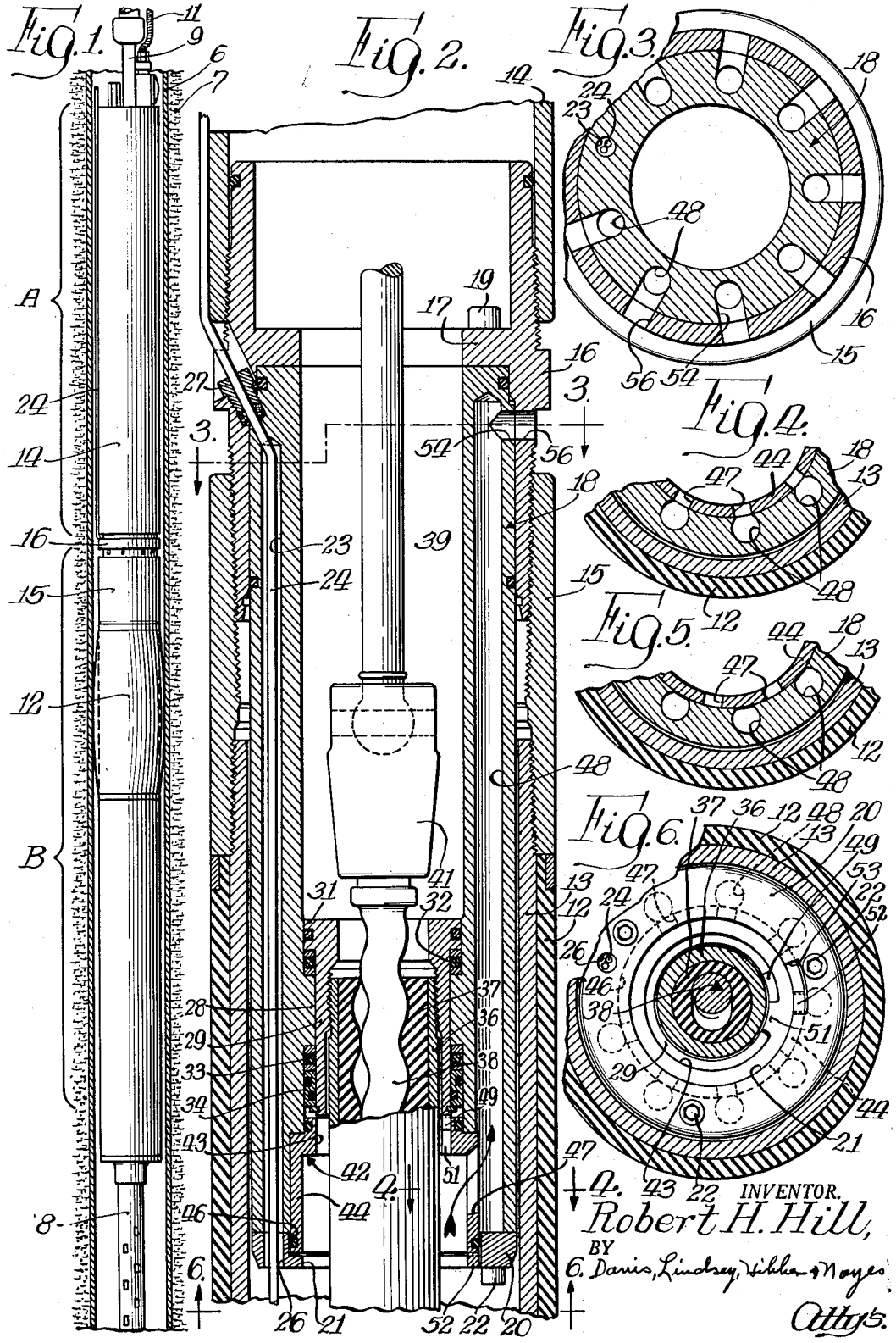
March 27, 1956 R. H. HILL 2,739,650

PUMPING APPARATUS

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PUMPING APPARATUS

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Fig. 7.

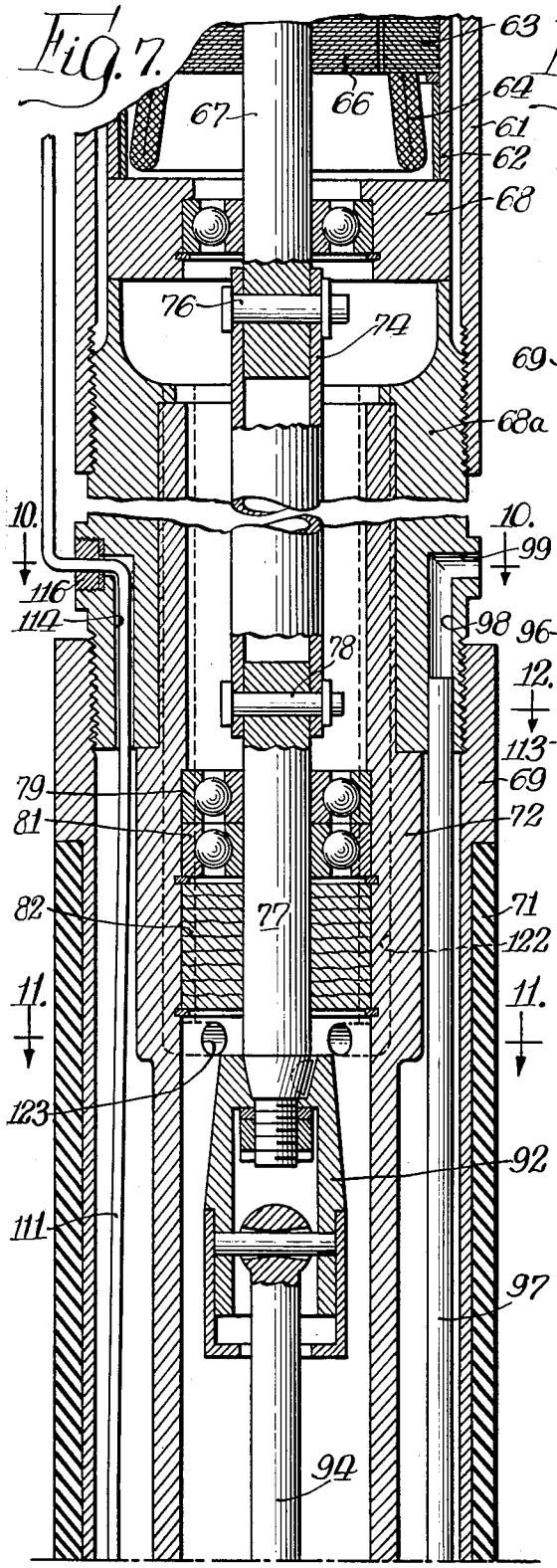
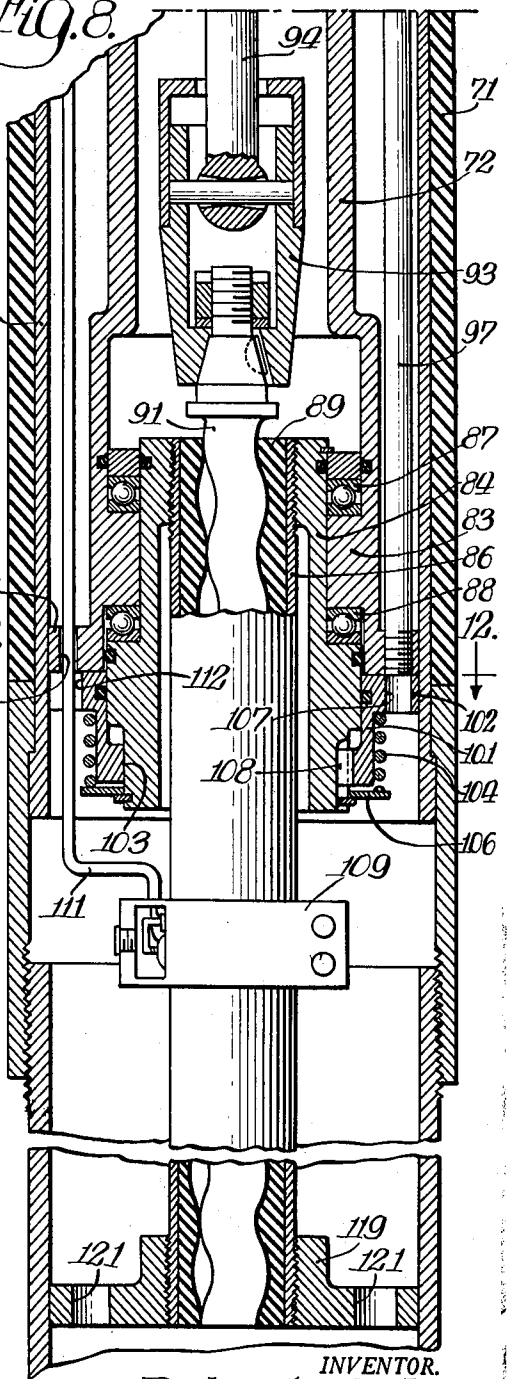


Fig. 8.



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PUMPING APPARATUS

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Fig. 9.

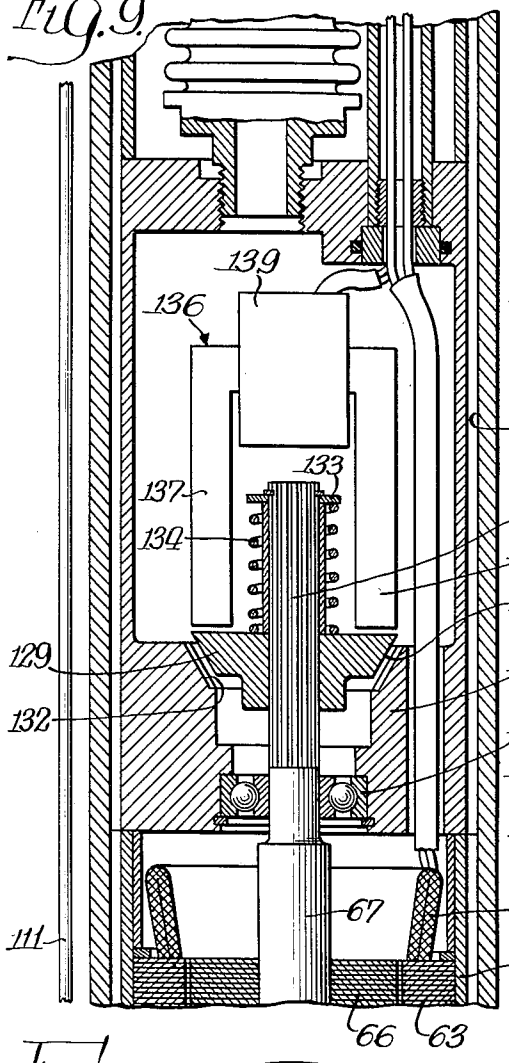


Fig. 11.

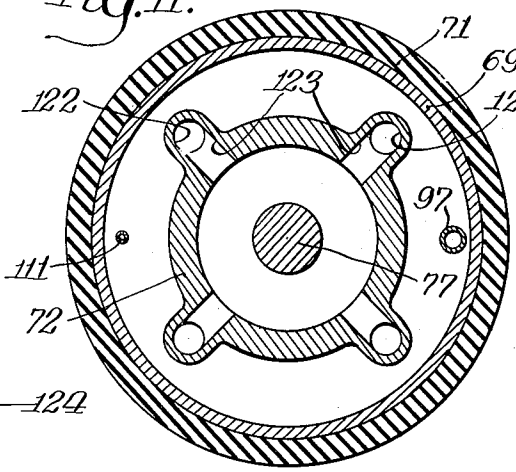


Fig. 12.

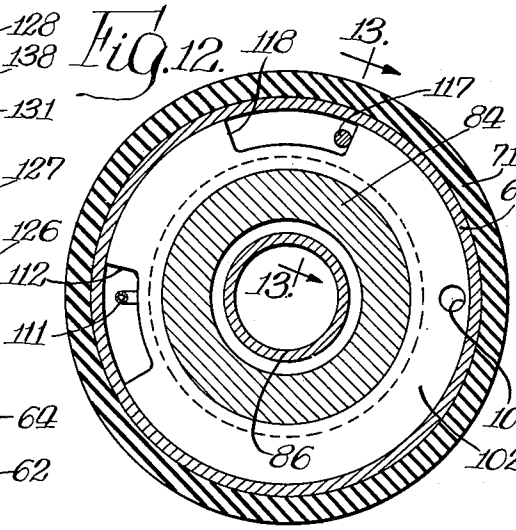


Fig. 10.

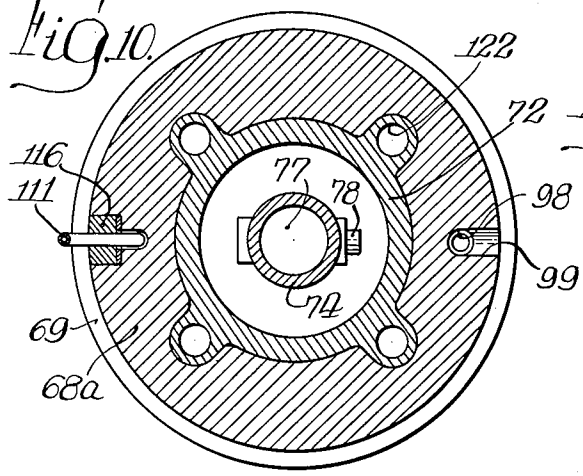
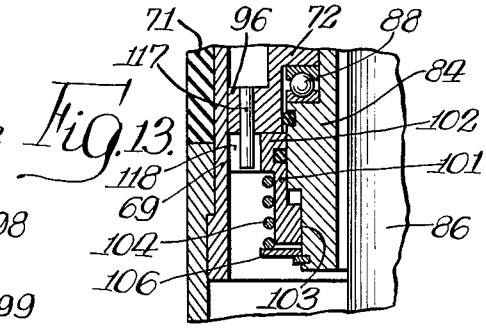


Fig. 13.



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2,739,650

PUMPING APPARATUS

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Application September 19, 1951, Serial No. 247,227

25 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 was 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 techniques. 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.

However, in some instances a reversible oil well pumping apparatus of the foregoing general type utilizing a reversible rotary pump introduces certain problems which must be overcome in order to permit use of the device in different types of wells and under varying operating conditions. For example, 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. Although a dual oppositely acting valve arrangement such as disclosed for example in my copending application Serial No. 247,437, filed September 20, 1951, will function satisfactorily in many instances, there are circumstances in which the oil or other fluid being pumped contains excessive amounts of sand or like abrasive material so that valves of conventional construction are subject to rapid and extreme wear.

In addition, I have found that after an oil well has been pressurized in the manner described briefly above, there is often a large accumulation of gas which introduces difficulty when the production cycle is resumed. It will be understood that a reversible rotary pump, particularly a pump of the preferred positive displacement type hereinafter described, cannot be operated for any appreciable length of time without liquid being present to provide the required lubrication between the stator and the rotor. Consequently, it is necessary to provide some means, preferably automatic, for quickly venting the accumulated gas from the well so that the pump can operate on liquid as soon as possible after a production period has started.

Accordingly, it is a primary object of my invention to provide novel reversible pumping apparatus for an oil well or the like which is adapted for use under widely varying well conditions.

A further object of the invention is to provide novel reversible pumping apparatus of the character described including novel flow control means for preventing loss of fluid head.

Another object of the invention is to provide novel reversible pumping apparatus of the character described which is capable of handling fluids containing abrasive solids without adverse effect on the apparatus.

Still another object of the invention is to provide novel reversible pumping apparatus of the character described including novel means for venting accumulated gas from the well.

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

Fig. 1 is 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;

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

Fig. 4 is a fragmentary transverse sectional view taken along the line 4—4 of Fig. 2 and showing the device in one of its operating positions;

Fig. 5 is a view similar to Fig. 4, but showing the device in a different operating position;

Fig. 6 is a fragmentary transverse sectional view taken along the line 6—6 of Fig. 2;

Figs. 7 and 8 are fragmentary vertical sectional views showing a modified form of the invention;

Fig. 9 is a fragmentary vertical sectional view of the upper portion of the apparatus as used with either of the modifications shown in Figs. 1–6 and Figs. 7–8;

Fig. 10 is a transverse sectional view taken along the line 10—10 of Fig. 7;

Fig. 11 is a transverse sectional view taken along the line 11—11 of Fig. 7;

Fig. 12 is a transverse sectional view taken along the line 12—12 of Fig. 8; and

Fig. 13 is a fragmentary vertical sectional view taken along the line 13—13 of Fig. 12.

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 and a reversible pump section B 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 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.

In the embodiment shown in the drawing, the packer 12 is of a conventional type comprising an axially compressible rubber sleeve. The rubber sleeve is secured around the upper portion of the pump casing, and as the apparatus is initially installed in the well casing the rubber sleeve is retracted as seen in dotted lines in Fig. 1. However, by means of a telescoping action, well known in the packer art, slidable sections of the pump casing are shifted after the apparatus is in place in the well and the rubber sleeve is compressed and bulged outwardly into tight fitting sealed relation with the inside of the well casing 6 as shown in full lines in Fig. 1. In this manner, it will be understood that the packer 12 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 comprising the packer 12 is disposed only around the upper portion of the pump so that 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 it upper end by the packer 12 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 the oil well is equipped with a pumping apparatus as described above in connection with Fig. 1, the desired 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 intermittent 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 Figs. 2–6 illustrating a preferred embodiment of the invention, it will be seen that 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 Moineau 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 an upper tubular member 13 connected to the lower end of the motor section casing, indicated at 14, by means of a coupling member 15 and a threaded connector or collar 16 having an inwardly directed radial shoulder 17. For supporting the pump within the casing 13, an elongated tubular member, indicated generally at 18, is secured at its upper end to the shoulder 17 of the collar 16 by means of a plurality of cap screws 19. The tubular member 18 extends downwardly through the coupling 15 into the pump casing 13 and terminates below the upper end of the packer or rubber sleeve 12 which is secured around the outside of the casing 13, as hereinbefore described. A cover plate 20 having an enlarged opening 21 is attached to the lower end of the tubular member 18 by means of a plurality of cap screws 22. A longitudinal bore 23 is provided at one side of the tubular member 18, and a thermocouple wire 24 connected to a thermocouple (not shown) adjacent the lower end of the pump extends upwardly through an aperture 26 in the cover plate 20, through the bore 23, and thence outwardly into the well casing through a seal closure 27 extending angularly into

the collar 16 and the tubular member 18. It will be understood that the upper end of the thermocouple wire 24 extends upwardly through the well casing 6 to the ground level and is connected to suitable indicating or control apparatus forming no part of the present invention.

An integral radial shoulder portion 28 is provided at the inner periphery of the tubular support 18 adjacent the lower end thereof, and a pump-supporting sleeve 29 having a flanged upper end 31 is rotatably supported on the shoulder 28, a pair of ball bearing assemblies 32 and 33 being provided above and below the shoulder 28, respectively, for facilitating rotation of the sleeve 29 relative to the tubular member 18. A double seal 34 is disposed below the bearing 33 for sealing the space between the sleeve 29 and the tubular member 18. The stator of the pump comprises an elongated conduit 36 having a female helical inner lining 37 of rubber or the like, as previously described, and the upper end of the conduit 36 is threadedly connected in concentric relation within the sleeve 29 for rotation as a unit therewith. The pump rotor comprises an elongated male helical member 38 operatively disposed within the stator 36 and having driving connections at its upper end with the rotor of the motor (not shown). In Fig. 2 the driving connections are shown fragmentarily as comprising a universal joint including a shaft 39 and an adaptor 41 securing the shaft to the pump rotor 38.

A cup shaped rotary valve member, indicated generally at 42, is disposed concentrically between the tubular member 18 and the pump stator 36 in operating relation with the rotatable sleeve 29. The upper end of the valve member 42 has an enlarged axial opening 43 through which the pump stator and rotor assembly extends, and the depending skirt portion, indicated at 44, of the valve member is received within a recess 46 at the inner face of the cover plate 20. The skirt portion 44 of the rotary valve member 42 has a plurality of radial apertures or ports 47 adapted to be aligned in one of the rotary positions of the valve with the lower ends of a plurality of longitudinal bores 48 extending axially within the wall of the tubular member 18. For actuating the rotary valve member 42, the lower end of the rotatable sleeve 29 is provided with a depending projection or lug 49 (Figs. 2 and 6) which extends into the opening 43 of the valve member and coacts with a radial abutment or tongue 51 extending inwardly from the periphery of the opening 43. For limiting the extent of rotary shifting movement of the valve member 42, a depending lug 52 at the lower end of the valve skirt 44 is received within an arcuate notch or slot 53 (Fig. 6) formed in the periphery of the cover plate opening 21.

During operation of the apparatus described above, it will be seen that the rotary valve member 42 is shifted in response to rotation of the sleeve 29 for placing the ports 47 in or out of flow communication with the bores 48. Thus, in Figs. 2, 4, and 6 the apparatus is shown in position for production or removal of oil from the well and the ports 47 are shown in open or aligned position with respect to the passageways 48 so that accumulated gas under relatively high pressure may be readily vented from the bottom of the well through the ports 47 into the bores 48, as indicated by the arrow in Fig. 2, thence radially through aligned apertures indicated at 54 and 56 in the tubular member 18 and the collar 16, respectively, and finally into the well casing 6 which communicates with the atmosphere at the ground level. Once the accumulated gas has been released from the well, the oil level at the bottom of the well rises until it reaches the suction or intake end of the pump and the latter then operates in the normal manner to withdraw liquid oil from the well. As best seen in Fig. 6, the valve member 42 is retained in open position during the production period by the fact that the rotor 38 is rotating in a clockwise direction, as viewed in Fig. 6, and the close frictional fit of the rotor within the stator lining 37 serves to retain the stator 36 and its rotatable supporting sleeve 29 in one of its limiting rotary positions with the lug 49 engaging one side of the tongue 51 and the lug 52 engaging one end of the slot 53.

Assuming now that the apparatus is being reversed to effect pressurizing of the well by reverse flow, as soon as the direction of rotation of the motor is reversed the rotor 38 will operate in a counterclockwise direction, i. e., opposite to the direction shown in Fig. 6, and as a result of the inherent frictional resistance of the stator lining 37 with the rotor 38, the stator 36 and its attached supporting sleeve 29 will likewise rotate in a counterclockwise direction until the lug 49 engages the opposite side of the tongue 51 thereby shifting the rotary valve member 42 in a counterclockwise rotary direction until the lug 52 engages the opposite end of the slot 53. In this limiting rotary position of the valve member 42 the ports 47 are out of alignment relative to the vertical passageways 48 and consequently are sealed off by the wall portions of the tubular member 18 intermediate the bores 48 as clearly seen in Fig. 5. Thus, it will be seen that during pressurizing of the well the gas release or vent passages are effectively closed or sealed whereby to permit the build-up of high fluid pressures within the well and the adjacent producing formation.

When it is desired to change the operation of the apparatus again from a pressurizing period to a production period, the motor is reversed to effect clockwise operation of the pump, as viewed in Fig. 6, and the valve member 42 is thereby shifted to open position whereby to permit immediate venting or release of accumulated gas from the well. As hereinbefore mentioned, it has been found that after a pressurizing period the well often contains a substantial accumulation of high pressure gas and the trapped volume of gas at the bottom of the well prevents the liquid oil from rising and coming into contact with the suction or lower end of the pump. A progressive cavity type pump, as illustrated herein, operates on a positive displacement principle and unless some means is provided for by-passing the pump and rapidly venting the accumulated gas, the gas will only be removed at a relatively slow rate by operation of the pump. However, a pump of the type illustrated cannot operate for more than a brief period of time without the presence of a liquid phase to effect adequate lubrication of the contact surfaces between the pump rotor 38 and the stator lining 37. Consequently, if the pump operates for any appreciable length of time with only gas present, the pump will eventually overheat and the lining 37 will be permanently damaged. By means of the present invention, however, the accumulated gas is immediately and rapidly released from the well as described above so that the level of liquid oil in the well rises quickly into flow communication with the suction end of the pump thereby obviating excessive periods of operation of the pump on gas alone.

From the foregoing description of the valve mechanism it will be seen that the rotatable sleeve 29 can undergo a greater degree of rotation than the rotary valve member 42. In other words, rotary movement of the sleeve 29 is limited only by engagement of the lug 49 with the opposite sides of the tongue 51, whereas rotary movement of the valve 42 is limited by engagement of the lug 52 with the opposite ends of the relatively short arcuate slot 53. As a result of this arrangement, it will be seen that the sleeve 29 can gain substantial momentum before the lug 49 engages the tongue 51 of the valve member. Consequently, the valve member 42 is actuated by a delayed sharp impact or blow whereby to overcome any tendency of the valve to stick in either of its open or closed positions.

After an accumulation of gas has been vented from the well in the manner described above, it may happen in certain cases, dependent upon the pressure of the liquid oil in the well, that oil will then rise through the vertical

passageways 48 and thence flow into the annular space between the pumping apparatus and the well casing 6 above the packer 12. The oil may continue to rise until its hydrostatic head is sufficient to balance the oil pressure at the bottom of the well. This accumulation of oil in the well casing is not objectionable and in fact may serve to supplement the sealing effect of the packer 12. Eventually, as the oil pressure in the well declines during a production period, the oil which has accumulated in the casing will drain downwardly by gravity through the passageways 48 and the open ports 47 of the valve into the well. A relatively small portion of oil between the upper ends of the passages 48 and the point of sealed contact of the packer 12 with the well casing 6 will remain trapped between the casing and the pumping apparatus, but, as mentioned above, the presence of this quantity of oil serves to improve and supplement the sealing effect of the packer 12.

An additional benefit of the gas venting arrangement described above is that it prevents the formation of a vacuum in the well. Because of the highly effective pumping action of the progressing cavity type pump, as herein described, there is sometimes a tendency to create a vacuum in a well after an extended production period which may be in contravention of statutory regulations in some states prohibiting the operation of a well under vacuum. However, by the venting arrangement described above, it will be seen that the valve member 42 is always open during production so that there is free communication between the well and the atmosphere of the ground level thereby avoiding the formation of a vacuum in the well.

Referring now to Figs. 7 to 13, a modified form of the invention will now be described. Fig. 7 shows an intermediate portion of the pumping apparatus adjacent the juncture of the motor section A and the pump section B. The motor section A comprises an outer tubular casing or housing 61 which surrounds an inner tubular sleeve 62 containing a stator 63 having windings 64 and a rotor 66 mounted on a rotor shaft 67. Abutting the lower end of the motor sleeve 62 is a bearing support 68 containing a bearing unit for the rotor shaft 67. Below the bearing support 68 is a connector or collar 68–*a* having the motor casing 61 threaded thereto adjacent its upper portion and having the pump casing, indicated at 69, threaded thereto adjacent its lower end. A packer in the form of a rubber sleeve 71 is secured around the pump casing 69 as in the first-described form of the invention.

An elongated tubular pump-supporting member 72 is secured within the connector 68–*a* and extends downwardly therefrom into the pump casing 69 for supporting the pump structure, as hereinafter described. The lower end of the rotor shaft 67 of the motor is connected to the pump rotor through a tubular extension 74 pivotally connected at its upper end to the rotor shaft 67, as by a pin 76, and a drive shaft 77 pivotally connected to the lower end of the extension 74, as by a pin 78. The drive shaft 77 is journaled in a pair of bearing assemblies 79 and 81 and is surrounded by a suitable seal 82, the bearings 79 and 81 and the seal 82 being secured within the tubular pump support 72.

Referring now to Fig. 8, the lower end of the pump support 72 is enlarged slightly and is provided with an inwardly directed radial shoulder portion 83 upon which is mounted a rotatable sleeve 84 having the upper end of the pump stator, indicated at 86, threaded therein for rotation as a unit with the sleeve 84. Suitable bearings 87 and 88 are provided above and below the shoulder 83 to facilitate rotation of the sleeve 84. The pump stator 86 has a female helical lining 89 of rubber or the like and a male helical rotor 91 is operatively disposed therein. The lower end of the drive shaft 77 is connected to the upper end of the pump rotor 91 by means of a universal connection comprising a pair of shaft adaptors 92 and 93 and an elongated shaft 94.

The lower end of the pump support 72 has a flange 96 into which is threaded the lower end of a tubular conduit 97 extending upwardly between the pump support 72 and the casing 69 into an aligned vertical bore 98 (Fig. 7) provided in the lower end of the connecting structure 68*a*. The bore 98 extends laterally, as at 99, at its upper end for communication with the well casing as hereinafter described.

A cup-shaped rotary valve member 101 having an upper flange 102 and a bottom central aperture 103 is fitted around the lower end of the sleeve 84 which extends through the aperture 103. A helical spring 104 coacts between the flange 102 and a thrust plate 106 mounted at the end of the sleeve 84 for urging the valve member 101 into tight endwise engagement with the flange 96 of the support 72. The flange 102 of the valve member has a port 107 adapted to be shifted into and out of alignment with the lower end of the tubular conduit 97, and the valve member 101 is operatively connected by a key 108 to the rotatable sleeve 84 for actuation of the valve in response to rotation of the sleeve.

A thermocouple 109 is attached to the exterior of the pump stator 86 for measuring the operating temperature of the pump, and suitable electrical connections 111 extend upwardly through a slot 112 in the edge of the valve flange 102 and thence through an aperture 113 in the flange 96 and upwardly therefrom between the casing 69 and the pump support 72. As seen in Fig. 7, the thermocouple wires 111 then extend through a vertical bore 114 in the end of the connector structure 68*a* and radially outwardly through a seal closure 116 into the well casing. It will be understood that the thermocouple connections 111 are likewise attached to suitable indicating or control instruments at the ground level as in the previously described form of the invention.

The operation of the rotary valve member 101 is generally similar to the operation of the valve means hereinbefore described in that the valve member undergoes limited rotation in either direction in response to rotation of the pump stator 86 and the attached sleeve 84, the opposite extreme positions of the valve member 101 corresponding to open and closed positions of the valve port 107 with respect to the tubular conduit 97. In this form of the invention, however, there is no relative movement between the rotatable sleeve 84 and the valve member 101 inasmuch as the two parts are directly connected by the key 108. For limiting the extent of rotary movement of the valve member 101, a coacting pin and slot arrangement is provided as best seen in Figs. 12 and 13. A pin 117 projects downwardly from the stationary flange 96 at the lower end of the pump support 72 and is received within an arcuate edgewise slot or notch 118 provided in the outer periphery of the flange portion 102 of the valve member 101. It will be understood that in the open position of the valve, as illustrated in Figs. 8, 12, and 13, the pin 117 is in engagement at one end of the slot 118 in which position the port 107 is aligned with the end of the conduit 97. When the valve 101 is in closed position, the pin 117 will abut the opposite end of the slot 118 and the port 107 will be out of alignment with the tube 97 so that the lower end of the latter is sealed off by the flange portion 102 of the valve.

As in the first described form of the invention, the valve 101 is opened by the frictional resistance between the pump rotor 91 and the stator lining 89 when the apparatus is operated to withdraw oil from the well thereby permitting preliminary venting of accumulated gas through the conduit 97 and the connected passages into the well casing. During reverse operation of the apparatus for pressurizing the well, the valve member 101 is closed in order to permit the desired build up of fluid pressure within the well. Also, during rotary shifting movement of the valve 101 it will be understood that the slot 112 provides sufficient clearance so as to avoid interfering engagement

of the valve member with the thermocouple connections 111.

In Fig. 8, the lower end of the pump stator 86 is shown as having a guide flange 119 threaded thereon for positioning the lower end of the pump within the casing. The flange 119 is provided with a plurality of apertures 121 to permit the passage of fluid upwardly into the gas release means comprising the valve 101 and the tube 97. During a production period oil is pumped upwardly between the pump stator and rotor and is discharged interiorly of the pump support 72 below the seal 82. The upper walls of the tubular support 72 are provided with a plurality of longitudinal bores or passageways 122 having inlet openings indicated at 123 directly below the seal 82. The oil thus flows through the passageways 122 and passes through the motor section A exteriorly of the operating parts of the motor (by means not shown) into the production tubing 9 (Fig. 1). The details of the motor section and the construction thereof whereby oil is passed through the motor section without contacting the operating parts of the motor do not form any part of the present invention and reference is made to my copending application Serial No. 231,192, filed June 12, 1951 for a more complete disclosure thereof.

In Fig. 9, the upper end portion of the motor section A is shown and it is to be understood that the features illustrated in Fig. 9 and described hereinafter are to be used with either of the valve and gas release arrangements hereinbefore described. It is a feature of the present invention that the lower end of the apparatus is not provided with any special foot or check valve arrangements to prevent loss of fluid head from the system. As previously mentioned, it has been found that in certain instances where the oil or other fluid being pumped contains objectionable quantities of abrasive materials such as sand, any conventional valve structure which may be provided at the intake end of the pumping apparatus is subject to severe erosion and consequently has a relatively short life. However, when the valve structure at the intake end of the pump is eliminated, it is still desirable to make some provisions for preventing loss of fluid head when the pump is stopped for any reason. For example, if the pump is stopped during a production period, it will be seen that the hydrostatic pressure of the head of oil in the production tubing 9 above the pump will tend to force oil downwardly through the pump causing the latter to "motor" with consequent loss of fluid head. According to the present invention, I prevent such undesirable "motoring" of the pump by utilizing a suitable brake which holds the pump rotor 91 in fixed position relative to the pump stator whenever the motor and pump are stopped for any reason.

In Fig. 9, the upper end of the rotor shaft 67 of the motor extends upwardly through a bearing 126 mounted in a partition structure 127. The upper extremity of the rotor shaft 67 is splined, as at 128, and is fitted with a brake member 129 which is rotatable with the splined portion 128 and is also shiftable axially thereon. The outer periphery of the brake member 129 has an angular braking surface 131 which is adapted to coact with a complementary braking surface 132 formed in the partition structure 127. A thrust washer 133 is mounted at the end of the splined portion 128 of the rotor shaft 67 and a helical spring 134 coacts between the thrust washer 133 and the axially shiftable brake member 129 for normally urging the latter into braking engagement with the partition structure 127.

A magnet 136 having pole pieces 137 and 138 and an energizing winding 139 is mounted above the brake member 129 for releasing the latter. The shiftable brake member 129 is formed from a magnetically attractable metal and the magnet winding 139 is connected in series (by means not shown) with the current supplied to one phase of the motor so that whenever the motor is in operation the magnet 136 will be energized and the brake member 129 will be held in released position against the magnet poles 137 and 138 and out of engagement with the stationary braking surface 132 regardless of the direction of rotation of the apparatus. However, if the current to the motor is interrupted for any reason so that the operation of the pump ceases, it will be seen that the brake member 129 will be immediately released by the magnet 136 and the spring 134 will then force the brake member 129 into automatic braking engagement with the braking surface 132. With the rotor shaft 67 thus held against movement by the magnetic brake described above, it will be understood that the pump rotor 91 cannot move relatively to the pump stator 86 and consequently it is impossible for the fluid head above the pump to flow through the pump structure. In other words, the pump itself then serves as a valve and there is no opportunity for the fluid pressure exerted by the hydrostatic head to effect "motoring" of the pump with consequent drainage of the fluid to the bottom of the well.

Another important effect of the brake means just described is that the brake serves not only to hold the pump rotor against rotation but also by the same braking action holds the rotary valve member against movement. Assuming that the apparatus is being operated to pump oil out of a well and the motor and pump are stopped momentarily, it will be seen that if no braking means were provided the pump rotor would begin to rotate or "motor" in the opposite direction and the rotary valve member would automatically shift to closed position necessitating a reversal to open position again when production is resumed. Similarly, if operation of the apparatus is stopped momentarily during a pressurizing period, the fluid pressure in the well might in some intances be sufficient to "motor" the pump in the opposite direction thereby opening the rotary valve and permitting pressurizing fluid to escape through the well casing and even to the ground level if there is no provision for braking the pump rotor. However, because the rotary valve member is operatively connected to the pump stator in my invention, it will be seen that the brake retains the valve in its most recent operating position.

From the foregoing, it will be seen that my invention provides a reversible pumping apparatus which is capable of use under widely varying well conditions. Inasmuch as the apparatus eliminates the necessity for separate valve structure at the inlet end of the pump, the device can operate on a working fluid containing appreciable amounts of sand or other abrasive material without the difficulty of valve erosion. Moreover, the invention provides an automatic valve means which is shiftable between open and closed positions in response to reversal of direction of the pump for quickly venting accumulated gas from the bottom of the well to the ground level thereby avoiding the necessity of operating the pump for any extended period of time without the presence of a liquid phase within the pump.

Although the invention has been described in connection with certain specific structural embodiments thereof, 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 including a stator and a rotor, reversible rotary driving means operatively connected to said rotor for reversibly rotating the latter, a tubular pump casing surrounding said pump means, a packer mounted exteriorly of said pump casing and adapted to engage the interior of the well casing in sealing relation therewith, a supporting sleeve rotatably mounted within said pump casing and having said stator rigidly attached thereto, said sleeve

and stator being adapted to undergo limited rotary movement in reverse directions in response to reversal of direction of rotation of said rotor and said driving means, and means for venting gas under pressure from below said packer into the well casing above said packer when the apparatus is being operated to pump oil out of the well, said means including a rotary valve member operably connected to said sleeve and shiftable between open and closed positions in response to said limited rotary movement of said sleeve.

2. 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 including a stator and a rotor, reversible rotary driving means operatively connected to said rotor for reversibly rotating the latter, a tubular pump casing surrounding said pump means, a packer mounted exteriorly of said pump casing and adapted to engage the interior of the well casing in sealing relation therewith, a supporting sleeve rotatably mounted within said pump casing and having said stator rigidly attached thereto for rotation therewith in reverse directions in response to reversal of direction of rotation of said rotor and said driving means, means including a rotary valve member operatively connected to said sleeve and actuated thereby for venting gas under pressure from below said packer into the well casing above said packer when the apparatus is being operated to pump oil out of the well, and stop means coacting with said valve member for positioning the latter in open and closed positions and for limiting the extent of rotary movement of said valve member and said sleeve.

3. 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 including a stator and a rotor, reversible rotary driving means operatively connected to said rotor for reversibly rotating the latter, a tubular pump casing surrounding said pump means, a packer mounted exteriorly of said pump casing and adapted to engage the interior of the well casing in sealing relation therewith, elongated pump-supporting structure rigidly mounted within said pump casing, a rotatable sleeve mounted adjacent the lower end of said structure and having said stator rigidly attached thereto for rotary movement in reverse directions in response to reversal of direction of rotation of said rotor and said driving means, means including a rotary valve member operatively connected to said sleeve and actuated thereby for venting gas under pressure from below said packer into the well casing above said packer when the apparatus is being operated to pump oil out of the well, and coacting stop means carried by said valve member and said pump-supporting structure for limiting the extent of rotary movement of said valve member and said sleeve.

4. 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 including a stator and a rotor, reversible rotary driving means operatively connected to said rotor for reversibly rotating the latter, a tubular pump casing surrounding said pump means, a packer mounted exteriorly of said pump casing and adapted to engage the interior of the well casing in sealing relation therewith, a sleeve rotatably mounted for limited rotary movement in reverse directions within said pump casing and having said stator rigidly attached thereto for rotation therewith, means including a rotary valve member openable for venting gas from below said packer into the well casing above said packer when the apparatus is being operated to pump oil out of the well, operating connections comprising coengageable abutments on said sleeve and said valve member for opening or closing the latter upon rotation of said sleeve in response to reversal of direction of rotation of said rotor and driving means, and stop means for limiting the extent of rotary movement of said valve member and said sleeve, the operating connections between said sleeve and said valve member being arranged to permit a substantially greater degree of rotary movement of said sleeve than said valve member whereby said valve member is actuated in either direction by delayed impact between said abutments for overcoming any tendency of the valve member to stick in one position.

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 including a stator and a rotor, reversible rotary driving means operatively connected to said rotor for reversibly rotating the latter, a tubular pump casing surrounding said pump means, a packer mounted exteriorly of said pump casing and adapted to engage the interior of the well casing in sealing relation therewith, an elongated tubular pump support rigidly mounted within said pump casing, a sleeve rotatably supported adjacent the lower end of said support for limited rotary movement in reverse directions and having said stator rigidly attached thereto for rotation therewith, an annular retainer plate secured to the lower end of said support, and means including a cup-shaped valve member openable for venting gas from below said packer into the well casing above said packer when the apparatus is being operated to pump oil out of the well, said valve member being rotatably mounted between said retainer plate and the lower end of said sleeve, the adjacent portions of said valve member and said sleeve having coengageable abutments whereby said valve member is opened or closed upon rotation of said sleeve in response to reversal of direction of rotation of said rotor and driving means, and the adjacent portions of said valve member and said retainer plate having coacting stop means for limiting the extent of rotary movement of said valve member and said sleeve.

6. 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 including a stator and a rotor, reversible rotary driving means operatively connected to said rotor for reversibly rotating the latter, a tubular pump casing surrounding said pump means, a packer mounted exteriorly of said pump casing and adapted to engage the interior of the well casing in sealing relation therewith, an elongated tubular support rigidly mounted within said pump casing and having a plurality of longitudinal passages in the wall thereof adapted to communicate at their upper ends with the well casing above said packer for venting gas from below said packer into the well casing above said packer when the apparatus is being operated to pump oil out of the well, a sleeve rotatably supported in said tubular support for limited rotary movement in reverse directions and having said stator rigidly attached thereto for rotation therewith, and a rotary valve member mounted within said tubular support adjacent the lower end thereof and having a cylindrical wall portion provided with a plurality of radial ports adapted to be shifted into and out of alignment with the lower ends of said passages, said valve member being operatively connected to said sleeve for actuation of the valve member between open and closed positions upon rotation of said sleeve in response to reversal of direction of rotation of said rotor and driving means.

7. 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 including a stator and a rotor, reversible rotary driving means operatively connected to said rotor for

reversibly rotating the latter, a tubular pump casing surrounding said pump means, a packer mounted exteriorly of said pump casing and adapted to engage the interior of the well casing in sealing relation therewith, an elongated tubular support rigidly mounted within said pump casing, a sleeve rotatably mounted within said tubular support for limited rotary movement in reverse directions and having said stator rigidly attached thereto for rotation therewith, valve means including a rotary cup-shaped valve member mounted adjacent the lower end of said tubular support for venting gas from below said packer into the well casing above said packer when the apparatus is being operated to pump oil out of the well, said valve member having a depending lug at its lower end and having an axial opening at its upper end with a radial tongue extending inwardly from the periphery of said opening, said sleeve having a depending lug received within said opening and adapted to engage with the opposite sides of said tongue for actuating said valve member upon rotation of said sleeve in opposite directions in response to reversal of direction of rotation of said rotor and driving means, and retainer means secured at the lower end of said tubular support for rotatably supporting said valve member and having an arcuate slot therein, the depending lug of said valve member being received within said arcuate slot for limiting the extent of rotary movement of said valve member and said sleeve and for positioning said valve member in open and closed positions.

8. 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 including a stator and a rotor, reversible rotary driving means operatively connected to said rotor for reversibly rotating the latter, a tubular pump casing surrounding said pump means, a packer mounted exteriorly of said pump casing and adapted to engage the interior of the well casing in sealing relation therewith, an elongated tubular support rigidly mounted within said pump casing and having a counterbore at its lower end and being provided with a plurality of longitudinal passages extending axially within the annular wall thereof, said passages being in communication at their lower ends with said counterbore and being adapted to communicate at their upper ends with the well casing above said packer for venting gas from below said packer into the well casing above said packer when the apparatus is being operated to pump oil out of the well, a sleeve rotatably mounted within the tubular support above the lower end thereof and having the upper end of said stator rigidly secured therein for rotation therewith in reverse directions, a rotary valve member mounted at the lower end of said tubular support within said counterbore and in axial alignment below said sleeve, said valve member having a cylindrical wall portion provided with a plurality of radial ports adapted to be shifted into and out of alignment with the lower ends of said passages for controlling fluid flow therethrough, and an annular retainer plate secured to the lower end of said tubular support for rotatably supporting the lower end of said valve member, said sleeve being operatively connected to said valve member for actuation of the latter upon rotation of said sleeve in response to reversal of direction of rotation of said rotor and said driving means, and said retainer plate and said valve member being provided with coacting stop means for limiting the extent of rotary movement of said valve member and said sleeve.

9. 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 including a stator and a rotor, reversible rotary driving means operatively connected to said rotor for reversibly rotating the latter, a tubular pump casing surrounding said pump means, a packer mounted exteriorly of said pump casing and adapted to engage the interior of the well casing in sealing relation therewith, an elongated tubular support rigidly mounted within said pump casing and having an outwardly extending flange at its lower end, elongated conduit means secured at its lower end in said flange and extending upwardly through the pump casing and adapted to communicate at its upper end with the well casing for venting gas from the pump casing to the well casing above said packer when the apparatus is being operated to pump oil out of the well, a sleeve rotatably mounted for limited rotary movement in reverse directions within said tubular support and having said stator rigidly secured therein for rotation therewith, and a rotary valve member rotatably mounted adjacent the lower end of said tubular support and adapted to open and close the lower end of said conduit means for controlling fluid flow therethrough, said valve member being operatively connected to said sleeve for actuation of said valve member upon rotation of said sleeve in response to reversal of direction of rotation of said rotor and driving means.

10. 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 including a stator and a rotor, reversible rotary driving means operatively connected to said rotor for reversibly rotating the latter, a tubular pump casing surrounding said pump means, a packer mounted exteriorly of said pump casing and adapted to engage the interior of the well casing in sealing relation therewith, an elongated tubular support rigidly mounted within said pump casing and having an outwardly extending flange at its lower end, elongated conduit means secured at its lower end in said flange and extending upwardly through the pump casing and adapted to communicate at its upper end with the well casing for venting gas from the pump casing to the well casing above said packer when the apparatus is being operated to pump oil out of the well, a sleeve rotatably mounted for limited rotary movement in reverse directions within said tubular support and having said stator rigidly secured therein for rotation therewith, a rotary cup-shaped valve member mounted adjacent the lower end of said sleeve and having a coacting flange portion at its upper end adapted to engage the flange on said tubular support, and means coacting between said sleeve and said valve member for normally urging the flange portion of said valve member into engagement with the flange on said tubular support, said flange portion of said valve member having an axial port therein adapted to be shifted into and out of alignment with the lower end of said conduit means for controlling fluid flow therethrough, and said valve member being operatively connected to said sleeve for actuation of the valve member upon rotation of said sleeve in response to reversal of direction of rotation of said rotor and driving means.

11. 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 including a stator and a rotor, reversible rotary driving means operatively connected to said rotor for reversibly rotating the latter, a tubular pump casing surrounding said pump means, a packer mounted exteriorly of said pump casing and adapted to engage the interior of the well casing in sealing relation therewith, an elongated tubular support rigidly mounted within said pump casing and having an outwardly extending flange at its lower end, vent means communicating with said flange for venting gas from the pump casing to the well casing above said packer when the apparatus is being operated to pump oil out of the well, a sleeve rotatably mounted within said tubular support and having said stator rigidly secured therein for rotation therewith in reverse directions, a rotary valve

member mounted adjacent said flange and shiftable between open and closed positions for controlling fluid flow through said vent means, said valve member being operatively connected to said sleeve for actuation of the valve member upon rotation of said sleeve in response to reversal of direction of rotation of said rotor and driving means, and stop means comprising coengageable portions on said tubular support and said valve member for limiting the extent of rotary movement of said valve member and said sleeve.

12. Pumping apparatus adapted to be inserted in the casing of an oil well comprising positive displacement pump means including a stator and a rotor having a valveless unobstructed fluid inlet at the lower end thereof opening into the well casing, an electric motor having a rotor shaft operatively connected to the pump rotor, and releasable brake means including a pair of relatively movable brake members one of which is operatively connected to said rotor shaft for rotation therewith, means normally urging said brake members into braking engagement for retaining said rotor shaft and said pump rotor against rotation when operation of said motor for driving the pump rotor is stopped whereby to prevent reverse rotation of the pump rotor and consequent loss of fluid head, and releasing means for disengaging said brake members when said motor and said pump means are in operation.

13. The apparatus of claim 12 further characterized in that said releasing means comprises electromagnetic means.

14. Pumping apparatus adapted to be inserted in the casing of a well comprising positive displacement pump means including a stator and a rotor having a valveless unobstructed fluid inlet at the lower end thereof opening into the well casing, driving means operatively connected to the rotor, releasable brake means including a pair of relatively movable brake members one of which is operatively connected to the rotor for rotation therewith, means normally urging said brake members into braking engagement for retaining the rotor against rotation when operation of said driving means is stopped whereby to prevent reverse rotation of the rotor and consequent loss of fluid head, releasing means for disengaging said brake members, and a common energizing means for said driving means and said releasing means whereby to effect automatic release of said brake means when said driving means is in operation.

15. 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 a pumping unit including reversible pump means, reversible rotary drive means connected to said pump means for reversely rotating the latter, and a packer carried by said unit and adapted to engage the interior of the well casing for confining the fluid pumped downwardly by said pump means to the lower part of the casing, vent means for discharging gas from below said packer to above said packer, shiftable valve means movable between different positions for opening and closing said vent means, means for limiting said valve means to movement between said positions, and means providing an operating connection between said pumping unit and said valve means for effecting shifting movement of said valve means by reversal of drive of said pumping unit for opening said vent means when the apparatus is being operated to pump oil out of the well and for closing said vent means when the apparatus is being operated to pump fluid downwardly into the well under pressure.

16. 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 including a stator and a rotor, reversible rotary driving means operatively connected to said rotor for reversibly rotating the latter, a tubular pump casing surrounding said pump means, a packer mounted exteriorly of said pump casing and adapted to engage the interior of the well casing in sealing relation therewith, vent means for discharging gas from below said packer into the well casing above said packer, rotatable means supporting said stator for limited rotary movement in reverse directions in response to reversal of direction of rotation of said rotor and said driving means, and valve means operatively connected to said stator for opening and closing said vent means in response to said limited rotary movement of said stator.

17. 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 including a stator and a rotor, reversible rotary driving means adjacent said pump means, a tubular pump casing surrounding said pump means, a packer mounted exteriorly of said pump casing and adapted to engage the interior of the well casing in sealing relation therewith, a tubular pump support rigidly mounted within said pump casing, driving connections extending through said pump support and operatively connecting said driving means with said rotor for reversibly rotating the latter, means adjacent the lower end of said support for supporting said stator for limited rotary movement in reverse directions in response to reversal of direction of rotation of said driving means, vent means for discharging gas from below said packer into the well casing above said packer, and rotary valve means operatively connected to said stator for opening and closing said vent means in response to said limited rotary movement of said stator.

18. 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 including an elongated stator and an elongated rotor, reversible, rotary driving means operatively connected to said rotor for reversibly rotating the latter, a tubular pump casing surrounding said pump means, a packer mounted exteriorly of said pump casing and adapted to engage the interior of the well casing in sealing relation therewith, a sleeve rotatably supported within said pump casing and having said stator rigidly attached thereto in concentric relation therein for limited rotary movement in reverse directions, and means including an annular rotary valve member mounted adjacent said sleeve in concentric relation with said stator and operable for venting gas from below said packer into the well casing above said packer when the apparatus is being operated to pump oil out of the well, the adjacent portions of said sleeve and said valve member being operatively connected for actuation to open or close said valve member upon rotation of said sleeve in response to reversal of direction of said rotor and driving means.

19. 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 a pumping unit including reversible pump means, reversible rotary drive means connected to said pump means, and a packer carried by said unit and adapted to engage the interior of the well casing for confining the fluid pumped downwardly by said pump means to the lower part of the casing, vent means for discharging gas from below said packer to above said packer, shiftable valve means movable to one position for opening said vent means when the apparatus is being operated to pump oil out of the well and movable to another position for closing said vent means when the apparatus is being operated to pump fluid into the well, and a member operably connected to said pumping unit for movement in reverse direction by reversal of drive of said pumping unit, said member and said valve means being relatively movable

and having coengageable abutments for restricting the extent of relative movement to opposite limiting positions of said abutments whereby said valve means is actuated by delayed impact with said member upon movement of the latter from one of said limiting positions to the other of said limiting positions.

20. Pumping apparatus adapted to be inserted in the casing of an oil well comprising positive displacement pump means including a stator and a rotor having a valveless unobstructed fluid inlet at the lower end thereof opening into the well casing, driving means operatively connected to the rotor, releasable brake means including a pair of relatively movable brake members one of which is operatively connected to said rotor for rotation therewith, means normally urging said brake members into braking engagement for retaining the rotor against rotation when operation of the driving means for driving said rotor is stopped whereby to prevent reverse rotation of the rotor and consequent loss of fluid head, and releasing means for disengaging said brake members when said driving means and said pump means are in operation.

21. Pumping apparatus adapted to be inserted in the casing of an oil well comprising positive displacement pump means including a stator and a rotor having a valveless unobstructed fluid inlet at the lower end thereof opening into the well casing, an electric motor operatively connected to said rotor for driving the same, and releasable brake means including a pair of relatively movable brake members one of which is operatively connected to said rotor for rotation therewith, means normally urging said brake members into braking engagement for retaining the rotor against rotation when the current supply to the motor is interrupted whereby to prevent reverse rotation of the rotor and consequent loss of fluid head, and electromagnetic releasing means adapted to disengage said brake members when said electric motor and said pump means are in operation.

22. Pumping apparatus adapted to be inserted in the casing of an oil well comprising positive displacement pump means including a stator and a rotor having a valveless unobstructed fluid inlet at the lower end thereof opening into the well casing, an electric motor having a rotor shaft operatively connected to the pump rotor, and releasable brake means including a movable brake member mounted on said rotor shaft for rotation therewith and shiftable axially thereon, a complementary stationary brake member provided in coacting position adjacent said movable brake member, spring means normally urging said movable brake member into braking engagement with said stationary brake member for retaining said pump rotor against rotation when operation of said motor for driving the pump rotor is stopped whereby to prevent reverse rotation of the rotor and consequent loss of fluid head, and releasing means for automatically disengaging said movable brake member from said stationary brake member when said motor and said pump are in operation.

23. Pumping apparatus adapted to be inserted in the casing of an oil well comprising positive displacement pump means including a stator and a rotor having a valveless unobstructed fluid inlet at the lower end thereof opening into the well casing, driving means operatively connected to said rotor, and releasable brake means for retaining said rotor against rotation when operation of the driving means for driving said rotor is stopped whereby to prevent reverse rotation of the rotor and consequent loss of fluid head, said brake means comprising a shiftable brake member operatively connected to said rotor, means for normally urging said brake member into braking position, and electromagnetic means adapted to operate said brake member for releasing the same when said driving means and said pump means are in operation.

24. The apparatus of claim 23 further characterized in that said driving means comprises an electric motor and said electromagnetic means has an energizing winding connected in series with the motor whereby said electromagetic means is automatically deenergized and said brake member is automatically shifted to braking position when the current to the motor is interrupted.

25. 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 positive displacement pump means including a stator and a rotor having a valveless unobstructed fluid inlet at the lower end thereof opening into the well casing, reversible rotary driving means operatively connected to said rotor for reversibly rotating the latter, a tubular pump casing surrounding said pump means, a packer mounted exteriorly of said pump casing and adapted to engage the interior of the well casing in sealing relation therewith, means within said pump casing for rotatably supporting said stator for limited rotary movement in reverse directions, means including a rotary valve member openable for venting gas from below said packer into the well casing above said packer when the apparatus is being operated to pump oil out of the well, said valve member being operatively connected to said stator for movement of said valve member between open and closed positions in response to said limited rotary movement of said stator upon reversal of the direction of rotation of said rotor and said driving means, and releasable brake means including a pair of relatively movable brake members one of which is operatively connected to said rotor for rotation therewith, means normally urging said brake members into braking engagement for retaining the rotor against rotation when operation of the driving means for driving said rotor is stopped whereby to prevent reverse rotation of the rotor and consequent loss of fluid head and whereby said stator and said valve member are also retained against rotary movement, and releasing means for disengaging said brake members when said driving means and said pump means are in operation.

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