June 30, 1970 G. K. ROEDER 3,517,741

HYDRAULIC WELL PUMPING SYSTEM

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FIG. 1a

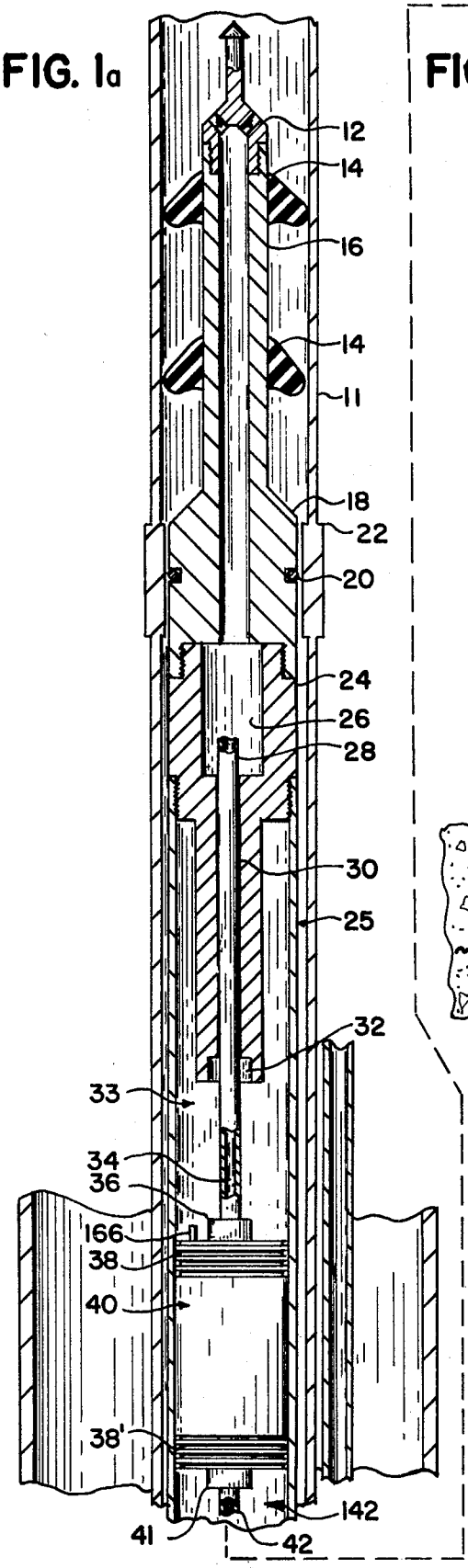
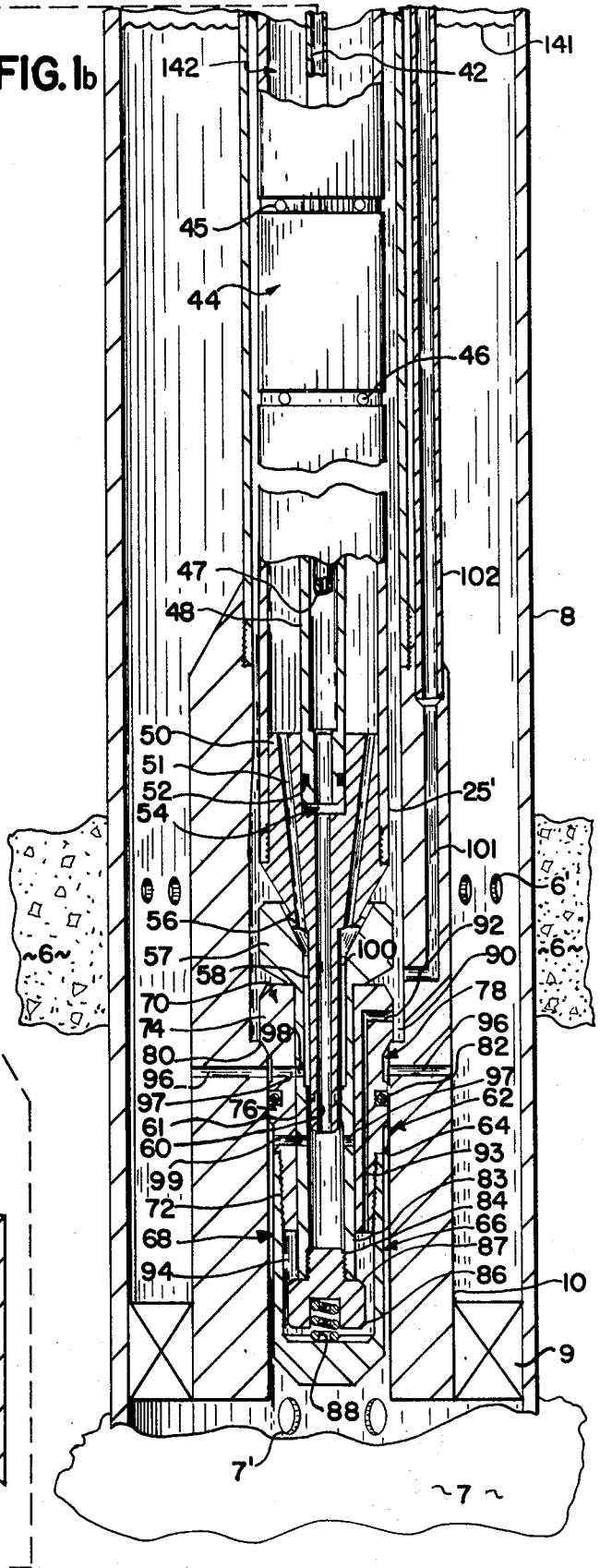


FIG. 1b



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FIG. 2

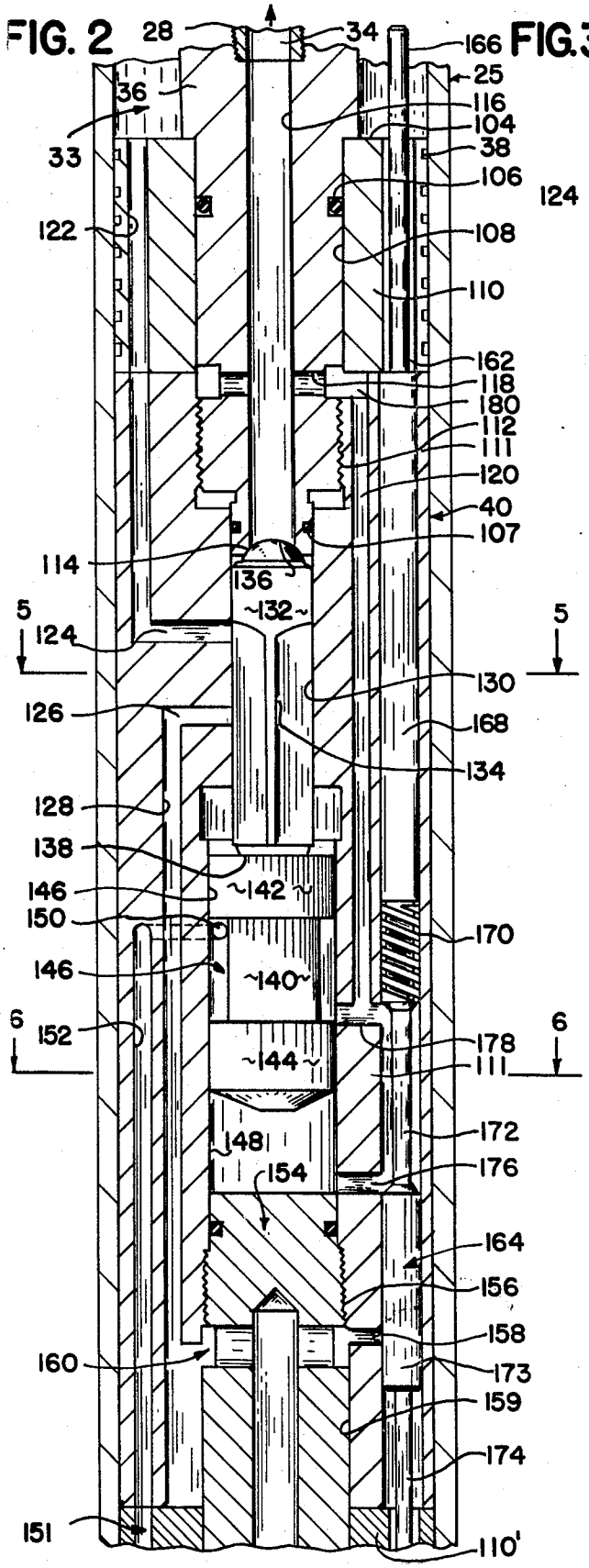
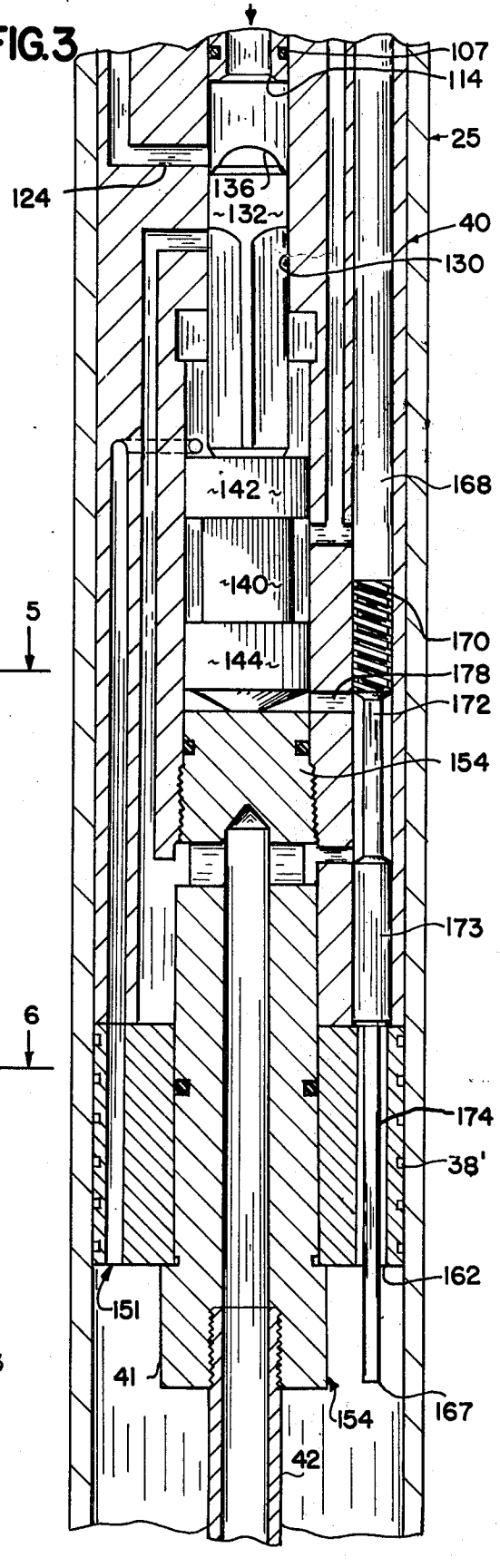


FIG. 3



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FIG. 4

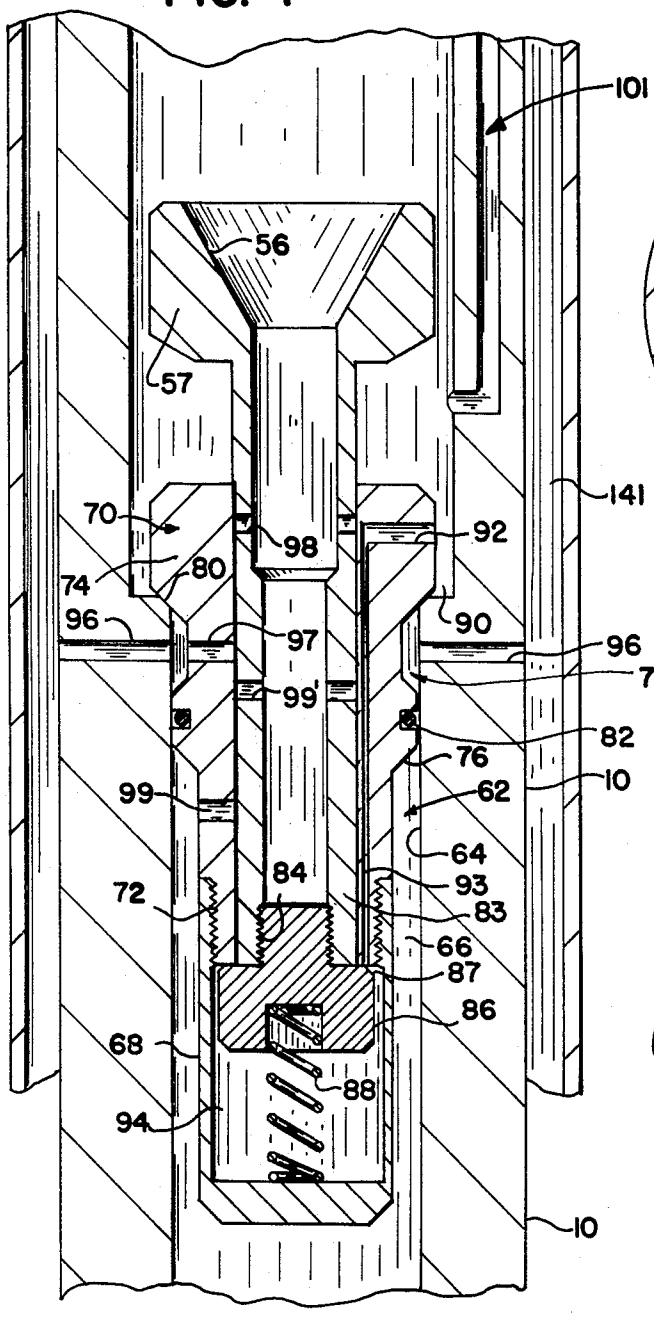


FIG. 5

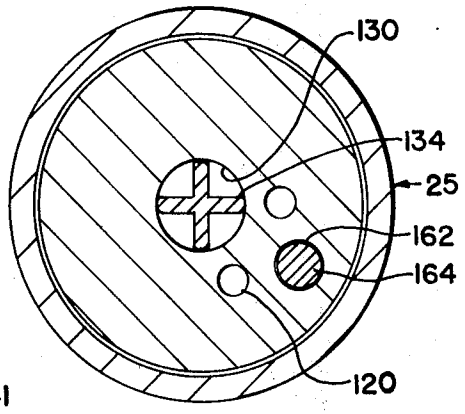
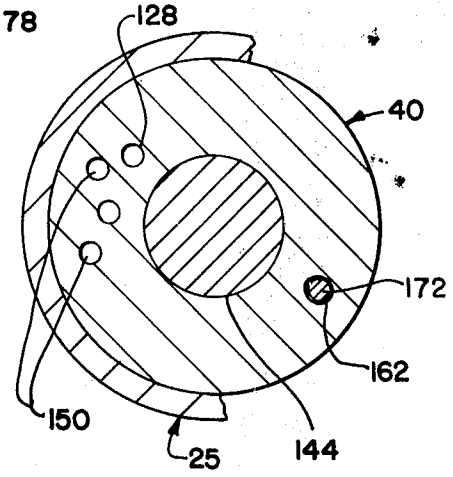


FIG. 6



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HYDRAULIC WELL PUMPING SYSTEM

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U.S. Cl. 166—106 13 Claims

ABSTRACT OF THE DISCLOSURE

Apparatus for operating a down hole hydraulic well pumping system. One aspect of the invention is directed to a method for injecting spent power fluid into a lower or upper stratum of the ground while extracting energy from the power fluid in order to pump oil from another stratum to the surface of the ground. The apparatus comprehends a new combination of a production unit having a piston and control valve assembly which forms an engine for actuating a down hole pump. The piston and control valve assembly cooperates with the down hole pump motor in a manner to enable spent power fluid from the engine to be injected through a standing valve assembly and into a stratum located below or above the producing formation.

BACKGROUND OF THE INVENTION

Various fluid operated deep well pumps, sometimes called hydraulic oil well pumping or production units, are known to those skilled in the art. These production units generally include a valve system which receives power fluid from a pump located above the surface of the ground and which controllably supplies the power fluid to an engine. The engine reciprocates a piston rod which in turn actuates a fluid pump. The spent power fluid is generally commingled with the production fluid and forced to the surface of the ground by the action of the pump. Various prior art control valve and engine assemblies have proven successful for use in deep wells.

In the production of oil and other fluids from deep wells having multiple producing formations, it may be desirable to dispose of either fresh or salt water which is sometimes produced along with oil. The disposal of this salt water is often costly. On the other hand, in water flooding programs and the like, it may be necessary to provide a source of water in order to flood various oil producing stratum with a low cost disposable fluid. Under these circumstances it may be necessary to purchase the water since its use in a controlled program results in an economic gain in the form of increased production. An advantageous expedient recognized by the oil industry is the injection of gases, steam, salt or fresh water, as well as other treating chemicals in order to produce various oil strata.

SUMMARY OF THE INVENTION

The present invention comprehends both a method and apparatus for transferring spent power fluid from a production formation into a water flood zone. The spent power fluid includes oil or water which is eliminated from a down hole pump in producing oil from an oil production stratum. The water flood zone or stratum may be located either above or below the production formation. In exemplifying the present invention, a standing valve assembly is used in conjunction with other apparatus as an illustration. The valve is placed in communication with a production formation with the valve assembly being separated from the water flood zone and the production formation by means of a packer. The valve cooperates with a hydraulic oil well production unit and includes telescopingly arranged parts having passageways

therein which normally permit the flow of produced oil through the valve and into the pump of the production unit where the pump lifts the produced oil to the surface of the earth. Simultaneously, the valve permits the spent power fluid from the engine to flow into a water flood zone, thereby precluding commingling of the spent power fluid with the produced oil as well as preventing commingling of the water flood zone with the production zone. The valve is selectively shifted to a shut off non-producing position in order to enable removal of the bottom hole production unit while precluding commingling of the two formations. In this latter position, the telescoping coacting parts of the standing valve assembly precludes the flow of fluid between the production formation and the water flood zone to thereby enable replacement of the bottom hole pump as well as to make possible the chemical treatment of either zone and to permit bottom hole pressure testing of either zone to be carried out separately from one another.

The present invention further comprehends a specific hydraulic oil well pumping system which enables the practice of the above method. The pumping system includes the before mentioned standing valve in combination with a production unit having a piston and control valve which unitizes the valve assembly and motor into a single reciprocating piston and control valve arrangement. The piston and control valve which forms the engine and valve assembly includes a hollow connecting rod reciprocatingly attached to the piston of a conventional double acting oil production pump. The hollow rod continues from the engine, through the pump, and into fluid communication with the standing valve by means of an isolation tube and stinger pipe. Production fluid from the standing valve flows about an annulus formed between the stinger tube and the standing valve and into the pump unit, while the spent power fluid flows through the stinger tube and through a series of passageways provided within the standing valve to where it is ultimately dissipated into a water flood zone, or the like.

A still further object of the present invention is the provision of apparatus for utilizing spent power fluid from a down hole production unit in order to treat another production zone.

A further object of the present invention is to provide an engine for a double acting bottom hole pump which utilizes a combination piston and control valve arrangement.

Still another object of the present invention is to provide a novel hydraulic pumping system which includes the combination of a piston and control valve, a bottom hole pump, and a standing valve.

A further object of the present invention is the provision of a standing valve which can be utilized with a fixed insert, fixed casing, free parallel, or free casing pump system.

Another object of the present invention is the provision of an improved bottom hole pumping system which includes a production unit comprised of the combination which includes a piston and control valve integrated into a single moving unit, and which provides an engine which reciprocates a pump, with the spent power fluid from the engine being controllably flowed into a disposal zone of the well by means of an improved standing valve assembly.

These and other objects of the present invention will become apparent to those skilled in the art after having digested the remainder of the present disclosure.

The above objects are attained in accordance with the present invention by the provision of a down hole pump assembly which is fabricated and used essentially as set forth in the above abstract.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1A and 1B are fragmentary vertical cross-sectional views illustrating the hydraulic well pumping system of the present invention;

FIG. 2 is an enlarged vertical cross-sectional view showing a portion of the device seen in FIGS. 1A and 1B;

FIG. 3 is a fragmentary vertical cross-sectional view of part of the device seen in FIG. 2, but shown in a different operating position;

FIG. 4 is an enlarged fragmentary cross-sectional view of part of the device seen in the foregoing figures;

FIG. 5 is a cross-sectional view taken along line 5—5 of FIG. 2; and

FIG. 6 is a cross-sectional view taken along line 6—6 of FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Looking now to the details of the drawing, and in particular to FIGS. 1A and 1B, in conjunction with the remaining figures, there is seen an oil producing stratum **6**, a water flood zone **7**, a vertical bore hole having a casing **8** coextensive therewith, and with a packer **9** separating the two strata from one another. The packer is attached to a foot **10** having power tubing **11** upwardly depending therefrom and with the hydraulic well pumping system being operatively connected to the piping and to the foot. Slidably located within the power tubing there is seen a portion of the hydraulic well pumping system which includes a production unit having an apertured nose **12** about which there are sealingly positioned spaced apart packers **14** located on the power fluid inlet **16**. The inlet diverges into a circumferentially extending packer seal assembly **18** which is provided with a circumferentially extending groove having an O-ring **20** sealingly located therein. The O-ring is slidably received in close tolerance fitting relationship within an O-ring collar **22**. The packer seal assembly is connected to a stroke chamber sub **24** which in turn is threadedly attached to a barrel, generally indicated by the numeral at **25**. The stroke chamber sub forms a chamber **26** within which the terminal end of an input rod **28** reciprocates. The stroke chamber reduces in diameter into an input rod passagesway **30** which includes a packing gland received within a counterbore **32** at the lower extremity thereof. The input rod is provided with a longitudinally extending hollow passageway **34** therethrough and is connected by inlet boss **36** to a novel piston and control valve arrangement generally illustrated by the arrow at numeral **40**. The piston and control valve reciprocates within a cylinder formed internally of the barrel. The piston includes expansible metal sealing rings **38, 38'** disposed at the upper and lower extremities thereof. The details of the piston and control valve will be discussed more fully later on.

From the piston a connecting rod extends downwardly from an outlet boss **41** in a manner as best seen at **42**. The connecting rod interconnects the piston with a double acting pump **44**. The details of the double acting pump are not set forth in detail, but generally the pump includes upstroke exhaust ports **45** and downstroke exhaust ports **46**. Further details of the pump are not deemed necessary for a full comprehension of the invention since the design and construction of several such pumps are well known to those skilled in the art.

A hollow discharge rod extends from the lower extremity of the pump at **47** where it is slidably received in a reciprocative manner within an isolation tube **48** with the free end of the rod terminating therein. The pump inlet is in communication with the chamber formed between the outer peripheral wall surface of the isolation tube and the inside peripheral wall surface of the barrel.

A bottom plug **50** is threadedly attached to the lower end of the barrel and includes a multiplicity of longitudinally extending radially spaced apart drilled passageways **51**. An isolation tube counterbore **54** sealingly receives the lower depending free end of the isolation tube in close fitting relationship therewith. About the isolation tube there is circumferentially disposed a groove having O-ring **52** fitted therein. The bottom plug includes a shoulder **56** which sealingly cooperates with the pump seat **56'**. The isolation tube counterbore reduces in diameter and continues as the lowermost portion of the hydraulic pump unit, also called a stinger, as seen at numeral **60**. The outside peripheral wall surface of the depending marginal end portion of the stinger is provided with O-ring seals **61** which are slidably received within the illustrated shoulder of the counterbore.

A standing valve assembly, generally indicated by the numeral **62** is slidably received within counterbore **64** of the foot and includes the before mentioned pump seat. The standing valve further includes a telescoped member **83** which is made integrally with and downwardly depending from the before mentioned pump seat, and which is telescopingly received within a main body member **70** thereby leaving an annular area **66** between the main body member and the foot. The main body member is comprised of a lower portion **68** which is screw-threaded onto an upper portion **74** by means of threads **72**. The two spaced apart enlargements are seen to be formed by members **74, 76** which cooperate to provide an annulus **78** therebetween. Enlargement **74** seats against the foot as seen at **80** while enlargement **76** is provided with seal means in the form of a circumferentially extending groove having an O-ring **82** therein. Pump seat **57** is provided with a lower hollow terminal end which is screw-threaded at **84** into engagement with a similarly threaded plug **86**. The lower extremity of the plug includes biasing means **88** which biases the telescoped pump seat member in an upward direction. Cavity flow passageway **90** communicates with ports **92**, and **93** and with chamber **94**; while port **96** located within the foot communicates with annulus **78**, ports **97, 98, 51**, and annulus **100** when the valve is in the operative position. Port **99** is flow connected to port **99'** which flow communicates the stinger with the lower formation by means of counterbore **64**.

Cavity flow passageway **90** also communicates with passageway **101** which is flow connected to the production tubing **102** and which carries production fluid from formation **6** to the surface of the ground.

Looking more particularly to the details of the integrated or unitized piston and control valve **40** (which is shown in greater detail in FIGS. 2 and 3) there is seen the before mentioned hollow input rod **28** and upper boss **36** at the uppermost portion of the figures. The boss has a shoulder near numeral **104** which abuts the uppermost face of the piston **40**. O-rings **106** seal the downwardly projecting portion of the boss which is received within counterbore **108** of the uppermost portion **110** of the piston. The threaded connection **112** rigidly affixes the boss to the cylinder. The lowermost end of the boss forms a valve seat **114** at the lower extremity of the passageway **116**. Radially extending passageways **118** provide fluid flow into drilled passageway **120**.

The longitudinally extending drilled passageways **122** connect the chamber formed within the barrel above the piston to radial passageways **124**. Second radial passageways **126** flow connect to the longitudinally extending passageways **128** by means of the chamber formed within the small cylinder **130**. Piston **132** has a lower portion in the form of a Maltese Cross having radiating guides or fins **134** thereon which are slidably received in close fitting relationship within the small cylinder **130**. The head **136** of the small piston seats against valve seat member **114**. The lower extremity of the Maltese Cross at **138** freely abuts against the uppermost face of intermediate piston **140**. Piston **140** includes an upper portion **142**, lower portion **144**, connected together by a reduced diameter portion which leaves an annulus **146** therewith. Piston **132** and **140** could be made into a single member,

however this particular construction is preferred since many alignment problems are eliminated by the illustrated construction.

Intermediate piston **140** reciprocates within intermediate cylinder **148** while the upper or small piston **132** reciprocates within the small cylinder **130**, with each piston coacting together in a reciprocating manner as a single unit. Radial passageway **150** is fluid connected to outlet **151** by means of longitudinal passageway **152**. Lower boss **154** is threadedly attached at **154'** to the main body of the piston. Radial ports **158** and **160** are provided in the boss. A counterbore receives the lower boss in a manner similar to the upper boss **36**. A drilled passageway **162** extends longitudinally through the piston and reciprocatingly receives pilot valve **164** therein. The pilot valve includes upper reduced terminal end **166**, enlarged upper portion **168**, spiral undercut **170**, reduced diameter portion **172**, lower enlarged portion **173**, reduced diameter portion **174**, and lower terminal end **167**. As seen at **166**, one terminal end of the pilot valve always protrudes from the piston and alternately engages or impacts against the packing gland **32** (FIG. 1) or the packing gland of the motor (not shown).

OPERATION

In operation the engine (i.e., the combustion piston and valve means) and pump are assembled into the illustrated production unit which is used in a system of the parallel free type. The production unit can also be used in a multiplicity of other systems. The entire production unit can be circulated into and out of the piping **11** by controlling the direction of flow through the piping and the production return line **102**. With the flow of power fluid being in a downward direction through the piping **11**, and the production unit assembled into a unitary apparatus with the unit being placed within the piping in the illustrated manner of FIG. 1A and 1B, the bottom plug seats within the pump seat **57** of the standing valve, with mutual contact being attained therebetween at **56**. Power fluid flows down through the piping and into the apertured nose, through the packer seal assembly, and into the stroke chamber. The O-ring collar prevents power fluid from flowing externally between the unit and the piping. The flow must therefore continue through the uppermost portion of the reciprocating hollow input rod **28** and into the piston and control valve assembly, where the power fluid reciprocatingly actuates piston **40** within the polished portion of the barrel.

In the operation of the combination piston and control valve, and as particularly seen in FIG. 2, the power fluid enters upper boss **36** where the main flow continues through radial passageway **118**, longitudinal passageway **120**, into the annulus **146**, and through outlet **151** where the power fluid exerts a force upon the bottom of the piston to thereby force the piston in an upward direction within the barrel **25**. Upper and lower rings **38** and **38'** prevent escape of fluid between the piston and barrel. Flow of fluid through passageway **178**, about the annulus formed by the reduced diameter portion of the pilot valve at **172**, and into the area below piston portion **144** exerts an upward pressure upon the piston **140**. Noting the difference in area of intermediate piston at **144** and small piston at **136**, it is seen that the area of piston **144** with respect to piston **136** is unequal and accordingly the small piston **132** is maintained forceably seated against valve seat **114**. The contoured valve portion **136** of the small piston together with the cooperative action between small cylinder **130** and the upper cylindrical portion of the piston prevents escape of fluid therethrough. This cooperative action between the recited elements provides a double seal.

As the piston **40** travels in an upward direction in order to assume the illustrated position of FIG. 2, the fluid within chamber **33** must escape to allow movement of the piston into the upper portion of the cylinder as the piston travels toward packing gland **32**. This is accomplished by the provision of passageways **122** which are interconnected to passageways **128** by means of radial passageways **124**, **126**, and to the free portion of cylinder **130** (i.e.: between the elements or fins of the Maltese Cross) in order to permit the flow of fluid through radial passageway **160** and through the hollow connecting rod **42**. As the piston travels in this manner in an upward direction, it reaches its limit of travel (FIG. 2) whereupon the upper terminal end of the pilot valve at **166** contacts the packing gland **32** to thereby drive the pilot valve in a downward direction to the position illustrated in FIG. 3.

Looking now to the details of FIG. 3 in conjunction with FIGS. 1 and 2, in order to explain the action of the engine valve system on the downstroke, those skilled in the art will now realize that power fluid from the hollow passageway **34** flows against small piston **132** thereby driving it in a downward direction along with the intermediate piston **140** within the cylinder **148** until the lowermost portion **144** of the piston abuts member **154**. This action bring the device into the configuration of FIG. 3 and permits the flow of fluid to occur through passageway **124**, **122**, whereupon the fluid pressure is exerted against the upper face of the piston thereby driving the main pistion **40** in a downward direction where the piston assumes the piston of FIG. 3. Fluid located below the main piston and above the seal pack-off liner (not shown but located in the area generally indicated by numeral **142**) must exhaust therefrom in order to enable the piston to travel downwardly within the barrel. This is accomplished by the provision of passageway **152** which permits fluid flow into the cylinder **130**, through radial passageway **126**, longitudinal passageway **128**, radial passageway **160**, and through the hollow connecting rod **42**, where the fluid ultimately reaches the isolation tube. The combination piston and control valve, or engine, continues to reciprocate in this manner so long as a power source is supplied to the engine and valve assembly, and so long as the outlet **42** is at a sufficiently reduced pressure with respect to the fluid in passageway **34**.

Connecting rod **42** reciprocatingly actuates the double acting pump **44** with the pump inlet being in communication with the annulus provided between the isolation tube **48** and the barrel. Pump outlets **45** and **46** deliver fluid in a downward direction into annulus **90**, up through passageway **101**, and into the production tubing **102** where the fluid is forced to ground level. The spent power fluid from hollow connecting rod **42** flows through central passageways located in the pump where it exits at the depending terminal end of the hollow discharge rod as seen at **47** in FIG. 1B. Since the isolation tube **48** is sealed within counterbore **54** of the bottom plug **50** the fluid must continue to flow through the lower hollow depending end of the plug and through the stinger as seen at **58**, whereupon the fluid then flows through radial passageways **99** and **99'**, into the annulus between the main body member and the foot at **66**, to where the spent power fluid then flows through the perforations **7'** below the packer **9** and into the water flood zone **7**.

Still looking to the details of FIGS. 1A and 1B it will now be realized that production fluid from formation **6** flows into the perforations **6'** to provide a production fluid level **141** within the casing **8**. The production fluid enters the foot through radial passageway **96** where the fluid flows through annulus **78**, through radial ports **97**, **98** and into the annulus about the lower depending end of the stinger where the fluid is then free to flow upwardly through the spaced apart radial production fluid inlet passageways **51** and into the barrel of the pump.

When it is desired to retrieve the production unit, the power fluid flow is discontinued and circulation is reversed by applying a positive pressure upon the production return line. This action simultaneously forces the production unit and the pump seat of the free standing valve in an upward

direction whereupon the unit is then forced from the pump seat and to the ground level as fluid is pumped through the production return line. It will be noted that the pump seat follows the pump for a limited distance when fluid pressure is exerted through radial passageway **92**, longitudinal passageway **93**, and into the chamber **94**. This action is due to the difference in area of the pump which is exposed to the fluid pressure from productine line **102**, which forces telescoping member **57** to move upward with respect to the main body member **74** thereby misaligning ports **97** with respect to ports **98** and misaligning ports **99** with respect to ports **99'**. Spring **88** assures the continued misalignment of the ports to thereby preclude comingling of liquid from the water flood zone **7** with fluid from the production zone **6**. When the production unit is pumped back into operative position, the lowermost depending end portion, or stinger, of the plug again enters the pump seat thereby forcing the standing valve back into the open position of FIG. 1B.

The free standing valve of the present invention also permits either or both zones **6** and/or **7** to be simultaneously treated with various chemicals while using an isolation tool and while the production unit is removed from the piping. This operation is best carried out by positioning an isolation tool onto the standing valve in order to expose the zone to be treated while blocking off the remaining zone. When the treatment has been accomplished, the isolation tool is pumped out of the hole. As the tool is pumped from the hole, the standing valve will shift to the closed position prior to the tool leaving the valve seat, in accordance with the previously described operation of the valve in conjunction with the pump.

It is contemplated to use the present invention in combination with various operations other than oil production. In sulphur production, for example, superheated water can be used as the power fluid with the spent power fluid being injected below the molten sulfur in order to place additional sulfur into solution. Accordingly, the use of water as the power fluid in order to produce oil from an oil bearing formation should be considered as one of many exemplifications of the present invention.

The foregoing is considered as illustrative only of the principles of the invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation shown and described, and accordingly all suitable modifications and equivalents may be resorted to, falling within the scope of the invention as claimed.

I claim:

1. A down hole production unit for pumping fluid from a fluid producing zone to the ground level;

said production unit including engine means, pump means, power fluid inlet means, spent power fluid outlet means, production fluid inlet means, and production fluid outlet means;

means connecting said engine means to said power fluid inlet means, said engine means being connected to said pump means by a hollow connecting rod, which is flow connected to said spent power fluid outlet means, a hollow discharge rod depending away from said pump means and having means by which it is flow connected to said hollow conecting rod; an isolation tube, said hollow discharge rod being received by said isolation tube in sealed relationship therewith, said hollow discharge rod adapted to move with respect to said isolation tube; means flow connecting said isolation tube to another zone isolated from the fluid producing zone

said production fluid inlet means adapted to connect said pump means for conducting fluid flow to the ground level;

said production fluid inlet means adapted to connect said pump means to a fluid producing zone; whereby:

power fluid can actuate said engine means which in turn actuates said pump means to thereby allow production fluid to flow to the surface of the ground while spent power fluid is maintained separated from said production fluid.

2. The production unit of claim **1** and further including a bottom plug positioned below said pump means, said spent power fluid outlet means including a spent fluid flow passageway through said bottom plug; said isolation tube being flow connected to said spent fluid flow passageway of said bottom plug; said production fluid inlet means including a flow passageway formed through a portion of said bottom plug; whereby:

production fluid can flow from one fluid producing formation, through said bottom plug, and to said pump while spent power fluid can flow from said isolation tube through said bottom plug and to another formation with the production and spent power fluid flow paths being maintained separate from each other.

3. The production unit of claim **2** wherein said bottom plug further includes a hollow downwardly depending free end portion which forms a stinger, said spent power fluid flow passageway through said bottom plug including said hollow stinger; whereby;

said stinger isolates the spent power fluid from the production fluid.

4. The production unit of claim **1**, and further including a bottom plug underlying said pump means, said plug having means forming a seat from which there downwardly depends a hollow portion in the form of a stinger, said isolation tube being flow connected to the hollow stinger;

said bottom plug further including a production fluid flow passageway therethrough which forms said production fluid inlet means;

a standing valve underlying said pump means and adapted to be positioned within a bore hole; said standing valve having a main body member and a pump seat member with said pump seat member being slidably received within said main body member and adapted to be moved from a producing to a shut-in position; said pump seat member and said main body member having means forming a spent power fluid flow passageway therethrough and a production fluid flow passageway therethrough with fluid flow occurring through the last two recited fluid flow passageways when the pump seat member is in the producing position; and

said pump seat member having means forming a seat therein which sealingly engages the plug seat in a manner to maintain said production fluid isolated from said spent power fluid.

5. The production unit of claim **1**, and further including a standing valve underlying said pump; said standing valve including a main body member and a pump seat member, said pump seat member having means forming a seat which is adapted to cooperate with said production fluid inlet means and said spent power fluid outlet means; said pump seat member having a portion thereof slidably received by said main body member with said pump seat member being movable from a producing to a shutin position;

means forming a spent power fluid flow passageway through said main body and adapted to be placed in flow communication with a portion of a borehole, means forming a spent power fluid passageway through said pump seat member which is aligned with said passageway through said main body when the standing valve is in the producing configuration and which is misaligned therewith when the standing valve is in the shut-in configuration;

the lower marginal end portion of said pump adapted to be received by said pump seat member to thereby urge said pump seat member into the production configuration to enable production fluid to flow from

another portion of the borehole to said pump while spent power fluid flows to the first recited portion of the borehole.

6. The production unit of claim 1, wherein said engine means including a barrel, a main piston reciprocatingly received within said barrel, means forming a stroke chamber, said hollow connecting rod depending from said piston and further including means by which it is sealingly and reciprocatingly received within said stroke chamber, said stroke chamber being flow connected to and forming part of said power fluid inlet means; said hollow connecting rod interconnecting said main piston to said pump for imparting reciprocatory motion to said pump while conducting spent power fluid from the engine, and means including said barrel forming an upper fluid chamber above and a lower fluid chamber below said main piston;

means forming a first cylinder chamber and a reduced diameter cylinder chamber within said main piston; large and small pistons, respectively, reciprocatingly received within said first and said reduced diameter cylinder chambers, respectively; said large piston having means associated therewith for controlling flow through said first cylinder chamber, said small piston having means associated therewith for controlling flow through said reduced diameter cylinder chamber;

a pilot valve means longitudinally extending through said main piston and adapted to shift from one to another flow position in response to the position of the main piston;

means forming a first flow passageway from said upper chamber, to said reduced diameter chamber and into communication with said hollow connecting rod; means forming a power fluid passageway from said input rod to said reduced diameter chamber;

means forming a second flow passageway from said lower chamber into said first cylinder chamber and into said input rod;

means forming a passageway from the lower extremity of said first cylindrical chamber into communication with said input rod; whereby:

said pilot valve means, when in said one position permits flow to occur from said input rod to the lower extremity of said first cylindrical chamber to cause said large and small pistons to move upwardly thereby allowing fluid flow to continue to the lower chamber to force the main piston in an upward direction while simultaneously flow occurs from said upper chamber to said hollow connecting rod.

7. In a hydraulic fluid actuated down hole production unit for pumping fluid from a fluid producing zone in a borehole to the surface of the ground while simultaneously treating a second zone located within the borehole with spent power fluid, in combination: a pump and engine assembly removably received within the borehole;

power fluid inlet means for actuating said engine with power fluid, production fluid inlet and outlet means for said pump, spent power fluid outlet means for said engine, means connecting said pump and engine assembly together to enable the engine to actuate the pump, a bottom plug underlying said pumps and having means forming a seat thereon and a spent power fluid passageway therein for the flow of spent power fluid therethrough, and further including means forming a production fluid passageway through said bottom plug for flow of production fluid therethrough;

a standing valve adapted to be attached within a borehole in underlying relationship to said pump and engine assembly, and including a main body member and a pump seat member, said pump seat member having means forming a seat thereon which can sealingly engage the seat of said bottom plug; said main body member having means by which said pump seat member can be slidably received by said main body member to enable said pump seat member to be moved from a producing to a shut-in position with respect to said main body member;

means forming a spent power fluid flow passageway and a production fluid flow passageway, respectively, through said main body member so as to enable fluid communication to be established with a second zone and with a fluid producing zone, respectively; means forming a spent power fluid passageway and a production fluid flow passageway, respectively, through said pump seat member which can be aligned with said spent power fluid flow passageway and said production fluid flow passageway, respectively, of said main body member when the standing valve is in the producing configuration and which is misaligned therewith when the standing valve is in the shut-in configuration;

the seat on said bottom plug adapted to be received by said pump seat member to thereby urge said pump seat member into the production configuration to enable production fluid to flow to said pump while spent power fluid flows to the recited second zone.

8. The downhole production unit of claim 7 wherein said engine and pump assembly includes a barrel, a main piston having a control valve assembly therein reciprocatingly received within said barrel, means forming a stroke chamber, a hollow input rod upwardly depending from said piston and sealingly and slidably received within said stroke chamber, said stroke chamber adapted to be flow connected to said power fluid inlet means; a hollow connecting rod connecting said main piston to said pump for imparting reciprocatory motion to said pump while conducting spent power fluid from the engine, and means including said main piston and said barrel forming a fluid chamber above and a fluid chamber below said main piston;

means forming a first cylinder chamber and a reduced diameter cylinder chamber within said main piston; large and small pistons, respectively, reciprocatingly received within said first and second reduced diameter cylinders chambers, respectively; said large piston having a reduced diameter mid-portion, said small piston having a reduced cross-sectional area along its lower marginal end portion;

a pilot valve means longitudinally extending through said main piston and adapted to be actuated by movement of said main piston;

means forming a first flow passageway from said upper chamber to said reduced diameter chamber and into communication with said hollow connecting rod;

means forming a passageway from said lower chamber into said first cylinder chamber, and into said input rod;

means forming a passageway from the lower extremity of said first cylindrical chamber into communication with said passageway from said lower chamber; said pilot valve means controlling fluid flow through said passageway from the lower extremity of said first cylindrical chamber to the reduced diameter mid-portion of said large piston and to said hollow connecting rod; whereby:

power fluid is alternately flow connected to said upper and lower chamber while spent power fluid is alternately connected to flow from said upper and lower chamber to said hollow connecting rod.

9. An engine for actuating a double acting down hole pump assembly comprising a barrel, a main piston having means forming a control valve assembly therein for causing reciprocation of said main piston with power fluid, said main piston reciprocatingly received within said barrel, means forming a stroke chamber, a hollow input rod upwardly depending from said piston and sealingly and reciprocatingly received within said stroke chamber, said stroke chamber adapted to be flow connected to a

source of power fluid; a hollow connecting rod interconnecting said engine to the pump for imparting reciprocatory motion into the pump while conducting spent power fluid from the engine, said means including said barrel forming a fluid chamber above and below said main piston;

said means forming a control valve assembly includes a first cylinder chamber and a reduced diameter cylinder chamber; large and small pistons, respectively, reciprocatingly received within said first and reduced diameter cylinder chambers, respectively;

a pilot valve means longitudinally extending through said main piston and adapted to shift from one to another flow controlling position in response to the position of the main piston in said barrel;

means forming a first flow passageway from said upper fluid chamber, to said reduced diameter chamber and from the last named chamber into communication with said hollow connecting rod; means forming a power fluid passageway from said input rod to said reduced diameter chamber;

means forming a second flow passageway from said lower fluid chamber into said first cylinder chamber and from said first cylinder chamber into said input rod;

means forming a passageway from the lower extremity of said first cylindrical chamber into communication with said input rod;

said pilot valve means, when in said one position permits flow to occur from said input rod to the lower extremity of said first cylindrical chamber to cause said large and small pistons to move upwardly thereby allowing power fluid flow to continue to the lower fluid chamber to force the main piston in an upward direction while simultaneously flow occurs from said upper fluid chamber to said hollow connecting rod;

said pilot valve means, upon being shifted to the recited another position, permits flow to occur from said input rod to the upper extremity of said reduced diameter chamber, causing said large and small pistons to move downwardly, thereby allowing power fluid to flow to the upper fluid chamber to force the main piston in a downward direction while simultaneously flow occurs from said lower fluid chamber to said hollow connecting rod.

10. The engine of claim **9** wherein said down hole pump assembly includes a double acting pump, means forming a longitudinal passageway through said pump; said hollow connecting rod flow connected to the last said passageway; a downwardly depending outlet tube flow connected to the last named passageway; an isolation tube which sealingly and reciprocatingly receives said outlet tube;

a bottom plug attached to said pump and having means forming a production fluid passageway therein with the last named passageway being in flow communication with said pump, means forming a hollow stinger which downwardly depends from said plug, said isolation tube being flow connected to said hollow stinger; whereby:

spent power fluid flows through said stinger while production fluid flows along a separate path and through said bottom plug.

11. The engine of claim **9** and further including a bottom plug, means forming a spent fluid flow passageway through said bottom plug; an isolation tube being flow connected to said spent fluid flow passageway of said bottom plug; means forming a production fluid flow passageway through said bottom plug with the last said flow passageway forming said production fluid inlet means; whereby:

production fluid flows through said bottom plug to said pump while spent power fluid flows from said isolation tube through said bottom plug with the production and spent power fluid flow paths being maintained separate from each other.

12. The apparatus defined in claim **11**, and further including a standing valve, said standing valve including a main body member and a pump seat member, said pump seat member having means forming a seat which cooperates with said production fluid and said spent power fluid passageways; said pump seat member having a portion thereof slidably received by said main body member with said pump seat member being movable from a producing to a shut-in position;

means forming a spent power fluid flow passageway through said main body and in flow communication with the second zone, means forming a spent power fluid passageway through said pump seat member which is aligned with said passageway through said main body when the standing valve is in the producing configuration and which is misaligned therewith when the standing valve is in the shut-in configuration;

a bottom plug having a seat, a spent power fluid outlet, and a produced fluid inlet, said bottom plug adapted to be received by said pump seat member to thereby urge said pump seat member into the production configuration to enable production fluid to flow to said produced fluid inlet of said pump while spent power fluid flows from the spent power fluid outlet to the second zone.

13. The apparatus defined in claim **9**, and further including a standing valve, said standing valve including a main body member and a pump seat member, said pump seat member having means forming a seat which cooperates with said production fluid and said spent power fluid passageways; said pump seat member having a portion thereof slidably received by said main body member with said pump seat member being movable from a producing to a shut-in configuration;

means forming a spent power fluid flow passageway through said main body and in flow communication with the second zone, means forming a spent power fluid passageway through said pump seat member which is aligned with said passageway through said main body when the standing valve is in the producing configuration and which is misaligned therewith when the standing valve is in the shut-in configuration;

the lower end of the pump adapted to be received by said pump seat member to thereby urge said pump seat member into the production configuration to enable production fluid to flow to the pump while spent power fluid flows to the second zone.

References Cited

UNITED STATES PATENTS

2,551,434	5/1951	Gray et al.	166—305
2,748,712	6/1956	Sargent	103—48
2,800,859	7/1957	Chenault	103—46
2,821,141	1/1958	Sargent	103—46
2,933,071	4/1960	Sargent et al.	91—222
3,199,592	8/1965	Jacob	166—305
3,414,057	12/1968	Harbison	166—105

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