May 31, 1966 R. P. VINCENT ETAL 3,253,549

FLUID ACTUATED PUMP

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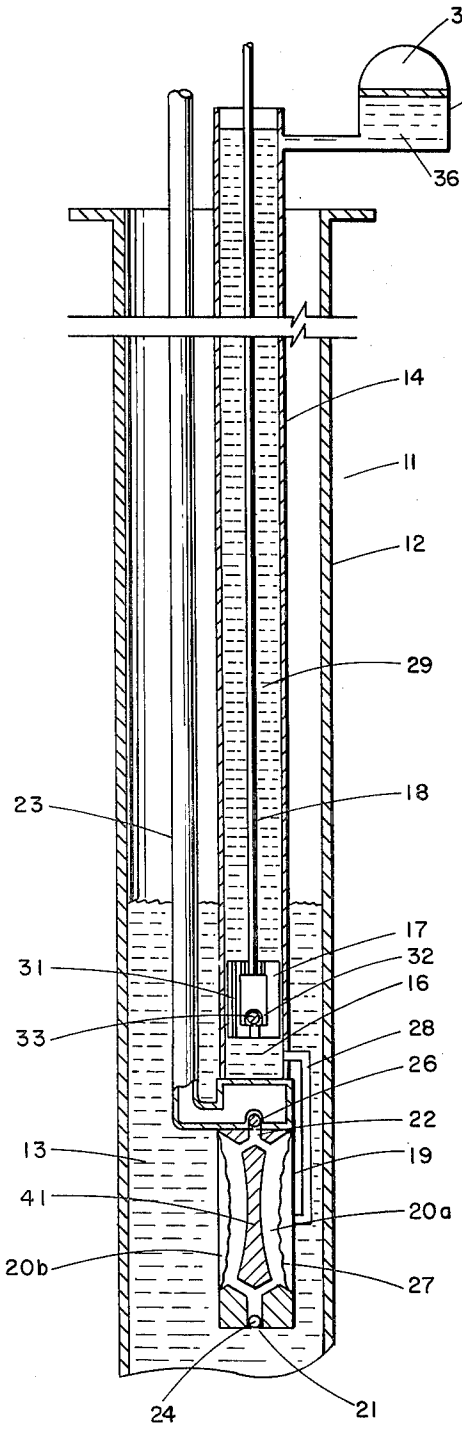

FIG 1

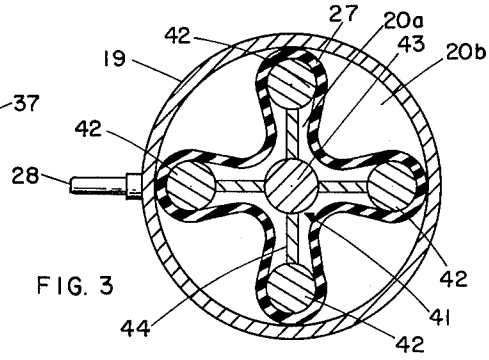

FIG. 3

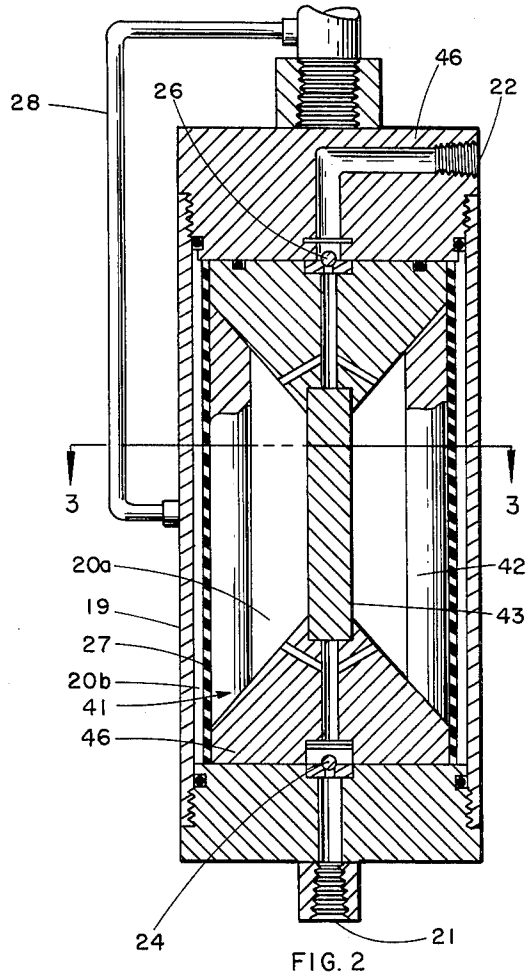

FIG. 2

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FLUID ACTUATED PUMP

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This invention relates to pumping equipment of the type often used in lifting fluids from wells, and more particularly, it relates to a fluid-actuated diaphragm pump for pumping corrosive fluids from a well.

Various reciprocating pumps are available for pumping fluids, such as oil, water or the like from wells, and a number of these pumps have been found satisfactory for handling most ordinary well fluids. However, the lifting of fluids liberated from underground oil-bearing formations by combustion recovery methods presents problems for which there are no feasible solutions at the present time. In some instances it has been necessary to pull pumps employed in such service at two- or three-day intervals to repair either the bottom hole pump or the tubing and sucker rod string because of damage resulting from the corrosive by-products of combustion. Corrosion and abrasion resulting from rod-on-tubing wear and wear of close fitting parts of the bottom hole pump accelerate metal loss on the parts and result in the early failure of the equipment. Needless to say, such maintenance is extremely expensive, and the resulting maintenance costs may, in some instances, render it economically infeasible to recover oil by this method.

An object of the present invention is a fluid-actuated diaphragm pump especially well suited for pumping corrosive or abrasive fluids.

Another object is such a pump wherein the pump fluids contacts a minimum number of moving parts in the pump.

Still another object is such a pump wherein the discharge tubing can be coated with a protective film without the opportunity for mechanical wear which tends to remove such coatings.

Yet, another object is such a pump having no tendency to gas lock.

A still further object is such a pump having increased diaphragm life during service.

Still, a further object is such a pump wherein the correct amount of power fluid employed to actuate the diaphragm is maintained between the diaphragm and a reciprocating plunger.

These and other objects of the invention will become apparent by reference to the following description and accompanying drawing of a preferred embodiment of the invention.

In accordance with the present invention there is provided a pumping device adapted to be connected into a string of well tubing and inserted into a well. A cylinder containing a reciprocating plunger is connected to a pump chamber having a flexible diaphragm, and power fluid, moved by the reciprocating plunger, actuates the diaphragm to pump fluids from the well. A power oil reservoir is provided above the plunger and a valved port between the reservoir and the lower end of the cylinder is provided to permit power fluid to be transferred

to the reservoir when the pressure on the lower end of the plunger exceeds the fluid pressure in the reservoir. Also, means are provided to pass power fluid from the reservoir to the space beyond the lower end of the plunger so the correct amount of power fluid is maintained on the power side of the diaphragm to assure maximum pumping efficiency and prevent gas locking.

A pump of the same general type as that contemplated by the present invention is described in U.S. Patent 2,814,993. The pump of the present invention has been determined to be highly advantageous over such pumps in that pumping efficiency is more easily maintained and the tendency for gas locking is reduced.

The present invention will be more fully understood by reference to the following description of a preferred embodiment thereof, given in connection with the accompanying drawings wherein:

FIGURE 1 schematically illustrates a pumping device according to the invention positioned in a well; and

FIGURE 2 illustrates a vertical cross-sectional view of a pump chamber and diaphragm employed in the device of FIGURE 1; and

FIGURE 3 is a sectional view of the chamber of FIGURE 2, taken at line 3—3.

Referring now to the drawings, wherein like numbers are employed in the various figures to designate like elements, a borehole **11** is formed in the earth penetrating one or more fluid-producing formations. Well casing **12** may be employed in the well, and the casing may be perforated opposite the fluid-producing formation, or other suitable means may be provided to admit the formation fluids **13** into the well. A string of well tubing **14** extends from the surface downwardly into the well, and cylinder **16** is connected to the lower end of tubing **14**. This cylinder may be merely an extension of the tubing or may be a separate element connected to the tubing string. Reciprocating plunger **17** is positioned in cylinder **16** and is reciprocated therein by sucker rod string **18** attached thereto and extending to the surface where it is attached to a drive mechanism (not shown) for reciprocating plunger **17**.

Connected to the lower end of cylinder **16** is elongated, cylindrical pump chamber **19** provided with inlet **21** below the level of fluid in the well and outlet **22**. Outlet **22** communicates with discharge tubing **23** which extends upwardly to the surface and conveys the pumped well fluids from the well. Lower standing valve **24** is provided in inlet **21** to permit unidirectional flow of well fluids into the interior of chamber **19**, and upper standing valve **26** is provided in outlet **22** to permit unidirectional flow of fluids from the interior of chamber **19** to discharge tubing **23**.

Positioned on the interior of chamber **19** is a diaphragm member, such as bladder **27** formed of a flexible, fluid impermeable material such as rubber, neoprene or other like materials compatible with the fluids to be handled by the pump. Suitable reinforcing may be used in the diaphragm to secure the necessary strength and durability. While various configurations of diaphragms may be employed, such as a bellows or flexible disc, an expansible and contractable bladder is preferred. The lower end of bladder **27** is connected in a fluid-tight manner to inlet **21** and the upper end connected similarly to outlet **22** to effectively

divide chamber **19** into two variable volume compartments, i.e., a first compartment **20***a* inside the bladder and another compartment **20***b* between the outside of the bladder and the interior wall of the chamber. The second compartment communicates with the lower end of cylinder **16** beyond the end of the stroke of plunger **17** by way of conduit **28** to supply a power fluid, such as a non-corrosive oil or other suitable liquid to the second compartment.

Power fluid reservoir **29** is provided in the annular space between the sucker rod string **18** and tubing **14**. Power fluid is maintained in this reservoir to supply the power fluid to the outside of bladder **27**. Tubing **14** may be partially or completely filled with the power fluid. Power fluid flow channel **31** is provided between the reservoir and the lower end of cylinder **16** so that power fluid may flow from the reservoir into the above-mentioned second compartment to keep it filled. Flow channel **31** may be provided by a relatively small diameter orifice extending through plunger **17**, as shown, or a loose fit between the plunger and the cylinder wall may accomplish the same purpose. Ordinarily, only a relatively small amount of power fluid will be lost from the second compartment **20***b*, and a small orifice, for example, one having an internal diameter of about ⅛ inch, may be used. The cross-sectional area of flow channel **31** should be maintained as small as possible, since pumping efficiency is adversely affected if too great a volume of power fluid is permitted to pass from cylinder **16** to reservoir **29** during the downward stroke of plunger **17**.

A second, larger capacity flow channel, such as valved conduit **32** is provided between reservoir **29** and compartment **20***b*. As shown, travelling valve **33** is positioned in conduit **32** near the lower or working end of plunger **17**, and conduit **32** passes upwardly from the working end of the plunger to the power end, or upper end thereof. Valve **33** permits unidirectional fluid flow from cylinder **16** into reservoir **29**. Normally valve **33** is closed during both the up stroke and down stroke of plunger **17**. However, if too much power fluid is present in cylinder **16** and compartment **20***b*, or if the fluid pressure in compartment **20**b exceeds the fluid pressure at the working end of the plunger, then valve **33** opens to permit the transfer of power fluid from the lower end of plunger **17** to the reservoir above the plunger.

Advantageously, the pressure of the power fluid at the top side of plunger **17**, i.e., at the lower end of reservoir **29** is greater than the hydrostatic head pressure of pumped fluid standing in discharge tube **23** extending to the surface. This may be accomplished by employing as power fluid a fluid of greater density than the formation fluid (where the vertical fluid columns are of equal height), by extending the height of the vertical power fluid reservoir to a level sufficiently greater than the elevation of the outlet end of the discharge tube, or by employing a pressured gas cushion on top of the fluid in reservoir **29**. For example, if the formation fluid is mostly water and the power fluid is an oil, tubing **14** may be filled with oil **36** from surge vessel **37** connected to the upper end of the tubing, and a suitable gas **38**, such as air or nitrogen, may be maintained under pressure in the vapor space above the oil in vessel **37** to achieve the desired pressure differential across the pump.

Advantageously, as shown in FIGURES 2 and 3, an internal support is provided inside of bladder **27**. This internal support **41** comprises an elongate "cage" formed of, for example, four vertical rods **42** equally spaced around the perimeter of the bladder when in the expanded condition. A central vertical rod **43** is connected to the outer rods **42** by vertical plate members **44**. The circumference of the expanded bladder is substantially the same as the internal dimension of chamber **19**, and the perimeter of support **41** is substantially the same as the circumference of the expanded bladder. End pieces **46** are tapered toward the middle in a conical shape. This configuration assures that the rubber-like bladder does not stretch during operation of the pump, and only flexing of the bladder occurs.

In the operation of the pump described above, power fluid is maintained in tubing **14** at the desired pressure. As plunger **17** moves upwardly the pressure in cylinder **16** below the plunger, and consequently in compartment **20***b*, is reduced by the upwardly moving plunger reducing the power fluid pressure below the plunger. Formation fluid pressure causes the formation fluid to enter compartment **20***a* through inlet **21** and expands bladder **27** outwardly against the wall of chamber **19**. When the direction of movement of plunger **17** is reversed and the plunger begins its downward movement and the full pressure of the column of power fluid in reservoir **29** is applied to the outside of bladder **27** to cause it to contract and expel the formation fluid through outlet **22** and into discharge **23** by which the pumped fluid is conveyed to the surface. During the travel of plunger **17** power fluid from the reservoir may pass through flow channel **31** as needed, and if the pressure below the plunger exceeds that above it, valve **33** permits power fluid to move from the space below the plunger to the reservoir as mentioned above.

A pump of the type described above has been constructed and operated very satisfactorily, with a volumetric efficiency very close to 100 percent being achieved at a discharge pressure between 800 and 900 p.s.i.g.

From the foregoing description of a preferred embodiment of the present invention, various alterations and modifications in the construction thereof may become apparent to those having ordinary skill in the art. It will be understood that such alterations and modifications fall within the spirit and scope of the invention as defined by the appended claims.

We claim:

1. A pump for pumping fluids from a well bore which comprises:

a first tubular member suspended within said well, and a power fluid cylinder provided at the lower end of said tubular member;

a second tubular member suspended within said well;

a string of sucker rods within said first tubular member;

a plunger within said power fluid cylinder and connected to said string of sucker rods;

conduit means in said plunger extending axially therethrough, said conduit means having a valve therein permitting unidirectional flow from beneath to above said plunger when the fluid beneath said plunger reaches a given pressure;

a pump chamber adapted to be connected to the lower end of said power fluid cylinder;

a flexible diaphragm member in said pump chamber, said diaphragm dividing said chamber into a first variable volume compartment and a second variable volume compartment;

a valve inlet in communication with said first compartment;

a valve outlet in communication with said first compartment for discharging fluid therefrom, said valve outlet being fluidly connected to said second tubular member;

second conduit means establishing fluid communication between said second variable volume compartment and said power fluid cylinder below said plunger.

2. An apparatus as described in claim **1** in which said plunger has an unobstructed flow channel axially extending therethrough.

3. An apparatus as described in claim **1** including a power fluid within said first tubular member, said fluid being of sufficient head and density so as to have a greater hydrostatic head pressure than that of the fluid being pumped within said second tubular member.

4. An apparatus as defined in claim 1 in which said diaphragm member comprises an expandable and collapsible cylindrical bladder and said apparatus further including an internal support within said bladder, said internal support including equispaced rods spaced inside said bladder around its permieter when in an expanded condition, a central rod, and plate members connecting said central rod with each said rods.

5. An apparatus as described in claim 3 including a surge vessel at the surface in fluid communication with the upper end of said first tubular member.

References Cited by the Examiner

UNITED STATES PATENTS

862,867	8/1907	Eggleston	230—162 X
2,395,330	2/1946	Houser	103—44
2,626,569	1/1953	Knudson	103—46
2,961,966	11/1960	Zillman et al.	103—46

FOREIGN PATENTS

6,657	1894	Great Britain.

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