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[54] **OIL WELL PUMP HAVING GAS LOCK PREVENTION MEANS AND METHOD OF USE THEREOF**

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[52] U.S. Cl. **166/314,** 166/105.5, 166/112, 417/435

[51] **Int. Cl.** **E21b 43/00,** F04b 21/04

[58] **Field of Search** 417/435, 503, 554, 546; 166/314, 105, 105.5, 106, 110, 112, 68

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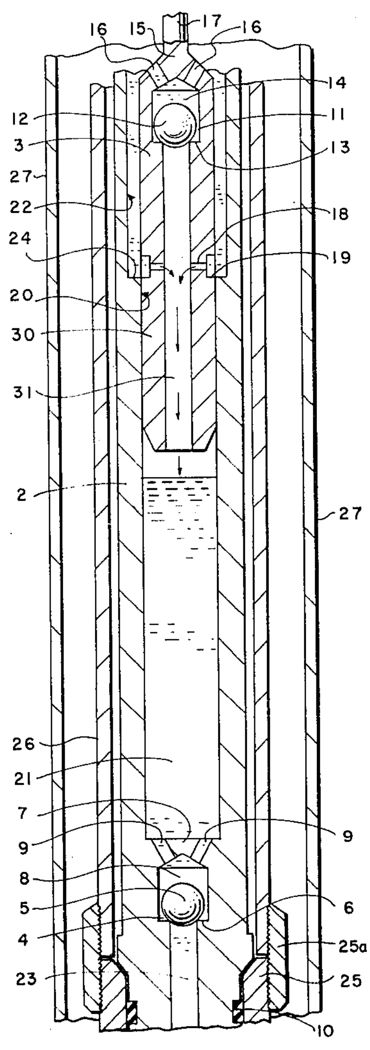
[57] **ABSTRACT**

An oil well pump is disclosed which features gas lock and fluid hammer prevention means utilizing a tubular plunger having relief port means and check valve means therein, said plunger telescopically located in a tubular pump barrel having check valve means and relief passage means therein.

8 Claims, 7 Drawing Figures



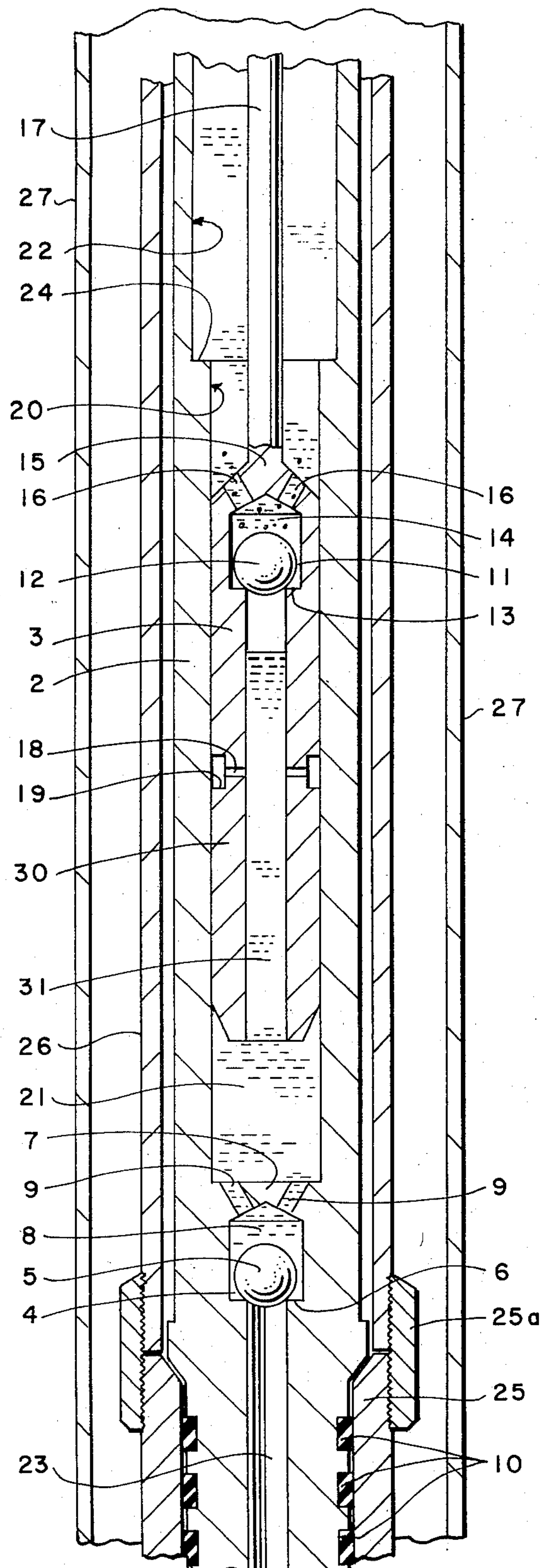

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FIG. 1A

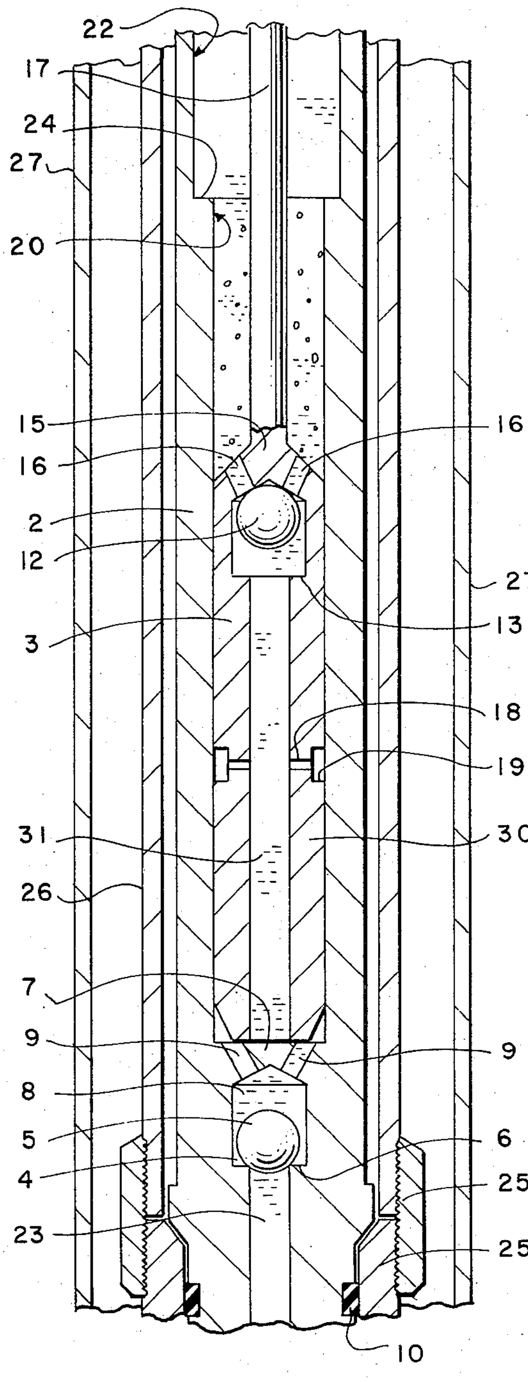
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FIG. 1B

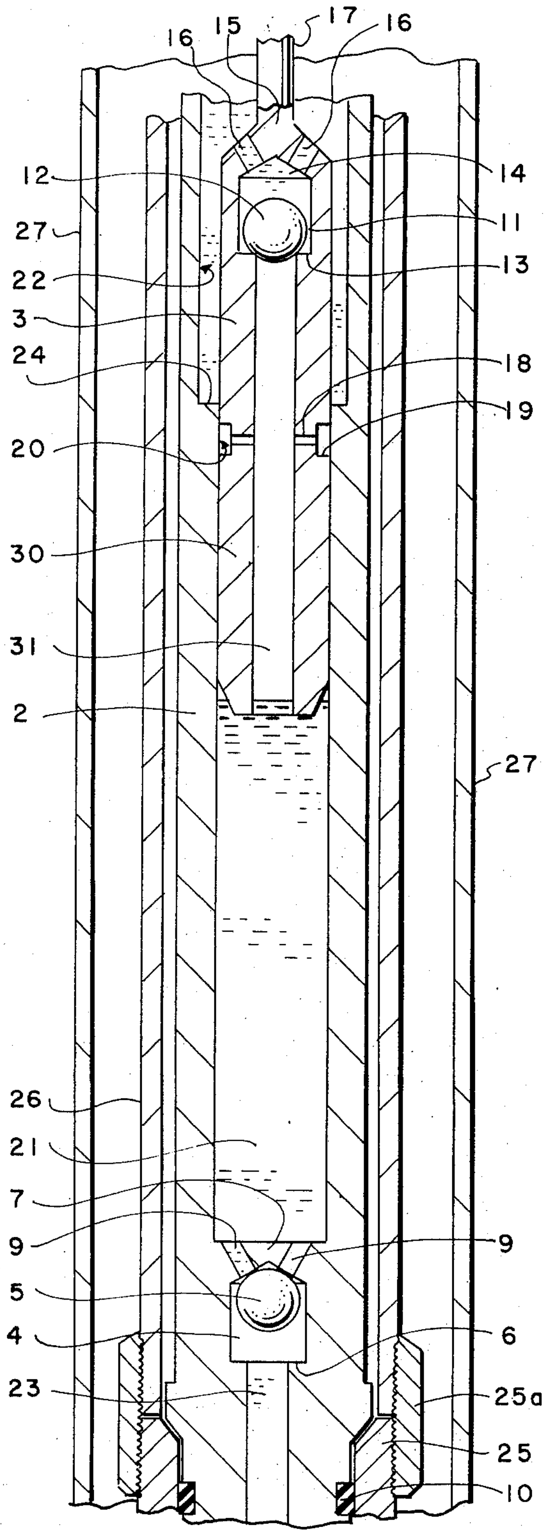
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FIG. 1C

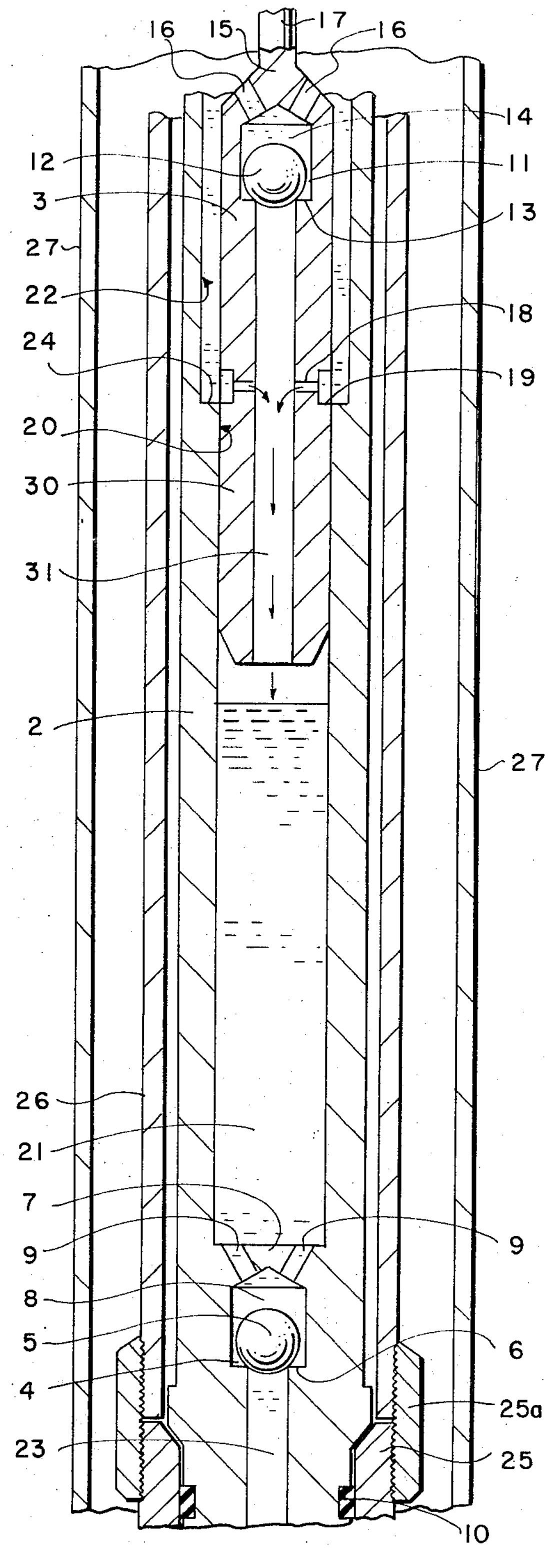
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FIG. 1D

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PRIOR ART

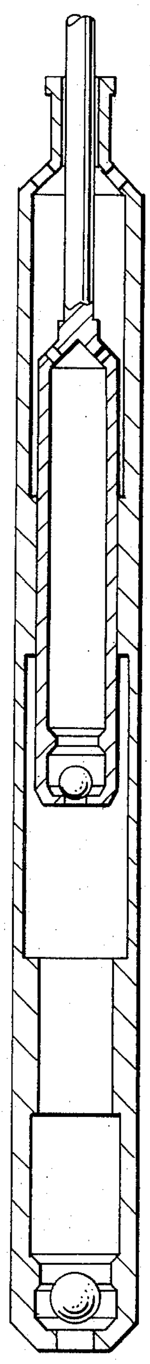

FIG. 2

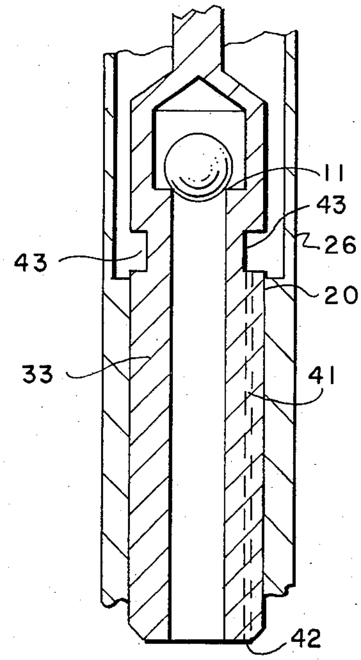

FIG. 3

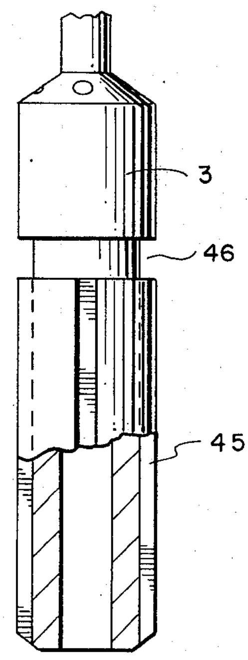

FIG. 4

OIL WELL PUMP HAVING GAS LOCK PREVENTION MEANS AND METHOD OF USE THEREOF

BACKGROUND OF THE INVENTION

In the recovery of liquid hydrocarbons from subteranean formations oftentimes the formation pressure is insufficient to force the liquid petroleum up the oil well bore to the surface and recovery of the desired fluids requires pumping the fluids out of the lower end of the well bore.

This can be accomplished by the use of sucker rod pumps, operating in the casing or production tubing of the well, to lift the liquid hydrocarbons up the well bore where they can be recovered and pumped to processing facilities.

One common type of sucker rod pump utilizes a tubular housing containing a plunger element reciprocably located therein. The housing which is commonly referred to as the pump barrel is usually formed of a tough, heavy tubular metal section with a close-tolerance machined inner bore.

The plunger is also formed of a tough metal tubular or bored section which is machined to close-tolerance to fit snugly within the pump barrel. Usually the barrel will contain a fluid check valve called a standing valve. The plunger will have a similar valve which is called the traveling valve. The barrel has anchor seal means for anchoring in a production string and the plunger section has attachment means for connecting to a reciprocating sucker rod string.

By reciprocating the plunger in the barrel, fluid is moved upward in the production string through the interaction of the two check valve systems.

A most serious problem that often arises in the operation of this type of pump and most other oil well pumps involves the phenomenon of fluid hammer. Another problem associated with fluid hammer is that of gas lock in the pump. Both of these problems result in inefficient operation and accelerated deterioration of the pump assembly.

These problems occur frequently when a well is producing fluid hydrocarbons having compressed or dissolved gas held therein. During the suction stroke of the pump assembly the gas comes out of solution and expands due to the low pressure of the fluid inside the pump. This expanded gas displaces fluid in the pump and reduces the amount of fluid pumped per cycle of pump operation. It often even reaches the point where no fluid is lifted by the pump because the pump merely operates on a charge of gas, alternately compressing and expanding it, and a pump efficiency consequently drops to zero. This is due to the fact that with a large volume of the relatively compressible gas, the pressure between the standing valve and traveling valve on the pump downstroke never reaches high enough level to overcome the hydrostatic pressure of the fluid on top of the traveling valve to open the traveling valve and pump the gas upward out of the pump assembly.

Fluid hammer occurs in a reciprocating oil well pump when, on the downstroke of the plunger, there is a large pocket of gas in the barrel instead of the normal well fluids and the gas offers little resistance to the downward movement of the plunger and sucker string. This results in a swift movement downward of the plunger and a resultant hard impact when it reaches the top of the fluid level in the barrel. This impact is very destructive on the tool parts and greatly reduces the life and efficiency of the pumping apparatus.

Pumps have been designated to alleviate this situation by providing means to allow fluid to drain back under the plunger after it has reached the top of the upstroke, to compress the trapped gas and provide a fluidic cushion for the plunger on its return downstroke.

The deficiencies of these devices are that they greatly lower the efficiency of the pump due to their design. One such unit utilizes a traveling valve which is designed to leak so that it never functions efficiently as a valve. Another design requires the plunger to be raised into an enlarged chamber in the housing so that gas below the plunger can move up around the sides of the plunger into the annular chamber. This is undesirable because on the downstroke the plunger must go from the relatively large chamber into the relatively snug fit in the pump barrel below the chamber. While in the chamber area the pump plunger is allowed to undergo substantial lateral freedom and movement. But, upon entering the lower, restricted section, the plunger may not be aligned with the opening and interference and high lateral and axial forces are introduced into the pump assembly which forces can be as destructive as the fluid hammer effect on the pump parts.

The present invention solves these problems and overcomes these deficiencies by providing a pump assembly utilizing a completely sealing ball valve, a continuously seated pump plunger in the pump barrel, and bypass means in the plunger to allow fluid to compress and drive back into solution gas below the traveling valve and plunger.

BRIEF DESCRIPTION OF THE DRAWING

FIGS. **1A** through **1D** illustrate in schematic cross section the structure and operation of the pump of this invention.

FIG. **2** illustrates a schematic cross-section view of a prior art device.

FIGS. **3** and **4** illustrate alternate embodiments of the apparatus.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The apparatus of this invention is more particularly described in FIG. **1a** in which an elongated tubular pump barrel **2** acts as a housing for reciprocating plunger **3** which is a tubular section having substantially similar outside dimensions to those of the internal dimensions of restricted portion **20** of barrel **2,** so that plunger **3** fits snugly but slidably within portion **20** of barrel **2.** Barrel **2** has relatively tough metal walls and a longitudinal bore passage **21** therethrough, capable of conveying hydrocarbons upward through an oil well bore. Barrel **2** usually has attachment means such as hold down cups **10** at the lower end for connection into a seating nipple **25** threadedly engaged in a standard production tubing string **26** by means of a threaded collar **25a.** The tubing string **26** is concentrically located within the oil well casing **27.**

A standing valve **4** is located in the lower portion of passage **21** and may consist of a standard ball and seat valve with a spherical valve element **5** and a circular valve seat **6** arranged to receive ball **5** and effectively seal off flow of fluid in the downward direction through passage **21.** Upward flow of fluid through standing valve **4** is relatively unhindered by ball **5.**

Pump barrel 2 further has an enlarged bore portion 22 located above bore section 20 and located concentrically around pump plunger 3 providing an annular space between the plunger and the barrel.

A strut or cage structure 7 is located across the upper end of valve cavity 8 to contain ball valve 5 in cavity 8. Strut 7 has openings 9 therethrough to allow fluid flow to pass through the pump. Bore passage 21 is continued below valve 4 as restricted bore 23.

A 3 cup hold down 10 utilizing expanding resilient means may be used on the lower end of barrel 2 to maintain the barrel stationary in the tubing string 26 and nipple 25 during reciprocation of the sucker string and plunger assembly.

The plunger 3 further comprises a tubular elongated section 30 having an axial bore passage 31 passing substantially therethrough, similar in size and flow capacity to bore 23 in barrel 2.

Near the upper end of plunger 3 is the traveling valve 11 comprising spherical valve element 12, valve seat 13, valve cavity 14, cage or strut 15, and fluid passages 16 all similar in structure to standing valve 4.

Below valve 11 are one or more relief ports 18 passing through the wall of plunger 3 from bore 31. A circumferential grooved channel 19 also communicates with ports 18.

Fluid flow upward through passage 21, standing valve 4, and bore passage 21 can continue relatively unhindered through bore 31 past traveling valve 11, through passages 16 and into bores 20 and 22 and consequently on up the production string.

Reciprocation of plunger 3 is achieved through a valve rod 17 attached to the sucker string extending from power driven reciprocating apparatus at the surface (not shown) through the production tubing and pump barrel 2 to plunger 3 where it is attached such as by welding, swaging, threaded connections, or any other known attachment means.

TYPICAL MODE OF OPERATION

In typical operation the apparatus will be located at or near the bottom of the well bore or isolated near a producing zone or formation and will generally exhibit the physical configuration as illustrated in FIGS. 1A through 1D. The production tubing string 26 will be located within casing 27 and will contain pump barrel 2 securedly attached therein. Pump plunger 3 will be slidably located within barrel 2 as shown in the figures and will be reciprocated vertically by means of sucker string 17 which passes through tubing string 26 to powered reciprocating machinery at the surface.

Upon activation of the reciprocating machinery, the sucker string will begin driving the plunger downward from the position shown in FIG. 1a to the position shown in FIG. 1B. Any fluid situated in areas 21 and 31 will be prevented from downward movement by the seating of valve 5 or seat 6. At the end of the downward stroke the sucker string will pull the plunger upward which seats valve 12 in seat 13 and allows well fluid to be pulled upward through valve assembly 4 as a result of the suction created in passage 21.

Normally, if the well is not a high gas producer, a substantial amount of fluid will be drawn into passage 21 and upon the next downward stroke of the plunger will move through valve 11 to be lifted up the tubing string on the next upward stroke.

Unfortunately, there are many wells which have large amounts of entrained or dissolved gases in the fluid hydrocarbons which could result in the passage 31 being almost completely gas filled as shown in FIG. 1C. With prior art devices this could result in gas lock and/or fluid hammer as previously described.

Operating with this apparatus that problem is eliminated by the use of gas relief ports 18 as shown in FIG. 1e. In this position the plunger has been pulled up to the uppermost point of travel, allowing ports 18 to clear restricted bore 20 and communicate with fluid at hydrostatic pressure in opened bore 22.

This results in the hydrostatically pressured fluid in passage 22 flowing into circumferential channel 19, through ports 18, and into bores 31 and 21, thereby compressing or driving into solution the gas trapped therein and displacing the gas with a fluid cushion. This alleviates both the gas lock and fluid hammer and greatly increases operating efficiency of the pump.

Channel 19 serves two purposes. First it provides equal flow around the periphery of the plunger through the plurality of ports 18, and secondly, it isolates ports 18 from shoulder 24 of bore 22, thereby greatly reducing wear and deterioration of ports 18.

The unique design of this invention allows the plunger to remain seated in the restricted bore 20 of barrel 2 at all times thereby avoiding high lateral forces and interference of the plunger and barrel as experienced by other devices which allows the plunger bottom end to come out of a restricted barrel portion.

In this embodiment, ports 18 pass directly radially through the wall of the plunger barrel. A second embodiment is shown in FIG. 3 which utilizes longitudinal axial channels 41 passing from lower ports 42, placing them in communication with upper external circumferential channel 43 in plunger 33. This embodiment allows the minimal amount of plunger withdrawal into open passage area 22 to provide fluid displacement of gas below traveling valve 11 to the production string 26 above the plunger.

In FIG. 4 another embodiment of the apparatus is disclosed in which one or more longitudinal external channels or grooves 45 are formed in the plunger exterior wall going from a circumferential groove 46 high on the plunger, to the bottom end of the plunger. Groove 46 is just high enough on the plunger so that at the highest point of plunger stroke in the barrel, groove 46 passes shoulder 24 and emerges into enlarged bore area 22 thereby allowing fluid in bore 22 under hydrostatic pressure to pass down longitudinal groove 45 and into the pump chamber area 21 compressing and/or driving back into solution gas which may have accumulated there.

This embodiment also allows the traveling valve 11 to be placed at any location within the plunger, thereby allowing the pump manufacture a wide variety of compression ratios for each pump.

Although certain preferred embodiments of the present invention have been herein described in order to provide an understanding of the general principles of the invention, it will be appreciated that various changes and innovations can be effected in the described pump without departure from these principles. For example, it would be possible to move the location of ports 18 and channel 19 upward or downward on plunger 3 to alter the time of gas relief and the amount of fluid bypass allowed. It would also be possible to lengthen or shorten channel **41** and/or move ports **42** and channel **43** upward or downward on plunger **33** to achieve the same variation of gas relief and fluid bypass. Furthermore, it is clear that by a few modifications the apparatus of this invention could be operated as a moving barrel, fixed plunger pump utilizing substantially the same general principles and apparatus as described herein. All modifications and changes of this type are therefore deemed to be circumscribed by the spirit and scope of the invention except as the same may be necessarily limited by the appended claims or reasonable equivalents thereof.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. An oil well pump comprising:

an elongated tubular barrel;

retaining means on said barrel for fixedly retaining and sealing said barrel in a production tubing string;

elongated plunger means slidably and concentrically located within said barrel, said plunger means having longitudinal bore passages therethrough and means for attaching said plunger means to a sucker string;

first axial passage means in said barrel, said first passage means arranged to receive said plunger means in relatively snug telescopic relationship, said first passage means extending axially through said barrel;

second passage means in said barrel, said second passage means arranged to provide an annular flow space between said plunger means and said barrel;

first valve means in said barrel arranged to permit only upward flow of well fluids through said first and second passage means;

second valve means located in said plunger, said second valve means arranged to provide only upward flow through said longitudinal bore passage; and

fluid bypass means arranged to provide fluidic and gaseous communication from said longitudinal bore passage in said plunger means, below said second valve means, to said second passage means in said barrel above said second valve means, thereby bypassing said second valve means when said plunger means is in an upper position with respect to said barrel.

2. The pump of claim **1** wherein said first and second valve means comprises ball type check valves and said fluid bypass means comprises a plurality of radial ports through the wall of said plunger means arranged to communicate with said annular flow space of said second passage means.

3. The pump of claim **2**, wherein said fluid bypass means further comprises a circumferential grooved channel formed in the outer wall of said plunger means and intersecting said radial ports.

4. The pump of claim **1** wherein said fluid bypass means comprises:

a plurality of lower ports in the bottom wall of said plunger means;

longitudinal axial channel means located in the wall of said plunger means and communicating with said lower ports; and

external ports connected to said channel means above said lower ports and passing through the external wall of said plunger means.

5. The pump of claim **4** wherein said fluid bypass means further comprises a circumferential grooved channel formed in the outer wall of said plunger means, said grooved channel intersecting said external ports.

6. An oil well pump having relief means for preventing gas lock and reducing fluid hammer, said pump comprising:

an elongated tubular pump barrel adapted to be inserted into a production tubing string, said barrel having an axial, longitudinal bore passage therethrough and an enlarged relief passage therein;

an elongated pump plunger telescopically and sealingly engaged in said barrel bore passage, said plunger adapted to be telescoped from a first uppermost position in said barrel to a second lowermost position in said barrel, said plunger having a longitudinal bore passage therethrough;

valve means in said barrel arranged to allow fluid flow only in an upward direction through said barrel bore passage;

valve means in said plunger arranged to allow fluid flow only in an upward direction through said plunger bore passage;

relief bypass means passing through the wall of said plunger between said plunger valve means and said barrel valve means and arranged to communicate between said plunger bore passage and said barrel bore passage when said plunger is in said first position and further arranged to prevent such communication when said plunger is in said second position.

7. A method of pumping from an oil well, fluids containing large amounts of dissolved or entrained gases therein, said method comprising the steps of:

placing in the well a production tubing string communicating with the formation to be produced;

locating a reciprocating pump sealingly within said tubing string, said pump having a plunger traveling telescopically within a barrel, traveling check valve means, and standing check valve means;

reciprocating said pump plunger between upper and lower positions into said barrel to provide lifting force to the fluids in said oil wells; and

communicating the area between said standing valve means and said traveling valve means to the area above said pump in said tubing string in the uppermost position of said plunger in said barrel while maintaining the bottom end of said plunger continuously telescoped in said barrel, thereby displacing gas between said two check valve means with pumped well fluid from above said two check valve means.

8. The method of claim **7** whereby said communicating step comprises providing a plurality of ports through the wall of said plunger below said traveling valve means, and moving said plunger telescopically upward in said barrel until said ports communicate with an enlarged annular bore in said barrel, thereby allowing fluid located above said plunger in said barrel to displace gas trapped in said plunger.

* * * * *