July 4, 1950 T. P. HOFFER 2,513,869

TWO-ZONE PUMP

Filed Oct. 11, 1946 5 Sheets-Sheet 1

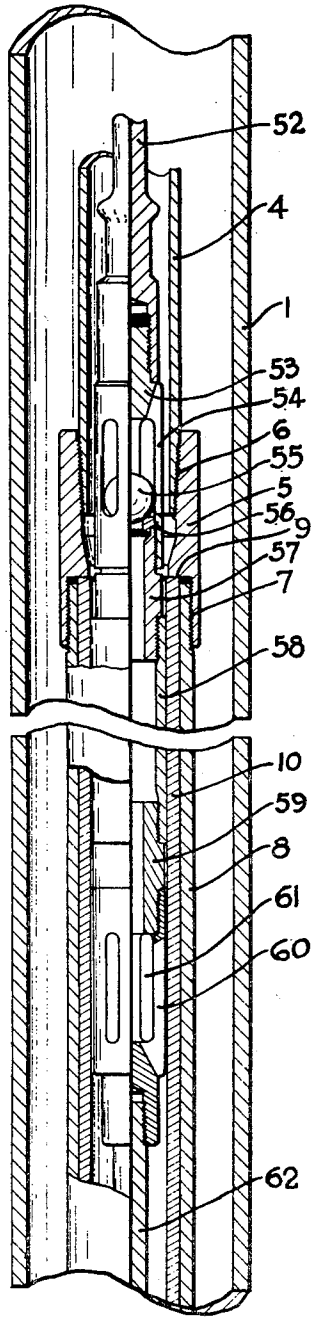


FIG. 1

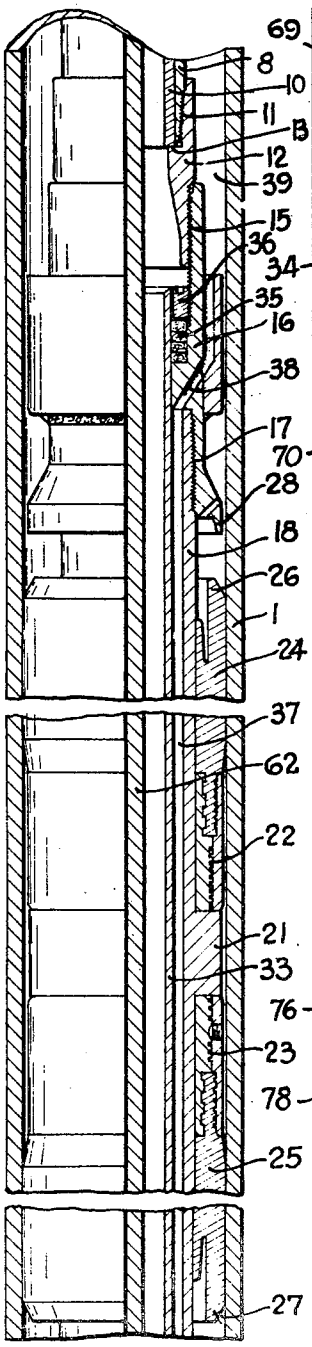


FIG. 2

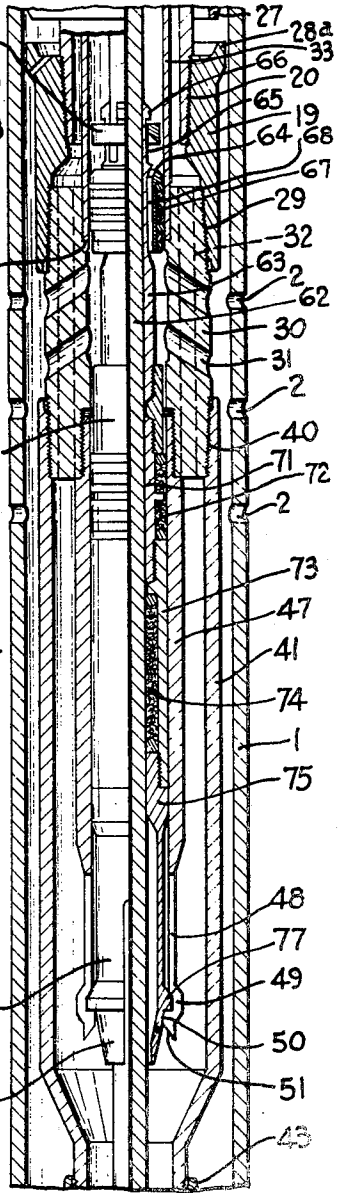


FIG. 3

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July 4, 1950 T. P. HOFFER 2,513,869

TWO-ZONE PUMP

Filed Oct. 11, 1946 5 Sheets-Sheet 2

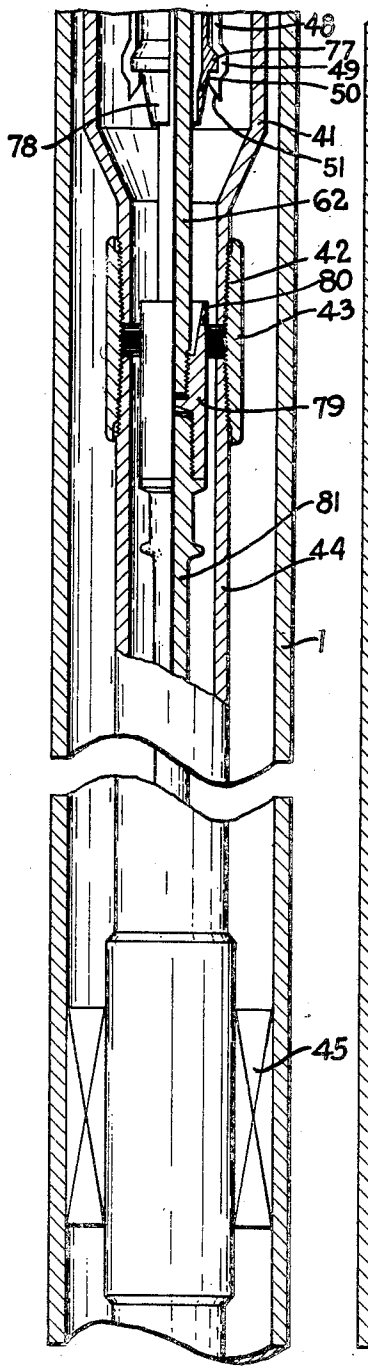


FIG. 4

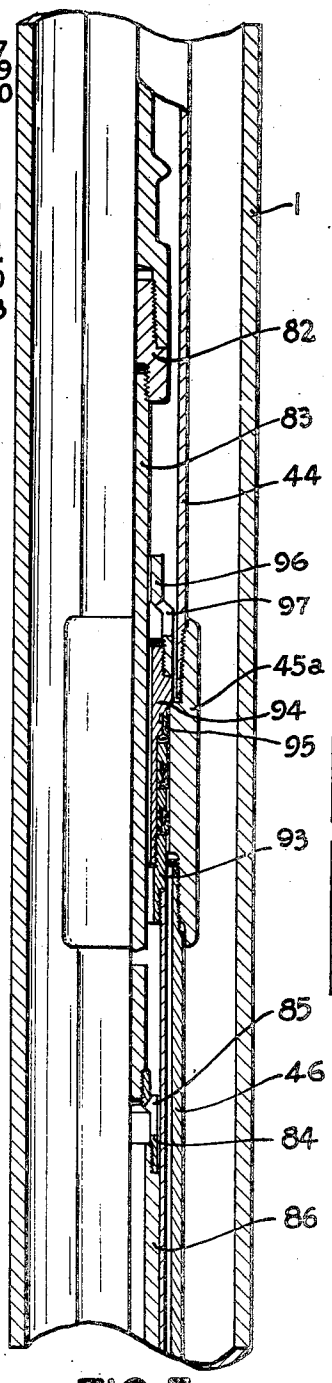


FIG. 5

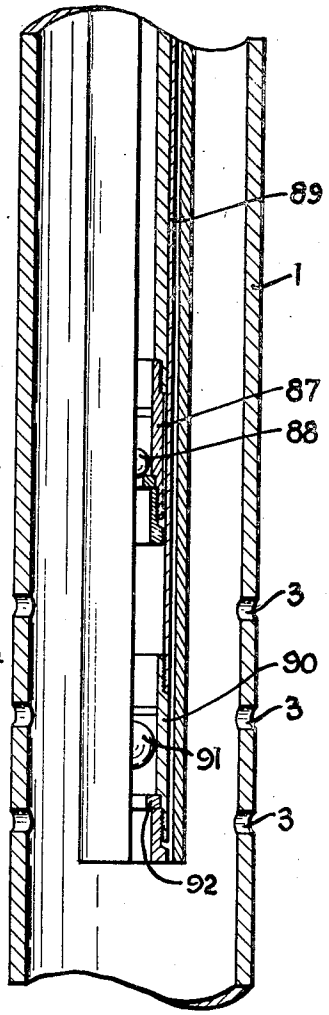


FIG. 6

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TWO-ZONE PUMP

Filed Oct. 11, 1946 5 Sheets-Sheet 3

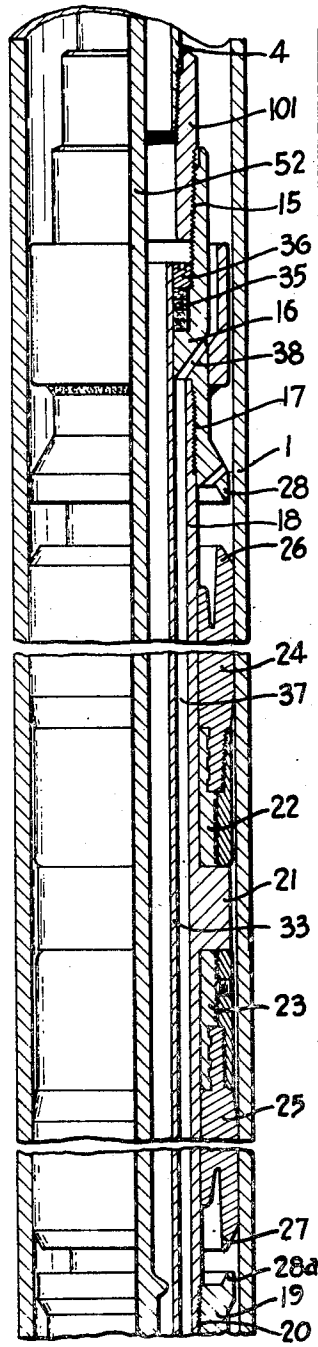


FIG. 7

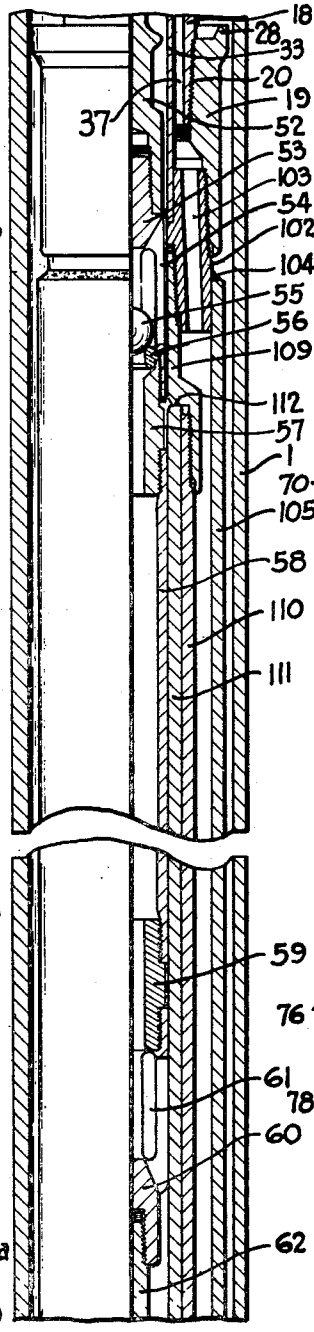


FIG. 8

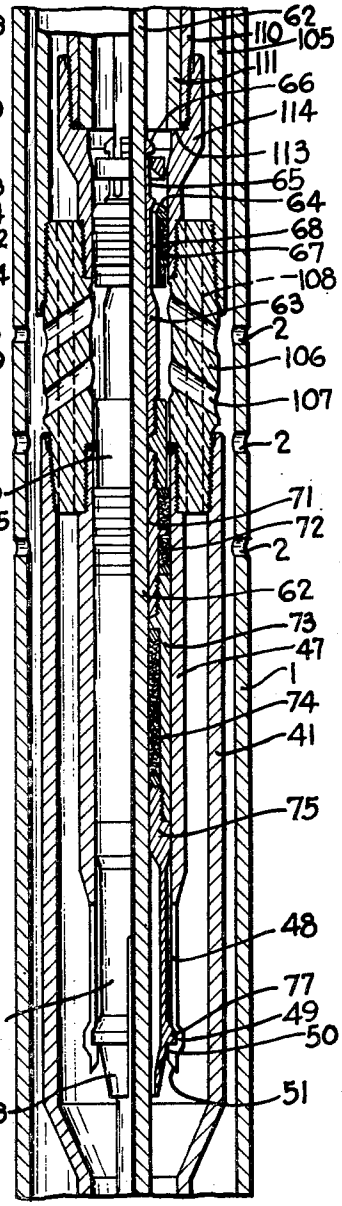


FIG. 9

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TWO-ZONE PUMP

Filed Oct. 11, 1946 5 Sheets-Sheet 4

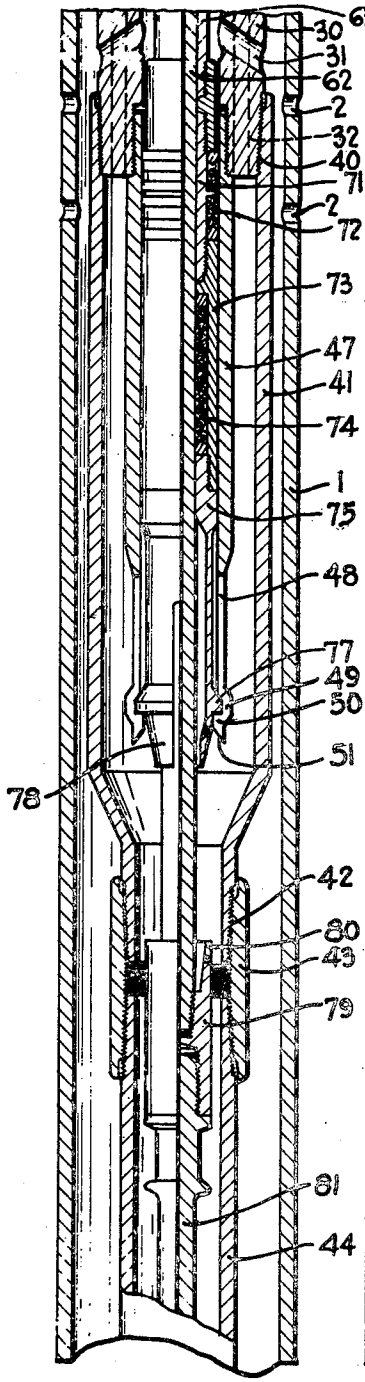


FIG. 10

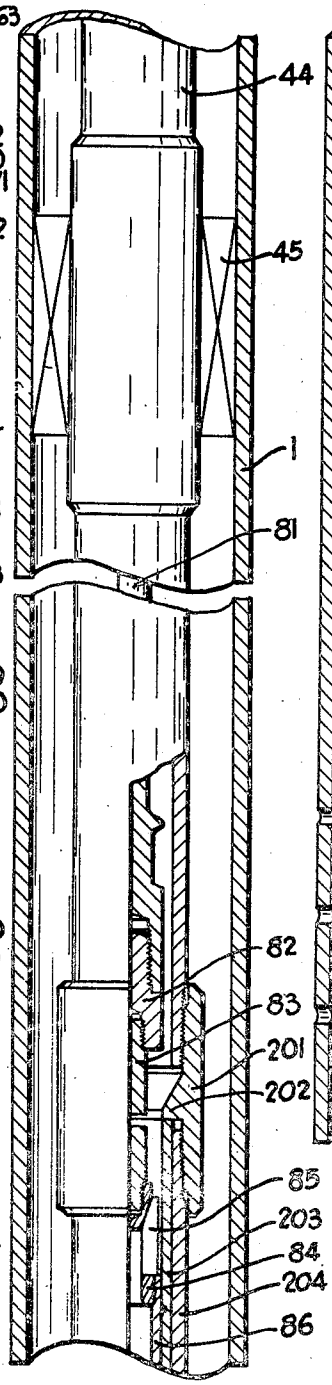


FIG. 11

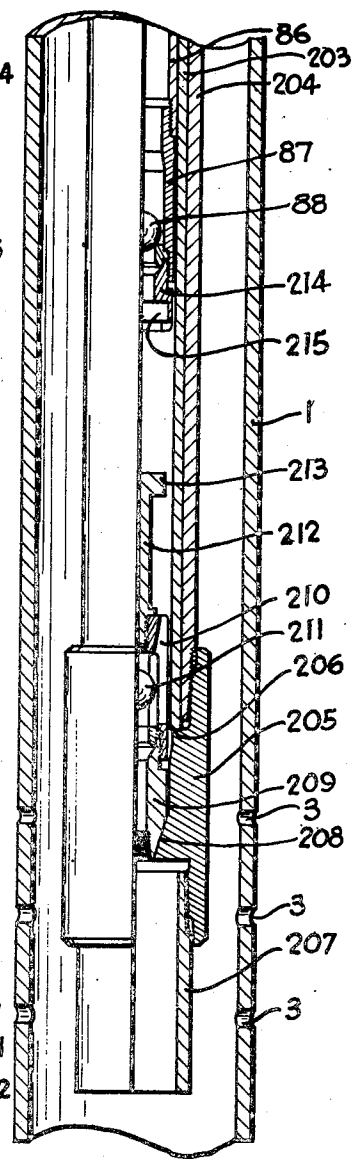


FIG. 12

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TWO-ZONE PUMP

Filed Oct. 11, 1946 5 Sheets-Sheet 5

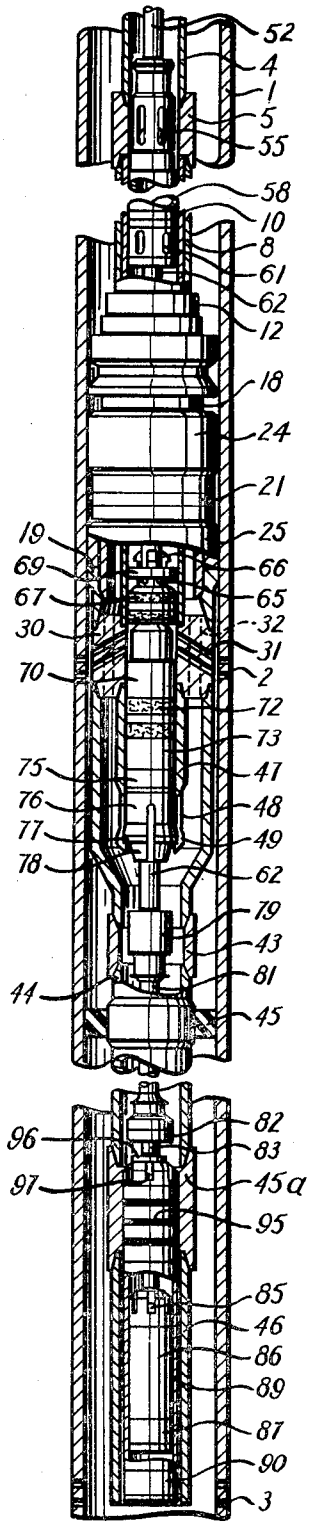


Fig. 13

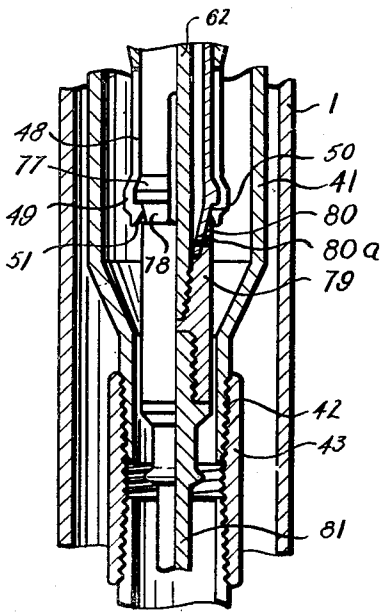


Fig. 14

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UNITED STATES PATENT OFFICE

2,513,869

TWO-ZONE PUMP

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Application October 11, 1946, Serial No. 702,769

15 Claims. (Cl. 103—4)

1

This invention relates in general to pumps of the type used generally in pumping fluid from deep wells and has for its general object the provision of such a pump which will efficiently pump fluid simultaneously from two different zones of production in a well and move such fluid toward the upper end of the well without intermingling of the production from the two zones.

More specifically it is an object of the present invention to provide such a structure which will be simple both in its construction and in its operation and will vary from the conventional construction of deep well pumps by the least possible amount.

Another object of this invention is to provide such a structure in which that portion of the pumping mechanism which pumps from the lower zone of production will not be subject to so-called "gas locking" in the event that the fluid being pumped contains substantial amounts of gas.

Another object of this invention is to provide such a structure in which the discharge from the portion of the mechanism which pumps from the lower zone will be through an annular space surrounding that portion of the mechanism which pumps from the upper zone.

Another object of this invention is to provide a modified form of structure in which the pumping mechanism for pumping from the upper zone may be located closely adjacent or within the zone of production itself so that it may pump efficiently from so-called low fluid level wells.

Another object of this invention is to provide a modified form of such a mechanism in which the space about the pumping assembly may be packed off immediately above the upper producing zone and the pumping mechanism for pumping from the upper producing zone located above such pack off so as to reduce the amount of structure necessary to provide for the passage of production from the lower zone through the pack off.

Another object of this invention is to provide a structure in which the necessary packing between the upper and lower cylinders, and the standing valve for the upper cylinder may be readily removed and inserted with the pump actuating rod.

Still another object is to provide such a structure in which the lower pumping cylinder and the standing valve therefore may likewise be removed and inserted with the pumping rod.

Yet another object is to provide a two zone

2

pump which will permit either zone to flow under its own pressure while pumping the other.

Other objects and advantages of this invention will become apparent from the following description taken in connection with the accompanying drawings wherein are set forth by way of illustration and example, and not by way of limitation, certain embodiments of this invention.

In the drawing:

Fig. 1 is a view principally in longitudinal cross section illustrating the upper end portion of a pump constructed in accordance with this invention located within a well casing.

Fig. 2 is a view similar to Fig. 1 illustrating a continuation of the same structure.

Fig. 3 is still another view similar to Figs. 1 and 2 and showing a continuation of the lower portion of Fig. 2.

Fig. 4 is a view partly in longitudinal cross section and partly in side elevation showing a continuation of the lower portion of Fig. 3.

Fig. 5 is a view similar to Fig. 4 and showing a continuation of the lower end portion thereof.

Fig. 6 is a view similar to Fig. 5 and showing the lowermost end portion of the pumping mechanism.

Figs. 7, 8 and 9 are views similar to and corresponding respectively to Figs. 1, 2 and 3 but showing a modified form of uper end construction of the pumping mechanism in which the upper pumping cylinder is located below the packer which packs off between the pumping mechanism and the upper producing zone, for use in low fluid level wells, instead of being above such packer as shown in Figs. 1, 2 and 3 intended for high fluid level wells.

Figs. 10, 11, and 12 are views similar to and corresponding respectively to Figs. 4, 5 and 6 but showing a modified lower end construction for the pumping mechanism in which the lower pumping cylinder is not removable with the pumping rod, so that it may be made of larger capacity than when it is made removable through the upper cylinder as shown in Figs. 4, 5 and 6.

Fig. 13 is a schematic view illustrating the mechanism shown in Figs. 1 to 6 inclusive.

Fig. 14 is a detail of a portion of the mechanism shown in Figs. 3 and 4 illustrating the stuffing box for the upper zone pump secured to the polish rod in position to be lowered into the well tubing.

Referring now more in detail to the drawing and particularly to Figs. 1 to 6, inclusive thereof, the pumping mechanism is illustrated as being located within a well casing 1 having openings

2 therethrough for the purpose of admitting a flow of fluid from an upper producing formation, and openings 3 therethrough for the purpose of admitting a flow of fluid from a lower producing formation.

The non-moving portions of the pumping mechanism are carried on the lower end of the customary well tubing 4 and connected thereto by means of a special coupling or fitting 5 which is threaded at 6 to the lower end of the tubing and is provided with internal threads at 7 for receiving the upper end of the upper cylinder jacket 8 of the pump. The fitting 5 also provides a downwardly facing shoulder 9 adapted to clamp against and hold in place the upper cylinder liner 10. On reference to Fig. 2 it will be seen that the lower end of the jacket 8 is threadedly received at 11 by the fitting 12 and that this fitting 12 likewise provides an upwardly facing shoulder 13 which abuts the lower end of the upper cylinder liner 10 so that the liner 10 is clamped in place between the shoulders 9 and 13.

The fitting 12 is provided with external threads 15 adapted to receive the upper end of the upper packer sleeve 16. This upper packer sleeve 16 is internally threaded at 17 to receive the packer mandrel 18 and the lower end of this mandrel is threaded into the lower packer sleeve 19 as shown at 20. Intermediate its ends the mandrel 18 is provided with an enlargement 21 against which are abutted the composite ring clamps 22 and 23 respectively which carry the upper and lower packer cups 24 and 25. Each of these cups is provided with a lip, the upper of which extends upwardly as shown at 26 and the lower of which extends downwardly as shown at 27 and both of which are normally of a size slightly larger than the interior of the casing so that they will bear lightly against the inner surface of the casing even when not subjected to fluid pressure. It will be seen that pressure from above encountering the upper packer 24 will tend to spread the lip 26 outwardly and urge it into more firm engagement with the casing and likewise that pressure from below will tend to urge the lip 27 more firmly into engagement with the casing.

The packer sleeve 16 is provided with a downwardly facing shoulder externally of the mandrel 18 and this shoulder is in turn provided with a lip 28 adapted when the sleeve is moved downwardly to engage the lip 26 on the packer element 24 and draw it inwardly away from the casing so that it may be moved readily through the casing. Likewise the packer sleeve 19 is provided with a lip 28*a* adapted to engage the lip 27 on the lower packer element 25 when the assembly is being moved upwardly through the casing.

The lower packer sleeve 19 is threaded at 29 to the cross over fitting 30 which has lateral openings 31 therethrough to permit flow from the upper producing zone through the openings 2 to pass inwardly through the openings 31 and into the upper cylinder as will be presently described. It will be understood that by "lateral openings" is meant any openings which will conduct fluid from the exterior of the cross over fitting to the interior thereof as distinguished from axially extending openings conducting fluid from one end of the fitting to the other. This cross over fitting also has a series of axially extending openings or passageways 32 extending between and in non-communicating relation to lateral openings 31 so as to provide for the conduct of fluid upwardly from the upper end of the lower cylinder as will likewise be presently described. These passageways 32 communicate at their upper ends with an annular space between the interior of the packer mandrel 18 and a thin walled tube 33. The lower end of this tube 33 is seated within the cross over fitting on an upwardly facing shoulder 34 as shown in Fig. 3 and the tube extends upwardly partly through the upper packer sleeve 16 within which it is sealed by means of the packing 35 held in place by the gland nut 36. The annular space 37 thus formed between the mandrel 18 and the tube 33 provides a conduit for the upward conduction of fluid emerging from the passageways 32 in the cross over fitting 30. At the upper end of this annular space 37 communication is had through ports 38 in the upper packer sleeve 16 between the annular space 37 and the annular space 39 between the casing 1 and the tubing 4. Thus flow from the lower pumping mechanism is conducted to the surface of the ground through the annular space 39, after emerging from the annular space 37 by which it is conducted through the packer.

The lower end of the cross over flow connection 30 is provided with exterior threads 40 which receive the swedge fitting 41, to the lower reduced end of which is threaded as at 42 a coupling 43 receiving the section of tubing 44 which extends downwardly to the lower producing zone to be pumped. At an appropriate place on this tubing 44 there is provided a packer 45 which may be of any suitable conventional construction such as for example the packer formed by the elements 24 and 25 previously described. To the lower end of this tubing 44 is threaded a special coupling 45*a* which is internally threaded at its lower end to receive the upper end of the tubular guide 46 for the lower pumping cylinder.

The cross over fitting 30 is also interiorly threaded at its lower end to receive the tubular latching member 47. This tubular member 47 extends downwardly from the cross over fitting 30 and is split adjacent its lower end into a plurality of spring fingers 48 having recesses 49 therein for a purpose presently to be described. Just below the recesses 49 are projections 50 which normally extend inwardly in a radial direction to provide an effective internal diameter less than that of the main portion of the tubular body 47. The extreme lower ends of these fingers are inwardly beveled at 51 so that they may be spread apart slightly by an object of slightly larger diameter than the effective diameter between the projections 50 being pulled up from below.

The reciprocating portions of the pumping mechanism just described are carried on conventional pumping or sucker rods 52 which may be reciprocated by the usual means at the top of the well or by any other means for applying power to them either at the top of the well or adjacent the pump itself.

To the lower end of the string of sucker rods is secured in this instance the upper traveling valve 53 consisting of a cage 54 in which is carried a ball valve 55 adapted to seat against a valve seat 56 carried on the upper end of the fitting 57. To the lower end of the fitting 57 is secured the polished tubular member 58 which forms the body of the upper pump plunger and is adapted to closely but slidingly fit within the cylinder liner 10. The lower end of this tubular member is connected by a fitting 59 with a special fitting 60 having radial flow passages 61 therethrough so that flow of fluid may take place up-

wardly through the pump liner 10, inwardly through the openings 61, thence upwardly through the fitting 59, hollow plunger body 58 and fitting 57 to pass through the traveling valve 55 and out through the openings in the cage 54 into the space within the tubing 4 around the sucker rods 52, and thence to the surface of the ground through the tubing 4.

The lower end of the fitting 60 is threaded to a rod 62 which in this instance is a solid polished rod that extends down through the tubular member 33 and the standing valve at the lower end thereof. This standing valve consists of an annular valve body 63 provided with a conical or spherical seat portion 64 around its upper end, an upstanding portion provided by the split fingers 65 extending above the seat portion and terminating in the lateral lugs 66. Intermediate its ends this body is provided with a lateral projection having a reduced portion adapted to receive packing 67 to form a seal about the body within the tubular member 33. Extending longitudinally through this lateral projection to bypass the packing 67 are flow passages 68, which emerge through the seat 64. This body 63 may be made in any suitable manner such as by making the parts which are inwardly and outwardly respectively from the passages 68 as separate tubular members, slipping them together, inserting spacers between them to provide passages 68, securing the parts together, and subsequently finishing the seat 64 on the composite body. Slidably carried about the upstanding parts 65 and adapted to seat against the seat 64 when in its lowermost position is an annular or ring valve 69. This ring valve is placed over the parts 65 by forcing them together to decrease their overall diameter at their upper ends before the rod 62 is put through the body. These parts 65 may then expand to admit rod 62 and lugs 66 will serve as upper limit stops for the valve ring 69. It will be seen that this arrangement permits flow upwardly from the lateral openings 2 in the casing and 31 in the cross over fitting through the passageways 68 in the valve body 63 and into the tubular member 33 and thence to the upper pumping cylinder, but that flow downwardly cannot take place along this path because the ring valve 69 will seat on the seat 64 and prevent it.

The valve body 63 is of an internal diameter to snugly but slidably engage the polished rod 62, and it is threaded at its lower end to receive a coupling 70 which carries a nipple 71 on which is mounted packing 72 to seal the nipple within the latching tube 47. Secured to the lower end of this nipple is a stuffing box element 73 having packing 74 therein to provide a seal about the polished rod 62. The lower end of this fitting 73 is threaded to an inner latching member 75 which in a manner similar to the tubular latching member 47 is of tubular formation at its upper end and is split to form flexible fingers 76 adjacent its lower end. These flexible fingers 76 have outwardly extending projections 77 thereon adapted to fit in the recesses 49 and downwardly and inwardly inclined lower end projections 78 below the projections 77.

Below the latching mechanism just described the polished rod is threaded into a special coupling 79 having an outwardly flared upper end 80 adapted when moved upwardly by an upward movement of the polished rod to engage with the downwardly and inwardly inclined projections 78 and draw the latching fingers 76 inwardly toward each other so as to make them readily removable

from the latching fingers 48. When the device is being run into a well, a shear screw is employed in the threaded openings shown in one of the projections 78 and the flared upper end 80 of coupling 79, to hold the flared end portion 80 in engagement with the projections 78 until such time as the packing arrangement and upper standing valve is moved into its correct position as indicated in the drawing. This is shown in Fig. 14 where 80a designates the shear screw. In this connection it is noted that the shoulder on the lower side of the projections 77 and that at the lower extremity of the notched portion 49 is a square shoulder so that the engagement of these parts positively limits downward movement of the packing arrangement and the standing valve unit, whereas, the surfaces on the upper sides of the projections 77 are inclined so that upon forcible upward movement the fingers 76 will be moved inwardly to permit upward movement of the packing and standing valve assembly.

To the lower extremity of the special fitting 79 is secured an additional length of sucker rod 81 which is connected by means of a connector 82 at its lower end with the pump rod 83. The pump rod 83 carries at its lower end a hollow pump plunger consisting of the cage 84 having radially opening passages therethrough as shown at 85, the tubular plunger body 86, and the traveling valve cage 87 with the traveling valve 88 therein at the lower end of the body 86. The body 86 is adapted to fit slidably but snugly within the lower pumping cylinder 89 that carries the standing valve cage 90, standing valve 91 and the standing valve seat 92 at its lower end. At its upper end this lower pumping cylinder is connected to a pack off arrangement consisting of a fitting 93 secured to a mandrel 94 carrying packing rings 95. This mandrel is of such size that flow may take place upwardly through the annular space between it and the pump rod 83. A bumper cage 96 is secured to the upper end of the mandrel 94 and has radial passages 97 therethrough so that fluid flowing from the lower pumping cylinder up through the annular space within the mandrel 94 may pass out through the openings 97 and into the annular space between the tubing 44 and the sucker rod 81.

It will be seen that when the cage 84 is pulled upwardly by upward movement of the sucker rods the shoulder at its upper end will engage beneath the fitting 93 and pull this fitting together with the lower pumping cylinder 89 and the standing valve at the lower end thereof upwardly out of the well. When being run in, it will be seen that the shoulder at the lower end of the fitting 82 may be made to engage with the upper end of the cage 96 to force the packing arrangement at the upper end of the lower pumping cylinder together with the lower pumping cylinder itself and the lower standing valve into operative position.

The pumping structure just described is provided with packings above and below the openings 2 in the casing and the openings 31 in the cross over fitting, which openings supply fluid to the upper pumping cylinder. Fluid from the lower pumping cylinder flows upwardly through the standing valve at the lower end of the lower pumping cylinder, thence through the traveling valve and hollow plunger in the lower pumping cylinder, thence upwardly through the passages 32 in the cross over fitting, and through the annular space 37 and passages 38 into the annulus 39 within the casing and about the tubing above the pump. Flow to the upper pumping cylinder

takes place through the passages 68 in the standing valve, upwardly through the tubular member 33 and into the upper pumping cylinder 8, thence through the upper hollow plunger and traveling valve and the openings 54 into the annulus within the tubing 4 and about the sucker rods 52, and thence to the surface.

The pump just described is intended for use in a well in which the production pumped by the upper pumping cylinders is of the so-called high fluid level type in which there is sufficient pressure within the formation to raise the fluid substantially above the openings 2 through which it flows into the casing. This arrangement makes it possible for the flow from the lower pumping cylinder after being conducted through the cross over fitting 30, to flow a relatively short distance through the packer mandrel 18 and thence into the casing annulus 39 and on to the surface of the ground. This avoids the necessity for a structure for conducting this flow to the upper end of the upper pumping cylinder before emptying it into the casing annulus, and inasmuch as the pressure within the formation is assumed to be sufficient to force the fluid upwardly through the tubular member 33 and into the relatively high upper pumping cylinder 8 this arrangement will work very satisfactorily. As will be presently described, a slightly different arrangement is provided as shown in Figs. 7, 8 and 9 for use in those cases in which the fluid level produced from the upper formation is not high enough to permit the use of this structure.

It will be seen furthermore that the packing 74 which surrounds the polished rod between the two pumping cylinders, the upper standing valve, the lower pumping cylinder and the lower standing valve, can all be either inserted or removed or both with the sucker rods, thus avoiding the necessity of pulling the tubing for the replacement of any of these elements. It is noted for example that not only is it possible to replace a lower worn pumping cylinder but it is also possible to replace a lower cylinder with a cylinder of different size in the event that becomes desirable.

It is further noted that by virtue of the fitting 79 and the shear screw used in securing this fitting to the projections 78 while the assembly is being run into a well, it is possible both to hold the portion of the latching mechanism on the lower end of the packing assembly in inactive position, and to pull the packing assembly and the upper standing valve into seated position without any danger of injuring them such as might occur if they were pushed into seated position. As soon as they have been seated the shear screw can be broken and the parts will be properly positioned, as illustrated, by means of the engagement between the parts on the latching fingers 48 and 76. In this connection it is noted that the fingers 48 are made in this fashion rather than as a complete annular member all the way to the lower end because of the possibility that the lower pumping cylinder might be of an outer diameter too large to pass between the inwardly extending projections 50 unless these projections could move apart.

It is further to be noted that the flow from the lower pumping cylinder passes upwardly through the lower plunger and traveling valve and up through and out of the upper end of this cylinder and thus that it is unnecessary to provide a separate conduit outside of this cylinder for conducting this flow upwardly therefrom.

Referring now to Figs. 7, 8 and 9 there is illustrated a somewhat modified form of arrangement for the upper portion of the pumping mechanism. In this instance a coupling 101 is provided to which the upper end of the upper packer sleeve 16 is secured, and the coupling 101 is secured directly to the lower end of the tubing. The packer structure need not be described in detail as it is identical with that heretofore described both in structure and in operation, although it differs in location in that it is located substantially above the upper pumping cylinder. Thus, the lower packer sleeve 19 instead of being connected directly to the cross over fitting 30 is connected to a special fitting 102 having longitudinal passageways 103 therethrough. The tubular member 33 is seated in a counterbored portion in the upper end of the fitting 102 in identically the same manner that in the previous illustration it was seated within a counterbored portion in the upper end of the cross over fitting 30. Welded at 104 to the exterior of the lower end portion of the fitting 102 is a sleeve 105 which extends downwardly from the fitting 102 to the cross over fitting 106 which is similar to but differs slightly from the cross over fitting 30 heretofore described. This fitting 106 has lateral openings 107 therethrough for receiving the fluid flow from the openings 2 in the casing and conducting it inwardly to be received into the upper pumping cylinder, and similarly has axially extending passages 108 for conducting flow from the lower pumping cylinder upwardly into the annular space within the sleeve 105.

Threaded to the interior of the lower end portion of the fitting 102 is a fitting 109 which is threadedly engaged with the upper end of the upper pumping cylinder jacket 110. The space between the exterior of the upper end of the upper pumping cylinder jacket 110 and the interior of the sleeve 105 provides an annular passage for the fluid from the lower pumping cylinder. Located within the upper pumping cylinder jacket 110 is the upper pumping cylinder liner 111 which bears at its upper end against the shoulder 112 within the fitting 109 and at its lower end upon the shoulder 113 within the fitting 114 which is threaded to the lower end of the upper pumping cylinder jacket. The lower end of this fitting 114 is in turn threaded into the interior of the upper end portion of the cross over fitting 106.

The remaining structure of the pumping mechanism shown in Figs. 7, 8 and 9 is identical with that heretofore described.

It will be seen that in this modified construction illustrated in Figs. 7, 8 and 9 it is possible to place the upper pumping cylinder just above and immediately adjacent to the intake openings 107 in the cross over fitting 106, and that the position of this cross over fitting 106 may be so adjusted that flow coming in from the upper producing formation will rise within the upper pumping cylinder. In order to place the upper pumping cylinder in this relatively low position, however, it is necessary to provide the extra structure consisting of the sleeve 105 and the cooperating parts for conducting the flow from the lower pumping cylinder past the upper pumping cylinder so that it may be passed through the interior of the packer, which in this instance is located above the upper pumping cylinder. In all other respects, the operation of this form of device is identical with that of the form previously described.

Referring now to Figs. 10, 11 and 12, there is

illustrated a modified form which may be used in place of the arrangement for the lower pumping cylinder and its related parts as the same were illustrated in Figs. 4, 5 and 6.

In this modification, the parts are the same and operate in the same manner down to the coupling **45***a* shown in Fig. 5. Instead of this coupling, the modified form referred to includes as shown in Fig. 11 a coupling **201**. This coupling is not intended to receive a packing structure such as is secured to the upper end of the lower pump cylinder in Fig. 5, but is instead provided with a downwardly facing shoulder **202** adapted to abut against the upper end of a pump liner **203** for the lower pumping cylinder jacket **204**. This lower pumping cylinder jacket is threadedly mounted within the lower end of the coupling **201** and is adapted to snugly embrace the liner **203**.

On its lower end, the pumping cylinder jacket is threaded into the upper end of another special coupling **205** which is provided with an upwardly facing shoulder **206** adapted to abut the lower end of the lower cylinder liner **203** thus clamping the same in position.

This coupling **205** is threaded to receive a tail pipe **207** at its lower end if such a pipe be desired, and intermediate its ends is provided with an inner upwardly facing conical seat **208** which receives and seats a base member **209** for the standing valve cage **210**. The standing valve **211** is carried within this cage, and mounted on the upper end of the cage is a projection **212** with a head **213** by which the standing valve may be removed.

The plunger and traveling valve are in substance the same as that illustrated in Fig. 6 but instead of the plain nut which holds the traveling valve seat in place in Fig. 6, there is a special nut **214** having a bayonet socket **215** adapted to be engaged over the head **213** so that the standing valve may be pulled from the well with the traveling valve upon removal of the sucker rods.

It will be seen that by the arrangement just described every advantage can be obtained that can be obtained with the structures shown in Figs. 4, 5 and 6 with the exception that in order to replace the lower pump cylinder jacket or liner it is necessary to pull the tubing, whereas in the structures shown in Figs. 4, 5 and 6 the lower pump cylinder may be replaced by merely pulling the rods. On the other hand, the structure shown in Figs. 10, 11 and 12 makes possible the use of a larger lower cylinder structure than would be possible with the structure shown in Figs. 4, 5 and 6.

Except as noted, the structure shown in Figs. 10, 11 and 12 will operate in the same manner as that shown in Figs. 4, 5 and 6.

It will be appreciated that not only may the upper end structure of the pump shown in Figs. 1 to 6 inclusive be replaced by the modified form of upper end structure shown in Figs. 7, 8 and 9 so that the upper end structure shown in Figs. 7, 8 and 9 is employed in conjunction with the lower end structure shown in Figs. 4, 5 and 6, but it is also possible to substitute the lower end structures shown in Figs. 10, 11 and 12 for that shown in Figs. 4, 5 and 6 and thus to employ the upper end structure shown in Figs. 1, 2 and 3 with the lower end structure shown in Figs. 10, 11 and 12. Furthermore, it is possible to replace both the upper end structure shown in Figs. 1, 2 and 3 with that shown in Figs. 7, 8 and 9 and the lower end structure shown in Figs. 4, 5 and 6 with that shown in Figs. 10, 11 and 12 so that the upper end structure shown in Figs. 7, 8 and 9 may be used in conjunction with the lower end structure shown in Figs. 10, 11 and 12. The combination of upper and lower end structures desired will be selected in accordance with the conditions and circumstances of the particular well in which the pump is to be employed.

Thus, the upper end structure shown in Figs. 1, 2 and 3 will be employed in all cases where the fluid level of the upper producing formation is high enough to warrant the use of such a structure because it is less expensive and more trouble free than that shown in Figs. 7, 8 and 9, and the upper end structure shown in Figs. 7, 8 and 9 will be used in all cases where the fluid level of the upper producing formation is insufficient to permit the use of the structure shown in Figs. 1, 2 and 3.

Likewise, the lower end structure shown in Figs. 4, 5 and 6 will be employed in all cases where the use of a liner of maximum size in the lower pumping cylinder is not imperative and where it may be desired to change the effective size of the lower pumping cylinder from time to time, but where such change in size is not essential and it is not anticipated that a vast amount of wear will be encountered in the pump liner, the cheaper structure shown in Figs. 10, 11 and 12 will be employed.

While the structures shown and described have been designed for pumping fluid from two different zones and have been referred to as two-zone pumps, it is to be understood that this invention is not limited strictly to pumping from two zones only, but that it may be used in conjunction with other structure embodying the same or different principles for pumping from any number of zones. The use of the term "two-zone" in this specification and the appended claims is intended only to refer to the fact that the invention is useful for pumping from two zones and is not intended as limiting the invention to use in situations where there are only two zones being pumped.

From the foregoing it will be appreciated that a means has been provided for carrying out and accomplishing all of the objects and advantages sought by this invention.

Having described my invention, I claim:

1. A well pump adapted to be disposed in a well casing and comprising two cylinders in substantially axial alignment with each other, a hollow pump plunger in each cylinder, said plungers having travelling valves for controlling flow of fluid therethrough, an operating rod for the lower plunger interconnecting said plungers, means sealing the upper end of said lower cylinder about said rod, means providing lateral intake openings for said upper cylinder at a location between the two cylinders and a passageway for conducting fluid from the upper end of said lower cylinder above the plunger therein past said intake openings, a packer above and a packer below said lateral intake openings for forming spaced seals between the pump and a well casing, and conduit means for conducting fluid from the passageway from the lower cylinder through the upper packer and exteriorly of the upper cylinder.

2. A well pump adapted to be disposed in a well casing and comprising two cylinders in substantially axial alignment with each other, a plunger in each cylinder, an operating rod for the lower plunger interconnecting said plungers,

means sealing the upper end of said lower cylinder about said rod, means providing lateral intake openings for said upper cylinder at a location between the two cylinders and a passageway for conducting fluid from the upper end of said lower cylinder past said intake openings, a packer above and a packer below said lateral intake openings for forming spaced seals between the pump and a well casing, the upper of said packers being located below the lower end of the upper cylinder, and conduit means for conducting fluid from the passageway from the lower cylinder through the upper packer and exteriorly of the upper cylinder.

3. A well pump adapted to be disposed in a well casing and comprising two cylinders in substantially axial alignment with each other, a plunger in each cylinder, an operating rod for the lower plunger interconnecting said plungers, means sealing the upper end of said lower cylinder about said rod, means providing lateral intake openings for said upper cylinder at a location between the two cylinders and a passageway for conducting fluid from the upper end of said lower cylinder past said intake openings, a packer above and a packer below said lateral intake openings for forming spaced seals between the pump and a well casing, the upper of said packers being located above the upper end of the upper cylinder, and conduit means for conducting fluid from the passageway from the lower cylinder through the upper packer and exteriorly of the upper cylinder.

4. A two-zone well pump comprising upper and lower pumping cylinders, a plunger reciprocable in each cylinder, a rod interconnecting said plungers, said lower cylinder having an intake opening at its lower end, a standing valve in said opening, means mechanically interconnecting said cylinders and providing a lateral opening into the lower end of the upper cylinder and a longitudinal passageway from the upper end of the lower cylinder past said lateral opening, a packing assembly forming a seal between said rod and the upper end of the lower cylinder, an annular standing valve assembly surrounding said rod above said lateral opening and spaced from said packing assembly to provide an intake valve for the upper cylinder, and means mechanically interconnecting said packing assembly and annular standing valve assembly to space them apart by a predetermined distance and form them into a combined unitary assembly.

5. A two-zone well pump comprising upper and lower pumping cylinders, a plunger reciprocable in each cylinder, a rod interconnecting said plungers, said lower cylinder having an intake opening at its lower end, a standing valve in said opening, means mechanically interconnecting said cylinders and providing a lateral opening into the lower end of the upper cylinder and a longitudinal passageway from the upper end of the lower cylinder past said lateral opening, a packing assembly forming a seal between said rod and the upper end of the lower cylinder, an annular standing valve assembly surrounding said rod above said lateral opening and spaced from said packing assembly to provide an intake valve for the upper cylinder, and means mechanically interconnecting said packing assembly and annular standing valve assembly to space them apart by a predetermined distance and form them into a combined unitary assembly, said combined packing assembly and standing valve assembly being removable upwardly through the upper cylinder, as a unit, and means for positioning said combined packing assembly and standing valve assembly between said cylinders with the packing assembly below and the standing valve assembly above said lateral opening.

6. A two-zone well pump comprising upper and lower pumping cylinders, a plunger reciprocable in each cylinder, a rod interconnecting said plungers, said lower cylinder having an intake opening at its lower end, a standing valve in said opening, means mechanically interconnecting said cylinders and providing a lateral opening into the lower end of the upper cylinder and a longitudinal passageway from the upper end of the lower cylinder past said lateral opening, a packing assembly forming a seal between said rod and the upper end of the lower cylinder, an annular standing valve assembly surrounding said rod above said lateral opening and spaced from said packing to provide an intake valve for the upper cylinder and means mechanically interconnecting said packing assembly and annular standing valve assembly to space them apart by a predetermined distance and form them into a combined unitary assembly, said combined packing assembly and standing valve assembly being removable upwardly through the upper cylinder as a unit, and means for positioning said combined packing assembly and standing valve assembly between said cylinders with the packing assembly below and the standing valve assembly above said lateral opening, said positioning means including downwardly extending resilient spaced fingers on said combined unitary assembly, said fingers having radially outwardly projecting portions and downwardly and inwardly inclined lower end portions and being biased to a normally expanded position with respect to each other, and retracting means on said rod below said positioning means adapted when said rod is pulled upwardly to engage the exteriors of said inclined portions and move said fingers inwardly to a retracted position to release the positioning means.

7. A two-zone well pump comprising upper and lower pumping cylinders, a plunger reciprocable in each cylinder, a rod interconnecting said plungers, said lower cylinder having an intake opening at its lower end, a standing valve in said opening, means mechanically interconnecting said cylinders and providing a lateral opening into the lower end of the upper cylinder and a longitudinal passageway from the upper end of the lower cylinder past said lateral opening, a packing assembly forming a seal between said rod and the upper end of the lower cylinder, an annular standing valve assembly surrounding said rod above said lateral opening and spaced from said packing assembly to provide an intake valve for the upper cylinder and means mechanically interconnecting said packing assembly and annular standing valve assembly to space them apart by a predetermined distance and from them into a combined unitary assembly, said combined packing assembly and standing valve assembly being removable upwardly through the upper cylinder as a unit, and means for positioning said combined packing assembly and standing valve assembly between said cylinders with the packing assembly below and the standing valve assembly above said lateral opening, said positioning means including downwardly extending resilient spaced fingers on said combined unitary assembly, said fingers having radially outwardly projecting portions and downwardly and in-

wardly inclined lower end portions and being biased to a normally expanded position with respect to each other, retracting means on said rod below said positioning means adapted when said rod is pulled upwardly to engage the exteriors of said inclined portions and move said fingers inwardly to a retracted position to release the positioning means, and frangible means for initially holding said retracting means in engagement with said fingers to hold them retracted during downward movement of the packer and standing valve assembly into position.

8. A two-zone pump for use in a well casing or the like comprising upper and lower substantially axially aligned cylinders, means mechanically interconnecting said cylinders in spaced relation to each other and providing a lateral opening for fluid to the lower end of the upper cylinder and a longitudinal passage for fluid from the upper end of the lower cylinder past said lateral opening to a position above the lateral opening and exteriorly of the upper cylinder, said lower cylinder having an intake opening at its lower end, a standing valve at the lower end of the lower cylinder and an annular standing valve between said lateral opening and the lower end of the upper cylinder, a combined hollow plunger and traveling valve in each cylinder, a rod interconnecting said hollow plungers, a packing surrounding said rod and forming a seal between the rod and the upper end of the lower cylinder, packers for providing a seal about the pump within a well casing above and below said lateral opening respectively, and means for conducting fluid discharged from the upper end of said lower cylinder past said upper packer and into the annular space surrounding the upper cylinder.

9. A two-zone well pump for use in a well casing or the like comprising a pair of substantially axially aligned cylinders, a plunger in each cylinder, a rod connecting said plungers, a packing providing a seal between said rod and the upper end of the lower cylinder, an annular standing valve spaced above said packing for controlling flow into the upper cylinder, means mechanically interconnecting the cylinders and providing a lateral opening between said packing and standing valve for flow into the upper cylinder, a standing valve carried by the lower end of said lower cylinder for controlling inflow into the lower end of said lower cylinder, said standing valves, lower cylinder, and packing being removable upwardly through said upper cylinder, and means carried by said rod for engaging said lower cylinder, packing and standing valves to remove them through said upper cylinder upon upward movement beyond the normal pumping travel of said rod.

10. A two-zone well pump for use in a well casing or the like comprising a pair of substantially axially aligned cylinders, a plunger in each cylinder, a rod connecting said plungers, a packing providing a seal between said rod and the upper end of the lower cylinder, an annular standing valve spaced above said packing for controlling flow into the upper cylinder, means mechanically interconnecting the cylinders and providing a lateral opening between said packing and standing valve for flow into the upper cylinder, said standing valve, lower cylinder, and packing being removable upwardly through said upper cylinder, and means carried by said rod for engaging said lower cylinder, packing, and standing valve to remove them through said upper cylinder upon upward movement beyond the normal pumping travel of said rod.

11. In a two-zone pump for use in a well casing or the like, a pair of substantially axially aligned pumps each comprising a pumping cylinder having an intake opening adjacent its lower end and a discharge opening adjacent its upper end, a standing valve in each intake opening, a hollow plunger and traveling valve in each cylinder, a rod connecting said plungers, a packing providing a seal between said rod and the upper end of the lower cylinder, said rod, packing, and plunger in the lower cylinder being removable upwardly through the upper cylinder, means mechanically connecting said two cylinders to provide a unitary assembly, a tubing connected to the outlet of said upper cylinder, a conduit connected to the outlet of said lower cylinder and discharging into the space surrounding said tubing, and spaced packers surrounding said assembly above and below the intake for said upper cylinder respectively.

12. A two-zone pump for use in well casings or the like comprising a pair of substantially axially aligned cylinders, a plunger in each cylinder, a rod connecting said plungers, a packing providing a seal between the said rod and the upper end of the lower cylinder, a standing valve carried by the lower end of said lower cylinder for controlling inflow into the lower end of said lower cylinder, said standing valve, lower cylinder and packing being removable upwardly through said upper cylinder, and means carried by said rod for engaging said lower cylinder, packing and standing valve to remove them through said upper cylinder upon upward movement beyond the normal pumping travel of said rod.

13. A two-zone well pump for use in a well casing or the like comprising a pair of substantially axially aligned cylinders, a plunger in each cylinder, a rod connecting said plungers, a packing providing a seal between said rod and the upper end of the lower cylinder, a standing valve spaced above said packing for controlling flow into the upper cylinder, a second standing valve adjacent the lower end of the lower cylinder for controlling flow into the lower cylinder, means mechanically interconnecting the cylinders and providing a lateral opening between said packing and first standing valve for flow into the upper cylinder, said second standing valve, lower cylinder and packing being removable upwardly through said upper cylinder, means carried by said rod for engaging said lower cylinder, packing and said second standing valve to remove them through said upper cylinder upon upward movement beyond the normal pumping travel of said rod, a packer above and packer below said lateral intake opening for forming spaced seals between the pump and a well casing, the upper of said packers being located below the lower end of the upper cylinder, and conduit means for conducting fluid from the lower cylinder through the upper packer to the space exteriorly of the upper cylinder.

14. A two-zone well pump for use in a well casing or the like comprising a pair of substantially axially aligned cylinders, a plunger in each cylinder, a rod connecting said plungers, a packing providing a seal between said rod and the upper end of the lower cylinder, a standing valve spaced above said packing for controlling flow into the upper cylinder, a second standing valve adjacent the lower end of the lower cylinder for controlling flow into the lower cylinder, means mechanically interconnecting the cylinders and providing a lateral opening between said packing and first standing valve for flow into the upper cylinder, said second standing valve, lower cylinder

and packing being removable upwardly through said upper cylinder, means carried by said rod for engaging said lower cylinder, packing and said second standing valve to remove them through said upper cylinder upon upward movement beyond the normal pumping travel of said rod, a packer above and a packer below said lateral intake opening for forming spaced seals between the pump and a well casing, the upper of said packers being located above the upper end of the upper cylinder, and conduit means for conducting fluid from the lower cylinder exteriorly of the upper cylinder and through the upper packer.

15. A two-zone pump for use in well casings or the like comprising a pair of substantially axially aligned cylinders, a plunger in each cylinder, a rod connecting said plungers, a packing providing a seal between the said rod and the upper end of

the lower cylinder, a standing valve carried by the lower end of said lower cylinder for controlling inflow into the lower end of said lower cylinder, said standing valve and packing being removable upwardly through said upper cylinder, and means carried by said rod for engaging said packing and standing valve to remove them through said upper cylinder upon upward movement of the rod beyond the normal pumping travel of said rod.

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The following references are of record in the file of this patent:

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