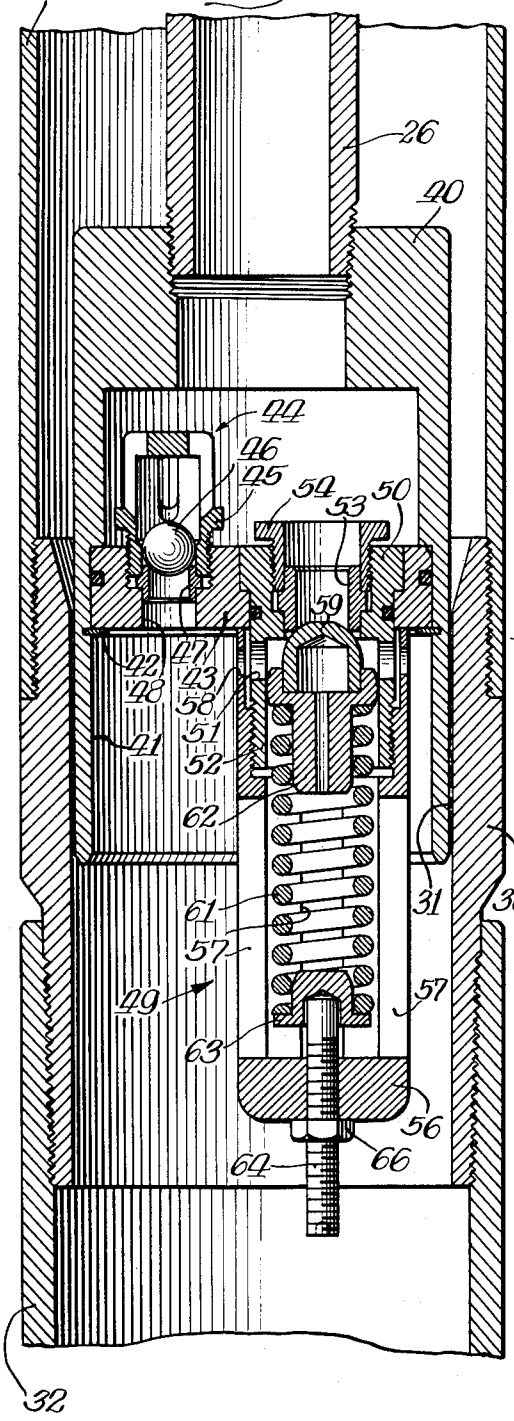
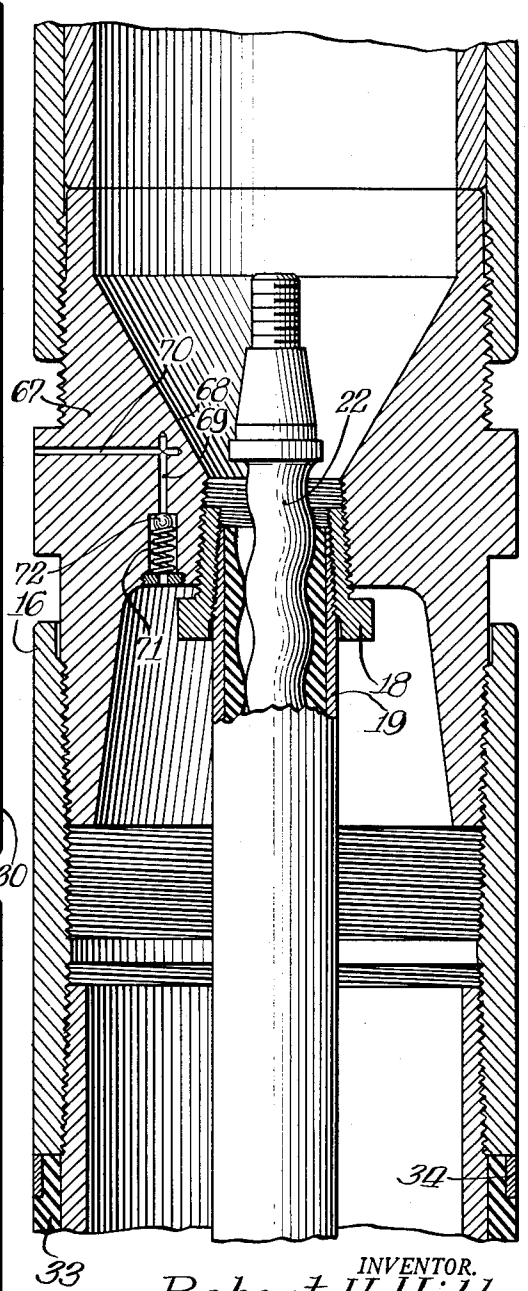



Fig. 5.




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# PUMPING APPARATUS

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5 Claims. (Cl. 166—106)

This invention relates generally to pumping apparatus and more particularly to a novel arrangement of reversible pumping apparatus and valve means for use in oil wells or the like.

It is a frequent occurrence in oil wells, particularly in oil wells of the low pressure type where it is necessary to remove the oil by pumping the same out of the well through suitable tubing, that the sand strata or other producing formations at the bottom of the well eventually become clogged or obstructed to such an extent that the yield from the well becomes too low to warrant further operation of the well. In some cases the well is abandoned, but in many instances an attempt is made to clean the well by forcing water, acid, or other suitable purging material into the producing formation whereby to remove the obstructions in the formation and restore the flow of oil to a profitable level. In some cases the purging fluid may even contain added solid material for the purpose of further expanding and enlarging the producing formation. Heretofore, in cleaning an oil well it has been necessary to remove the production tubing from the well together with the usual reciprocating pump and sucker rod in order to permit the insertion of a temporary pipe into the well casing for injecting the cleaning fluid into the well. Upon completion of the cleaning operation, the temporary pipe had to be removed and the reciprocating pump with its sucker rod and tubing reinstalled before the production of oil could be resumed. Obviously, this manner of cleaning an oil well is cumbersome and time consuming and involves substantial expense. In fact, in many cases where the production of the well at best is small, it is questionable whether the expense of cleaning the well is warranted.

However, it has been found that by means of a novel reversible pumping arrangement, hereinafter described in detail, it is possible to effect alternate or intermittent periods of production and pressurizing or purging of the well in a very convenient and reliable manner and at relatively low cost. In general, this apparatus comprises the combination of a reversible rotary pump and a reversible electric motor connected closely adjacent the pump so that the entire apparatus may be positioned adjacent the bottom of the well. When the production of the well diminishes to an undesirably low level, the operation of the apparatus can be reversed to pump oil or other suitable purging fluid downwardly and under pressure through the production tubing into the well whereby to purge or otherwise remove obstructions from the production strata and the fluid intake of the apparatus. A suitable packer is provided in the well casing for confining the fluid pressure to the lower portion of the well during the pressurizing periods.

A pumping apparatus of this character offers a number of important advantages over the previous oil well cleaning techinques. Perhaps the most important advantage is the fact that the apparatus is adapted for more or less permanent installation in an oil well in the sense that it is unnecessary to remove the apparatus or the



production tubing in order to effect pressurizing or cleaning of the well.

The present invention is particularly concerned with a novel valve arrangement for use in a reversible oil well pumping apparatus of the character described above. Oil well pumps of the reciprocating type are normally provided with a foot valve or check valve adjacent the intake to the pump in order to prevent loss of the head of oil in the pump and production tubing both during operation of the pump and during a period when the pump is stopped for any reason. However, it will be understood that such a unidirectional check valve adjacent the pump intake will not suffice in the case of a reversible pumping arrangement wherein it is desired to pump oil or other fluid in a reverse manner into the well at certain times. Additional oppositely acting valve means must also be provided so that oil can be pumped in either direction through the pump intake during alternate periods of production and pressurizing of the well.

Accordingly, a primary object of my invention is to provide novel reversible pumping apparatus for a well by means of which fluid may alternately be pumped out of the well and returned to the well under pressure.

Another object of the invention is to provide a novel combination of a reversible pumping apparatus and valve means for permitting alternate production and pressurizing of an oil well or the like.

A more specific object of the invention is to provide novel valve means for use with a reversible oil well pumping apparatus whereby to permit alternate removal of oil and introduction of fluid under pressure without loss of fluid head at any time.

A further object of the invention is to provide novel means in a reversible oil well pumping apparatus for preventing the formation of a vacuum at the bottom of 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 an elevational view on a reduced scale of a complete oil well pumping apparatus embodying the features of my invention and showing the apparatus in position in a well casing;

Fig. 2 is a fragmentary vertical sectional view on an enlarged scale of a portion of the apparatus illustrated in Fig. 1 and showing the relative positions of parts of the device when being inserted in the well casing;

Fig. 3 is a view similar to Fig. 2 but showing the final position of the device after installation in the well casing;

Fig. 4 is an enlarged sectional view showing one embodiment of the valve means constituting the prinicpal feature of my invention; and

Fig. 5 is a fragmentary vertical sectional view showing a modification of one portion of the apparatus.

Referring first to Fig. 1, the fragmentary lower portion of an oil well casing 6 is shown and the surrounding earth formation is indicated diagrammatically at 7. It will be understood that the casing 6 extends in the usual manner from the ground level to the bottom of the well although neither of the extreme ends of the casing are illustrated in the drawing. A pumping apparatus is shown in position in the well casing and comprises generally a reversible motor section A, a reversible pump section B, and a valve section C connected in end-to-end relation for fluid flow therebetween. An intake 8 comprising a length of perforated or slotted pipe is provided at the bottom of the pumping apparatus, and an outlet pipe 9 extends upwardly from the top of the pumping apparatus through the well casing to the ground level. Suitable electrical conductors comprising a cable 11 extend from the ground level downwardly through

the casing 6 to the motor section A for operating the latter.

During production, the reversible motor section A is operated so that the reversible pump section B draws oil from the bottom of the well casing through the inlet 8 and the valve section C and discharges the oil through suitable passageways in the motor section A to the outlet pipe 9 which is connected to a tank or other storage facilities at the ground level. When the producing formation and/or the intake 8 become clogged or obstructed to an objectionable degree, as indicated by a low volume of oil issuing from the well, the motor is reversed and the pump is thereby operated in reverse fashion so that oil or other suitable purging material is pumped downwardly through the pipe 9 and is discharged from the intake 8 under pressure. In order to insure that the oil or other material is forcibly injected into the adjacent producing formation at the bottom of the well, a portion of the pump section B is fitted with an expansible packer 12 of a type adapted to resist upward pressure, as hereinafter described in detail.

Referring now to Figs. 2 and 3, there is shown an enlarged view of the principal portions of the pump section B and the valve section C together with the packer 12.

The pump section B comprises a reversible pump of the positive displacement type in which there is an elongated rotary pumping member having driving connections with the motor of the device for operation in either a clockwise or counterclockwise direction. More particularly, the invention contemplates the use of the progressing cavity type pump known commercially as the Moyno pump and comprising an elongated female helical member which constitutes the stator of the pump and an elongated male helical member mounted in the female member and constituting the rotor of the pump. The outer member or stator is provided with one helical thread more than the inner member or rotor, and the two members are so arranged and shaped that every thread of the rotor is constantly in contact with the stator in any transverse section through the pump. This relation of the rotor and stator is such that a plurality of closed spaces or cavities are defined between the two members because of the difference in the number of threads on each member. When the rotor is rotated relative to the stator, the cavities or spaces between the members are displaced in a longitudinal direction with the result that a fluid material can be axially transported between the two members to obtain the desired pumping effect. Reference is made to U. S. Patents Nos. 1,892,217 and 2,028,407 for a detailed consideration of the theory and operation of the progressing cavity type of pump. A reversible pump of the progressing cavity type is particularly suitable for use in the pumping apparatus of the present invention because it is capable of generating very high pressures and because sand or other solids in the fluid being pumped do not cause undue wear or operating difficulties in a pump of this type.

The casing of the pump section B comprises a pair of telescoping tubular members 13 and 14, the upper tubular member 13 being connected to the lower end of the motor casing, designated at 15 in Fig. 1, by means of a threaded connector or collar 16 which is threadedly connected to a coupling member 20 (Fig. 1) which is in turn threadedly connected to the motor casing 15. An elongated cup-shaped pump support 17 is rigidly carried in the connecting structure, including the coupling 20, between the motor and pump casings and has threadedly secured in its bottom wall a bushing 18 which is in turn threadedly connected to a tubular conduit 19 comprising the outer portion of the pump stator. The interior of the tube 19 is provided with a helical lining 21, preferably of rubber, which constitutes the female helical member hereinbefore referred to. An elongated male helical member or rotor 22 is operatively disposed within the helical liner 21 of the pump stator for rotation in either direction. A driving connection in the form of a universal joint (not shown) extends between the lower end of the rotor shaft of the motor and the upper end of the helical rotor 22 in order to compensate for any misalignment between the rotating parts and for facilitating assembly and installation of the apparatus. A cup-shaped pivotally connected shaft adaptor 23 comprising part of this universal connection is shown in Fig. 2. The lower end of the stator tube 19 is threadedly connected by a bushing 24 to a nipple or conduit 26 which is in turn threaded at its lower end into the housing structure for the valve means, indicated generally at 27 and described in detail hereinafter.

The lower telescopic casing member 14 is supported from the upper tubular member 13 by means of a pair of coacting shoulder portions 28 and 29 (Fig. 2), and the member 14 is threadedly attached at its lower end to a coupling member 30 surrounding the valve means 27 with a slight annular clearance therebetween, as indicated at 31. An adaptor 32 is threaded to the coupling member 30 and has the intake pipe 8 connected thereto.

In the embodiment shown in the drawing, the packer 12 is of a conventional type comprising an axially compressible rubber sleeve 33 secured, as at 34, at its upper end around the upper telescopic casing member 13 adjacent the collar 16. The lower end of the rubber sleeve 33 is firmly attached, as at 36, to the upper end of lower telescopic casing member 14. As the pumping apparatus is lowered into place in the well casing, the telescopic members 13 and 14 are in extended relation with the shoulder portions 28 and 29 in abutment, as seen in Fig. 2, whereby the rubber sleeve 33 is retained in non-compressed close-fitting engagement with the exterior of the casing section 13. This initial non-compressed condition of the packer sleeve 33 is also shown in dotted lines in Fig. 1. A plurality of shear pins (not shown) serve to prevent telescoping movement of the casing sections 13 and 14 during insertion of the apparatus into the well. However, when the intake pipe 8 at the bottom of the pumping apparatus comes to rest against the bottom of the well, the weight of the apparaus against the upper casing section 13 causes the retaining pins to shear in a manner well known in the packer art. Upon shearing of the shear pins, the upper casing member 13 shifts downwardly to a limited extent relative to the casing member 14 whereby to effect compression and outward bulging of the rubber sleeve 33 into tight fitting sealed engagement with the inside of the well casing 6, as seen in Fig. 3 and in full lines in Fig. 1.

In this manner, it will be understood that the sleeve 33 effectively segregates the lower portion of the well so as to define a reservoir space between the packer and the bottom of the well. The rubber sleeve 33 comprising the packer 12 is disposed only around the upper portion of the pump casing so that the extension nipple 26 at the lower end of the pump extends below the packer into the reservoir space. Thus, when oil or other purging material is pumped downwardly into the well under pressure, the reservoir space is sealed at its upper end by the sleeve 33 and the oil is therefore readily forced under high pressure into the obstructed producing formation or strata for purging and cleaning the same. At the same time, the perforated or slotted intake 8 is also cleaned and flushed out.

When an oil well is equipped with a pumping apparatus as described above in connection with Fig. 1, free flowing conditions in the well may, if desired, be maintained by periodically reversing the flow of oil on a predetermined cycle so that the intake and the producing strata of the well are subjected to frequent back flow of oil for cleaning and flushing purposes. Such inter-

mittent operation may obviously be effected manually, but it is possible to utilize an automatic means such as a time controller device in the electrical circuit for the motor section A so that the well is automatically cleaned on a predetermined time schedule. Other control schemes may also be employed, for example, reversal of the motor for pressurizing of the well may be arranged to occur in response to a decrease in the pressure or flow rate of the effluent oil below a predetermined level.

Referring now to Fig. 4, the valve section C of the apparatus will be described in detail. The valve means 27 which is disposed between the intake pipe 8 and the pump inlet nipple 26 comprises an inverted cup-shaped valve housing 40 threadedly secured at the lower end of the nipple 26. Disposed transversely across the valve housing 40 and retained in a counter-bored portion 41 thereof by means of a retainer ring 42 is a valve mounting plate 43. In one portion of the plate 43 there is mounted an upstanding check valve or foot valve, indicated generally at 44, which comprises a slotted valve body 45 threaded in an opening in the plate 43, a movable ball check 46, and a valve seat member 47 retained in place in the plate 43 by engagement with the lower end of the valve body 45. During a production period when oil is being pumped out of the well, the ball check 46 is lifted upwardly by the effluent oil which passes through an aligned aperture 48 in the plate 43 and through the slotted portions of the valve body 45 and thence upwardly through the nipple 26 into the pump. During reverse flow or pressurizing of the well or during a period when the pump is stopped for any reason, the ball check 46 seats forcibly against the valve seat 47 to prevent downward flow through the check valve 44, as a result of reverse rotation or "motoring" of the pump, and thereby maintaining the fluid head in the pump and production tubing 9.

A depending adjustable pressure valve, indicated generally at 49, is likewise supported from the plate 43 adjacent the valve 44. This pressure valve 49 comprises a tubular valve body 50 extending downwardly through the plate 43 and seated therein, the valve body 50 being provided with a plurality of radial openings 51 and having a threaded lower end portion, as at 52. A valve seat 53 is retained in the valve body 50 by means of a lock nut 54 threaded into the upper end of the valve body 50 and engaging the seat member 53. Depending below the plate 43 is an elongated pressure valve cap 56 having a plurality of axial slots 57 and threadedly secured to the threaded portion 52 of the valve body 50. The valve cap 56 is provided with a plurality of radial apertures 58 adapted to be aligned with the apertures 51 in the valve body 50. A valve member 59 is disposed in coacting relation at the lower end of the annular valve seat 53 and is urged into normally seated relation therein by an adjustable helical spring 61. The upper end of the spring 61 engages a guide 62 having the valve member 59 seated therein, and the lower end of the spring 61 seats against a coacting spring guide member 63. An adjusting screw 64 having a lock nut 66 extends through the lower end of the cap 56 into engagement with the guide member 63 for regulating the tension or pressure of the spring 61. Inasmuch as the valve 49 and its adjusting screw 64 extend downwardly below the housing 40, it will be seen that the desired spring adjustment can be made without removal of the valve means 27 from the nipple 26.

During a production period when oil is being pumped upwardly out of the well, the spring 61 engaging the guide 62 under predetermined pressure as regulated by the adjusting screw 64 causes the valve member 59 to remain in closed position against the valve seat 53, and as previously described, the oil passes upwardly through the unidirectional check valve 44. During pressurizing or reverse flow, the check valve 44 remains closed but the outlet fluid pressure from the pump forces the valve member 59 to open position away from the seat 53 and against the action of the spring 61 whereby to permit oil or other pressurizing fluid to pass downwardly through the valve seat 53 and radially through the aligned apertures 51 and 58 and thence into the intake pipe 8. It will be understood that the spring 61 is adjusted so that the valve member 59 will remain closed under the static pressure of the head of oil or other fluid above the valve but will open at a predetermined excess pressure as applied by the pump during reverse flow.

It will thus be seen that the valve means of the apparatus comprises a dual check valve and pressure valve arrangement adapted for operation in opposite directions so that only one of the valves 44 and 49 is open during flow in a given direction. The check valve 44 opens automatically during a production period, and the spring 61 is set to retain the pressure valve 49 in closed position during this time in opposition to the static head pressure of the oil above the valve 49. When the well is being pressurized by reverse fluid flow, the check valve 44 is automatically retained in closed position by the pressure of the fluid thereabove and the pressure valve 49 is forced open at a predetermined pressure to permit injection of the pressurizing fluid into the reservoir space below the packer 12 and thence into the producing formation of the well. By adjustment of the tension of the spring 61 through the screw 64, the particular pressure at which the valve member 59 will open can be controlled, it being understood that this opening pressure is always in excess of the static head pressure above the valve so that the valve 49 opens only during reverse operation of the pump.

Because of the highly effective pumping action of the progressing cavity type pump, as herein described, it will sometimes be necessary to provide the pumping apparatus with a vacuum breaking arrangement in order to comply with statutory regulations in some States prohibiting the operation of a well under vacuum. In Fig. 5, I have shown a modification of the pump casing and support structure at the upper end of the pump which provides the necessary vacuum breaker arrangement. This modification differs from the form shown in Fig. 2 in that the pump stator tube 19 and its bushing 18 are threadedly secured in a threaded collar or connector 67 having an inwardly extending shoulder formation 68 into which the bushing 18 is threaded and through which the pump rotor 22 extends. The connection between the upper end of the pump rotor and the rotor shaft of the motor is not shown in Fig. 5. The connector member 67 is provided with a vertical bore 69 and a communicating horizontal bore 70 which extends radially through the connector 67 into the annular space between the apparatus and the well casing (not shown in Fig. 5). The lower portion of the bore 69 is enlarged, as at 71, and contains a spring pressed ball check valve 72. The outer end of the bore 70 is in flow communication through the well casing with the atmosphere at the ground level, and the connected bore 69 is in flow communication with the bottom of the well through the pump casing and the annular space 31 between the connector 30 and the valve housing 40. Accordingly, it will be seen that with such an arrangement it is impossible to impose a vacuum at the producing formation of the well during a production period. If oil is pumped out of the well to an extent approaching a vacuum condition at the bottom of the well, it will be seen that the check valve 72 will automatically admit air from the ground level to the bottom of the well whereby to avoid formation of a vacuum. It will be understood that the tension of the spring holding the ball check 72 is such that the valve will open at a desired predetermined subatmospheric pressure. In the event that, for any reason, fluid should collect in the annular space between the pumping apparatus and the well casing above the packer 33, it will be apparent that the valve 72 will open automatically when the head of

fluid builds up to a sufficient extent above the outlet of the bore 70 thereby permitting this fluid to drain to the bottom of the well.

Although the invention has been described in connection with certain specific structural embodiments, it will be understood that various modifications and equivalent structures may be resorted to without departing from the scope of the invention as defined in the appended claims.

I claim:

1. Pumping apparatus adapted to be inserted in the casing of an oil well for pumping oil out of the well and also for pumping fluid downwardly into the well under pressure, said apparatus comprising reversible pump means of the progressing cavity type having elongated helical rotor and stator members and adapted to extend downwardly in the well casing, and valve means connected to said pump means, said valve means including a check valve adapted to open to permit oil to be pumped upwardly out of the well but remaining closed when fluid is being pumped downwardly into the well, and a spring-pressed pressure valve adapted to remain closed under the static pressure of the fluid head thereabove and adapted to open at a predetermined excess pressure above said static pressure for permitting fluid to be pumped downwardly under pressure into the well but remaining closed when oil is being pumped upwardly out of the well.

2. The apparatus of claim 1 further characterized in that said spring-pressed pressure valve is adjustable for varying the predetermined excess pressure at which said pressure valve opens whereby said valve means is adapted for use in wells of different depths.

3. The structure of claim 1 further characterized in that said pumping apparatus also comprises a tubular pump casing adapted to extend downwardly in the well casing in spaced relation therefrom, expansible packer means mounted exteriorly of said pump casing and adapted to be expanded into sealing relation with the interior of the well casing when the apparatus is in operating position therein whereby to provide a reservoir space between said packer means and the bottom of the well, said pump means extending downwardly through said pump casing and below said packer means, supporting means secured to the upper end of said pump casing above said packer means for supporting the upper end of said pump means, and an automatic vacuum release valve provided in said supporting means above said packer means, said supporting means having a fluid passage therein connected to said vacuum release valve for venting air from the ground level and the space between said



pump casing and the well casing through said valve to the bottom of the well whereby to prevent the formation of a vacuum therein.

4. The structure of claim 3 further characterized in that said valve means is connected to the lower end of said pump means below said packer means for permitting fluid flow from the pump means downwardly under pressure into said reservoir space and for permitting pumping of oil upwardly out of the well, said pump means and said valve means being of lesser size than said pump casing to provide clearance therebetween, and said vacuum release valve communicates through said clearance with the bottom of the well to prevent the formation of a vacuum in the well when said pump means is pumping oil upwardly out of the well, said vacuum release valve being adapted to close when the pump means is pumping fluid downwardly.

5. Pumping apparatus adapted to be inserted in the casing of an oil well for pumping oil out of the well and also for pumping fluid downwardly into the well under pressure, said apparatus comprising reversible pump means of the progressing cavity type having elongated helical rotor and stator members and adapted to extend downwardly in the well casing, and valve means connected to said pump means, said valve means including a valve housing, a valve support extending transversely across said housing, a pair of oppositely acting valves mounted in said support, one of said valves comprising a check valve extending upwardly above said support within said housing for permitting unidirectional flow of oil upwardly and out of the well and the other of said valves comprising a normally closed spring-pressed pressure relief valve extending downwardly from said support for permitting unidirectional flow of fluid downwardly under pressure into the well, and adjusting means for regulating the opening pressure of said pressure relief valve and depending below said valve housing whereby to provide ready access thereto.

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