# United States Patent

[11] 3,625,288


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[45] Patented Dec. 7, 1971


[54] METHOD AND APPARATUS FOR VENTING GAS THROUGH A DOWNHOLE PUMP ASSEMBLY
10 Claims, 12 Drawing Figs.


[52] U.S. Cl. ..... 166/314, 166/68.5, 166/105.5
[51] Int. Cl. ..... F21b 43/00, F04b 47/00
[50] Field of Search ..... 166/314, 68.5, 105.5, 105.6, 106, 53, 68; 417/404, 358



[56] References Cited

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| 2,674,198 | 4/1954 | Howe | 166/314 |
| 3,453,963 | 7/1969 | Roeder | 417/404 |
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*Primary Examiner*—James A. Leppink
*Attorney*—Marcus L. Bates



**ABSTRACT:** Method and apparatus for venting gas through a downhole pump assembly by producing fluid through the casing annulus, forcing power oil to the pump by either one of the tubing annulus or the innermost string, and using the one remaining flow path for the gas vent.

The pump is flow connected to the producing formation through a packer. The gas is vented through a lower hollow rod of the pump, through the pump piston and connecting rod, through the engine piston and valve control rod, where the gas continues to the surface of the earth along one of the recited flow paths.

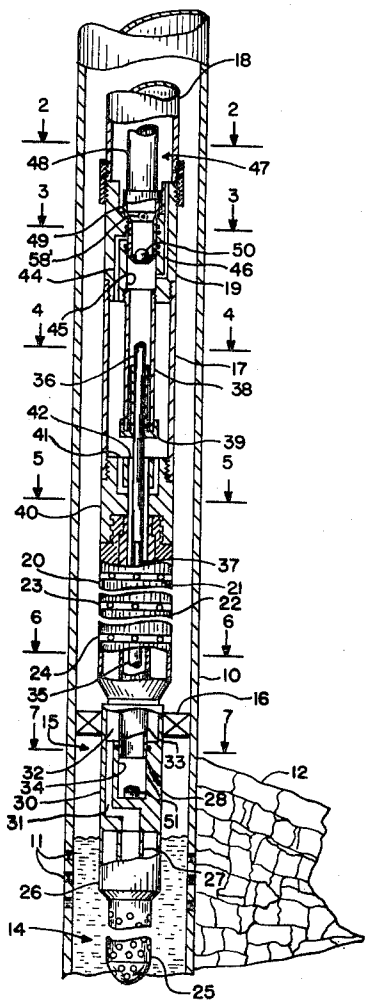



FIG. 1

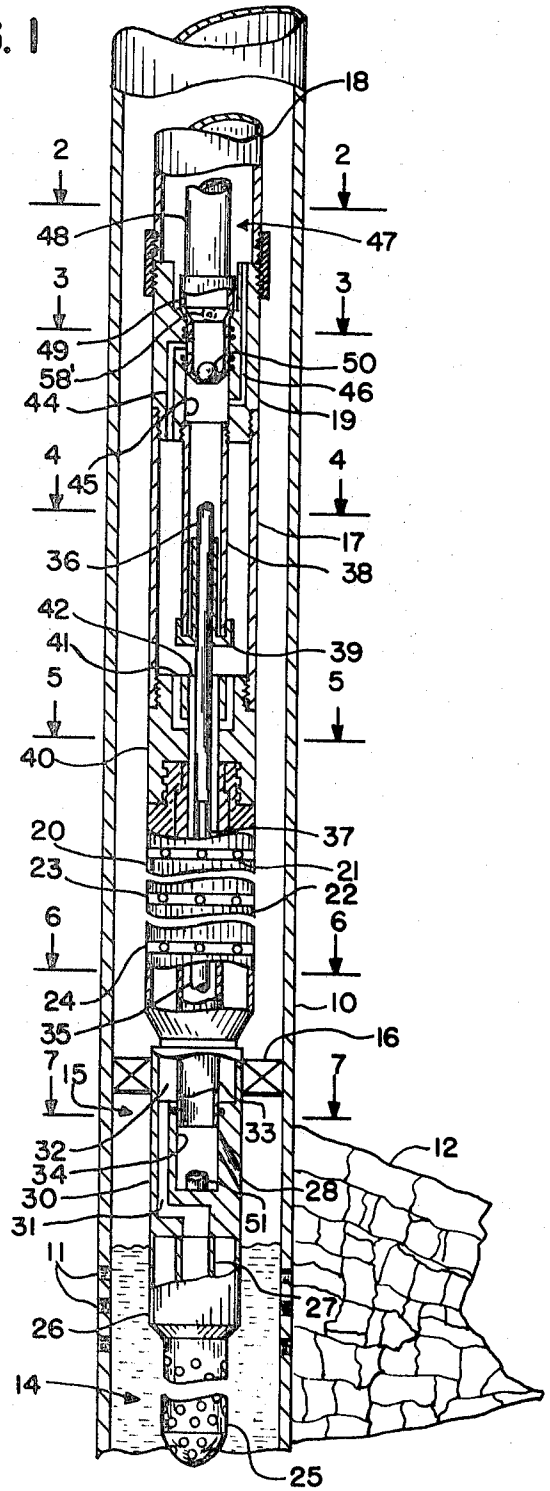



FIG. 2

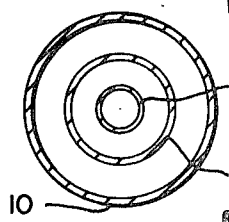



FIG. 3

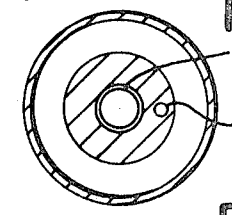



FIG. 4

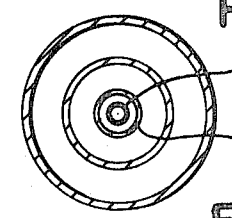



FIG. 5

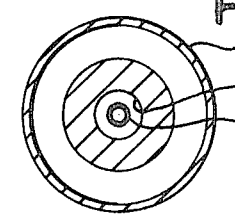



FIG. 6

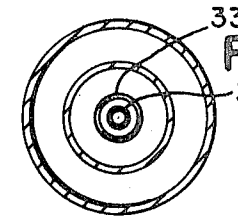
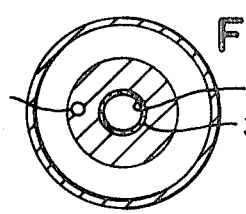



FIG. 7




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FIG. 8

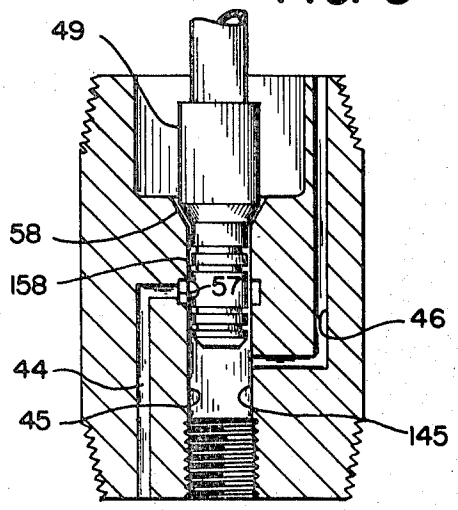



FIG. 9

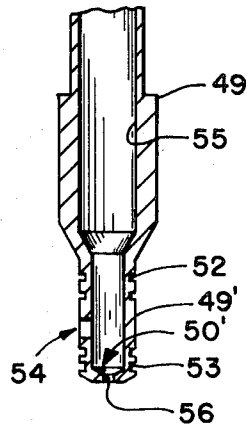



FIG. 9A

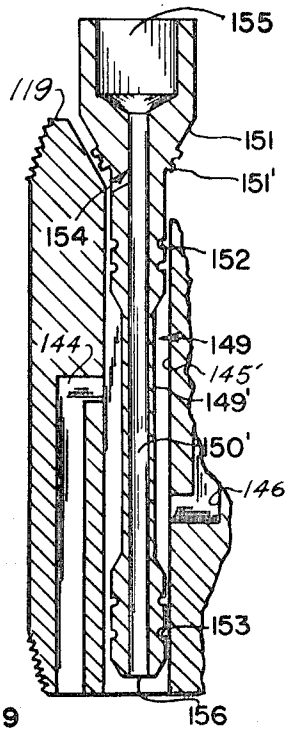



FIG. 10

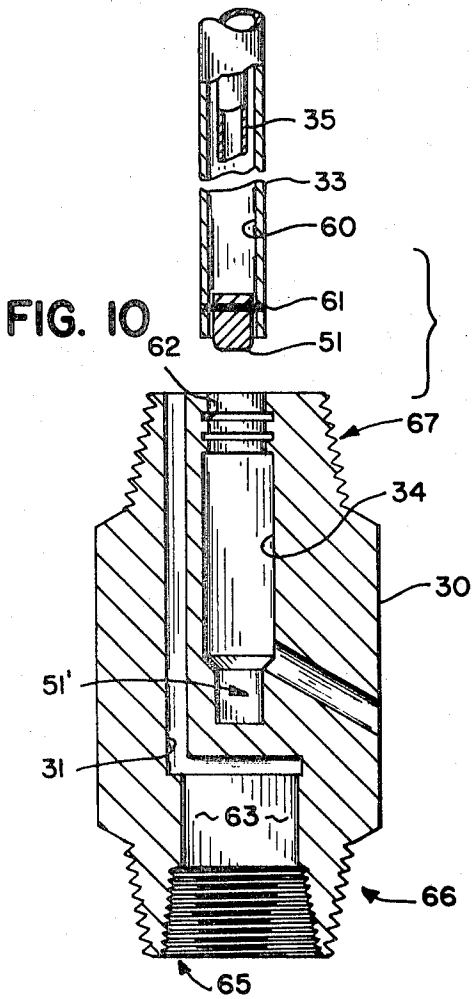
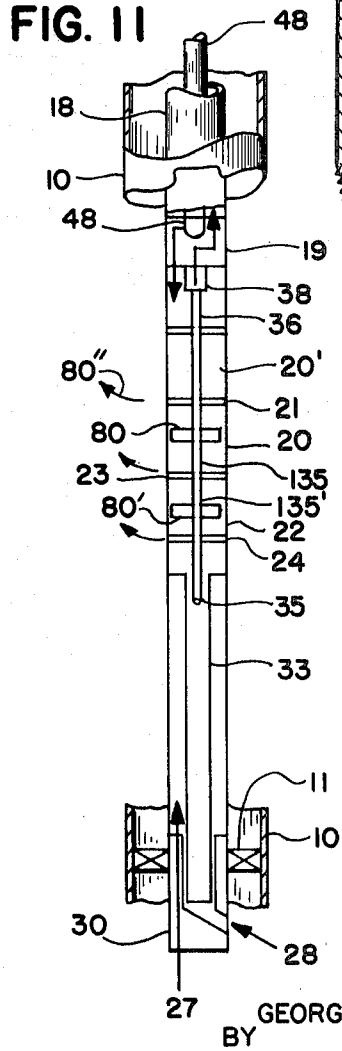



FIG. 11




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# METHOD AND APPARATUS FOR VENTING GAS THROUGH A DOWNHOLE PUMP ASSEMBLY

## BACKGROUND OF THE INVENTION

My previous U.S. Pat. No. 3,453,963, granted July 8, 1969; and the C. J. Coberly U.S. Pat. Nos. 2,081,223; 2,230,830; and 2,338,903; to which reference is made in order to supply ample background for a better comprehension of the present invention.

## SUMMARY OF THE INVENTION

The present invention relates to downhole fluid operated pump assemblies for use in lifting fluid from a fluid producing strata associated with a borehole by using hydraulic power, or fluid, provided from the surface of the ground, and suitably conveyed downhole to the engine of the pump assembly. The pump assembly is generally comprised of an elongated cylindrical unit having an upper end connected to concentrically arranged pipe to thereby provide three different concentrically arranged flow paths towards and from the surface of the earth, while at the same time the pump is positioned, or suitably affixed, to the casing or borehole wall by a packer means, with the packer means being located above but closely adjacent a producing formation.

The pump assembly includes a valve means, a motor or engine end, and a pump end; all connected together into a single unit.

The lower end of the pump is provided with two passageways, one of which is located below the other and in communication with liquid which flows from the hydrocarbon producing strata, while the remaining passageway is located closely adjacent to the lowermost portion of the packer so as to provide a vent for gaseous products which may otherwise accumulate in the borehole below the packer.

The pump assembly includes a lower hollow rod extending from the lowermost piston thereof, which is placed into communication with the gas inlet, and the internal passageway of the rod continues on through the pump piston or pistons, through the pump-connecting rod or rods, through the engine piston or pistons, and through the pilot or valve control rod of the valve assembly, and thence on to one of the before mentioned three flow paths extending to the surface of the earth so as to isolate the vented gas from the spend power fluid, the produced fluid, and the power oil supply.

This expedient enables the production zone to be continuously vented by the passageway which forms a vent extending through the pump means, the engine means, the valve assembly, and to the surface of the earth.

Several different embodiments of the invention are included herein which enables selection of the desired concentric passageway associated with the borehole to be used as the gas vent or the power oil supply.

Therefore, a primary object of this invention is to provide a downhole pump assembly with means for venting gas from a hydrocarbon producing formation to the surface of the earth.

Another object of this invention is the provision of a method of venting gas through a downhole pump assembly by forming a gas vent passageway therethrough.

A still further object of the present invention is the provision of an improved downhole pump assembly which enables gas, which would otherwise accumulate under a packer means, to be vented through a central passageway of the pump assembly and uphole to the surface of the earth.

These and other objects of the present invention are attained in accordance with apparatus fabricated essentially as outlined in the above abstract and summary of the invention. Various other objects and advantages of this invention will become readily apparent to those skilled in the art upon reading the following detailed description and by referring to the accompanying drawings.



## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a part cross-sectional, part diagrammatical, fragmentary representation of a downhole pump assembly which sets forth both method and apparatus for venting gas from a gas producing zone to the surface of the earth;

FIGS. 2, 3, 4, 5, 6, and 7, are cross-sectional views, respectively, taken along lines 2—2, 3—3, 4—4, 5—5, 6—6, and 7—7, respectively, of FIG. 1;

FIG. 8 is an enlarged cross-sectional view of part of the apparatus seen in FIG. 1, with some parts not being shown in section so as to enable one to more fully understand the invention;

FIG. 9 is a cross-sectional view of a part of the apparatus disclosed in FIG. 8;

FIG. 9A is a fragmentary view of another embodiment which is similar to the disclosure of FIG. 8;

FIG. 10 is an enlarged exploded cross-sectional view of part of the apparatus seen in FIG. 1; and

FIG. 11 is a part diagrammatical, part schematical, part cross-sectional fragmentary side view which shows the essence of the method taught by the present invention.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

As seen in FIGS. 1 and 11, along with the remaining FIGURES, there is disclosed a borehole, preferably provided with a casing 10. The casing has perforations 11 formed therein through which hydrocarbons such as, for example, oil and gas flow from a production formation 12. The liquid accumulates at 14 while gaseous products separate from the liquid and accumulate at 15 while debris settle by gravity towards the bottom of the borehole. It will be noted that a gas phase 15 is formed within the area defined by a packer 16, the casing, and the liquid level of the liquid phase of the hydrocarbon products located in the lower extremity of the borehole.

The packer can take on several different forms so long as it effectively prevents communication between the gas space and the upper hole annulus, and so long as it suitably affixes the pump assembly to the casing or side wall of the borehole in the illustrated relative position of FIGS. 1 and 11.

A downhole fluid actuated pump assembly 17 is run into the borehole by supporting the upper extremity of the pump assembly at the lower extremity of production or central tubing 18. The illustrated crossover 19 joins the tubing to the remainder of the pump assembly. The pump assembly includes an engine 10 having the usual spend power fluid outlet 21, the details of which are disclosed in the before mentioned U.S. Pats. The engine drives or otherwise actuates a pump assembly 22, the details of which are also disclosed in the before mentioned U.S. Pats. The pump assembly preferably is of the double action type, and is provided with production exhaust ports 23 and 24 which exhausts oil produced from 14 into the casing annulus where the oil is forced to the surface of the earth and disposed of by conventional means.

The lower extremity of the pump assembly is provided with an inlet screen 25 which may be of any length and which downwardly extends from a housing 26 so as to provide a production fluid source for the inlet end of production stinger 27. The stinger inlet is spaced apart from and underlying the gas vent inlet 28, with the gas vent inlet normally being located above the liquid level and in close proximity to and underlying packer. The lower crossover 30 includes a passageway 31 which communicates annulus 32 with the production stinger inlet. Accordingly, gas free settled fluid is available at the production stinger inlet.

A tube 33, similar in some respects to an elongated balance tube, and hereinafter called a sleeve, is received within central passageway 34. The sleeve reciprocatingly receives the lower marginal end portion of a lower hollow rod 35. The hollow rod is connected to and reciprocates with a lowermost production piston of the production pump. The pump may have one or more pistons and may be of the single- or double-action type. The passageway formed within the hollow rod continues

through the production piston to a hollow connecting rod which interconnects the production piston (or the uppermost production piston) with the engine piston. The passageway continues through the engine piston and into the hollow valve rod seen at **36**. The valve rod includes the usual flat **37** thereon for controlling the action of the valve means as the valve is manipulated so as to control the flow of power fluid to and from the engine valve assembly in the usual manner, such as taught by Coberly, for example.

Pack-off sleeve **38** includes a packing assembly **39** at the lower extremity thereof for reciprocatingly and sealingly receiving the upper marginal end portion of the valve rod within the interior thereof.

Intermediate connector **40** provides the illustrated fluid flow passageway **41** and **42** to the valve assembly of the engine. The details of the valve assembly are well known as evidenced by the above referred to patents.

Looking again to the upper crossover there is seen a power fluid inlet passageway **44**, a central passageway **45** which receives the upper terminal end of the pack-off tube, and a gas port **46** which is flow connected to an annulus **47**.

Innermost tubing **48**, which is in this particular embodiment is used for conducting power fluid flow to the engine, is concentrically disposed within the central tubing and includes stab-in **49** attached to the lower extremity thereof. The details of the stab-in and its cooperative action with the upper crossover is more fully discussed later on.

A ball **50** can be placed in the upper extremity of tubing **48** where it will fall into its illustrated seated position. Another ball, larger than ball **50**, can be sealingly received upon the seat in the area illustrated by numeral **58'**, for a purpose which will be more fully appreciated later on.

Looking now to the details of FIGS. **8** and **9**, the before mentioned seat **50'** of the stab-in which sealingly receives ball **50** thereon is shown in greater detail. Spaced apart upper and lower pairs of O-rings (not shown) are placed in the O-ring grooves seen at **52** and **53** so as to effect a seal above and below port **54**. Passageway **55** is in communication with port **54**, while port **56** can be sealed off by engagement with the before mentioned seated ball. Longitudinally extending passageway **55** is flow connected to the innermost string, which usually is the power oil source. The before mentioned port **54** is aligned with circumferentially extending annulus **57** of the upper crossover member, with annulus **57** communicating with passageway **44** so as to provide power oil to the connector power oil inlet. Seat **58** of the crossover receives the illustrated complementary seat located on the midportion of the stab-in. The lower portion of the passageway **145** preferably is polished so as to enable an adapter, similar in construction to the adapter of FIG. **9A** to be received therein when it is desired to change the flow path through the crossover and through the concentrically arranged piping in a manner to be more fully discussed later on.

Looking now to the details of the lower-crossover, it will be noted that a plug **51** is sealingly received within passageway **60** of the sleeve, with the plug being spaced apart from the lower depending terminal end of lower rod **35**. The plug is provided with a brass shear pin **61** with the plug normally closing the end of the sleeve until the shear pin is ruptured or sheared. The cavity **51'** receives the sheared plug **51** in the illustrated manner of FIG. **1**. O-rings (not shown) are provided in O-ring grooves **62** for sealingly engaging a marginal end portion of the sleeve while the lower hollow rod **35** is reciprocatingly received in the illustrated manner of FIG. **10** at a spaced apart location from the lower extremity of the sleeve. Passageway **63** flow communicates with passageway **31**, while the threads at **65** engage the before mentioned production inlet stinger.

As seen in the embodiment of FIG. **9A** an adapter **149** having reduced midportion **149'** and longitudinally extending passageway **150'** is slidably received in sealing relationship within passageway **145'**. Spaced apart pairs of O-rings are placed in grooves at **152**, **153** so as to seal annular area **149'** from flow longitudinally of the passageway and to connect passageway **144** to passageway **146** by means of the annulus, thereby enabling the inner annulus at **47** to be used for conveying power fluid to the engine while the passageway **156** now functions as the vent passageway, thereby communicating the area **15** with gas collecting facilities located at the surface of the earth. Seat **151** further includes a circumferentially disposed projection thereon with the projection having an outwardly and downwardly disposed face within which an O-ring can be provided at the O-ring groove seen at **151'**. Passageway **154** prevents upthrust of the stab-in should leakage occur through the upper pair of O-rings.

Looking now to the details of FIG. **11**, which sets forth the essence of the method claimed in the present invention, there is seen the before mentioned casing **10** having packer **11** affixed thereto so as to sealingly and supportingly cooperate with the pump assembly. Gas, which accumulates below the packer, flows through vent port **28** of the lower crossover, upwardly through the extended sleeve **33**, through the extended lower hollow rod **35**, through pump piston **80'**, through the connecting rod **135'** which interconnects pump piston **80'** with the engine piston **80**, through the engine piston and into the hollow valve rod **36** where the flow continues through the extension tube or pack-off sleeve **38**, and into the upper crossover **19** where the gas is received within the annulus formed between tubing **48** and the production tubing **18**. Power oil is forced downward and through innermost tubing **48** where it flows to the valve means or valve assembly at **48'** so as to actuate the engine of the pump assembly. As the engine reciprocates the pump piston or pistons (depending upon the design details of the pump), production fluid and spent power fluid emerges from the pump and engine in accordance with the indicated outwardly directed arrows **80''** at the pump and engine exhaust.

It is evident that one skilled in the art, having now read the present disclosure, will readily understand how to apply the teachings of the present invention in engines which drive a pump having one or a plurality of pistons therein. Moreover, various known pump, valve, and engine combinations can be readily modified to include the present invention therein by following the teachings set forth herein.

## OPERATION

When making up a string, the pump assembly is run into the casing on the end of the production or central tubing with the packer being attached to a lower marginal portion of the outer surface of the pump, as illustrated in the drawings. The packer is set in the usual manner, by manipulation of the production tubing from the surface, for example. After all of the tubular goods are properly made up, placed into the hole, and it is ascertained that the assembly is ready to commence production, the stab-in is placed in the upper crossover an power fluid is pumped down tubing **48**. Since the lower extremity of the sleeve **33** has the illustrated plug therein, introduction of the pump into the borehole cannot contaminate the critical components of the engine and pump mechanism for the reason that flow cannot occur back up through the vent passageway. As the power fluid pressure is increased, the force against the plug causes the brass pin to be sheared, and the plug comes to rest within the cavity **51'**, as seen in FIG. **1**. Continuation of the application of pressure flushes the unit with clean power oil. The plastic ball **50**, about one-half inch diameter, is dropped through the power oil string until it comes to rest in the illustrated manner of FIG. **1**, whereupon power oil is now diverted through passageway **44** where it then flows upper the valve assembly by means of passageways **41**, **42**, thus reciprocating the engine piston which in turn drives the pump in a manner to cause oil to flow from **14** through the exhaust ports **23**, **24** and up through the casing annulus. Gas which accumulates below the packer flows through the gas vent inlet port, through passageway **34** into the lower end of the lower rod, through the pump assembly, through the engine, up through the valve rod, and then into the extension

tube where the gas then enters port 46 of the upper crossover and continues to flow through the inner annulus 47 formed between the central and innermost tubing.

Should it be desired to treat the well with chemicals so as to acidize the formation 12, for example, the chemical is forced down through the annulus 47 where it flows through the central longitudinally disposed vent passageway and out through the vent port 28 where it continues through the perforations and into the oil producing formation.

Should it be desired to leak test the tubing 48, a larger ball can be seated in the area indicated by numeral 58', whereupon the string can be pressure tested by using the power oil surface pump, for example.

Should it be desired to flow power oil down through the annulus 47 while using the innermost tubing for the vent gas, the embodiment of FIG. 9A enables the vent gas to continue up through passageway 156 into the innermost string, while power oil flows down annulus 47 through port 146 into annulus 149 through port 144 and to the engine valve assembly. It is readily apparent that the embodiment disclosed in FIG. 9A offers a further means of chemically treating the formation since the inner string can be flow connected to a treating agent.

I claim:

1. In a fluid operated pump assembly having an engine which actuates a pump means and with the assembly being located downhole within a borehole, with the pump assembly being connected to the borehole by a packer means, the method of venting gas while producing the well comprising the steps of:

1. pumping power fluid through a conduit to the engine to cause the engine to actuate the pump means;
2. flowing fluid from a fluid producing formation to the pump means so as to enable the pump means to lift the fluid through another conduit towards the surface of the borehole;
3. venting gas from the formation towards the surface of the borehole by permitting the gas located below the packer to flow through a passageway formed within the pump assembly.

2. The method of claim 1 wherein 3 is carried out by the following steps:

4. forming a vent passageway through a pump piston, through a connecting rod attached between the pump piston and an engine piston, through a valve control rod, and from the valve control rod into a conduit means which extends to the surface above the borehole;
5. flow connecting the passageway of the pump piston to an area underlying packer and in communication with the borehole annulus so as to permit gas which accumulates below the packer to flow to the passageway of the pump piston.

3. The method of claim 1 wherein step (3) is carried out by forming a passageway through a piston of the pump and a piston of the engine and through the connecting rod located therebetween;

flow connecting the lower extremity of the passageway to an area below the packer and

flow connecting the upper extremity of the passageway to a gas collection means located above the surface of the ground.

4. The method of claim 3 and further including the step of flowing gas, power oil, and produced oil along three different flow paths formed within a borehole casing.

5. In a fluid operated pump assembly for operation downhole in a borehole and adapted to receive power fluid from the surface of the ground while venting gas from a fluid producing formation and pumping produced fluid to the surface of the ground along with the spend power fluid, the improvement comprising:

said pump assembly adapted to be attached to the borehole by a packer means so as to enable the lower extremity of the assembly to be placed in contact with gas and liquid which flows into the borehole from the producing formation, with the gas accumulating under the packer means;

said pump assembly including a valve means, an engine means, and a pump means with said valve means receiving the power fluid from the surface of the earth so as to actuate said engine which in turn reciprocates said pump means;

a piston in said engine means, a piston is said pump means; said engine and pump pistons being connected together by a connecting rod; a lower rod depending from said pump piston in opposed relationship with respect to said connecting rod; a valve control rod depending from said engine piston in opposed relationship with respect to said connecting rod;

means forming a vent passageway through said control rod, through said engine piston, through said connecting rod, through said pump piston, and through said lower rod;

means connecting one end of said vent passageway to an area which is in flow communication with gas produced by the formation so as to enable gas to flow thereinto;

means connecting the remaining end of said vent passageway to the surface of the ground so as to effect the stated function of venting gas from a fluid producing formation.

6. The pump assembly of claim 5 and further including an extended sleeve, said lower rod having a lower marginal end portion thereof received within said extended sleeve; said sleeve having means by which one terminal end thereof is in communication with a lower adapter; means forming a gas flow passageway through said adapter so as to place the lower extremity of the sleeve in communication with the borehole;

said pump means having an intake and an outlet;

said lower adapter having a liquid passageway, the inlet of which is disposed below said gas inlet, and with an outlet thereof being in communication with said pump intake.

7. The pump assembly of claim 5 and further including an upper adapter, said adapter having a power oil inlet, a gas passageway, and a central passageway;

said central passageway adapted to receive said valve control rod therein so as to enable gas to be vented from said control rod, through said central passageway, and to the surface of the ground while power oil flows through said power oil inlet about said valve control rod, and to said valve assembly.

8. The pump assembly of claim 5, and further including a lower crossover affixed to the lower extremity of said pump means;

a sleeve depending from said pump means and received within said crossover;

means forming a gas flow passageway through said crossover and into communication with said sleeve; means forming a liquid flow path through said crossover and into communication with said pump; with the last named passageway having an inlet which underlies the inlet of the gas flow passageway;

said lower rod having a lower marginal end portion thereof reciprocatingly received within said sleeve;

said gas flow passageway and said sleeve forming a portion of said vent passageway.

9. A pump assembly for producing gas free liquid from a borehole; said assembly including means forming an engine and a pump; said pump having a piston which is connected to said engine by a connecting rod;

means associated with said pump assembly and said borehole for enabling gas to separate from fluid to be pumped; means forming a passageway from the separated gas, through said pump piston, through said connecting rod, through said engine, and to the surface of the ground;

means forming a liquid inlet and a liquid outlet for said pump to enable liquid to be pumped from the bottom of the borehole to the surface of the earth along one flow path while gas is vented from the bottom of the borehole to the surface of the earth along another flow path.

10. The pump assembly of claim 9 wherein the liquid is separated from the gas by an area at least partially defined by a packer means which attaches the pump to the borehole wall; said liquid inlet underlying said gas inlet and said gas inlet underlying said packer means.

* * * * *

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(5/69)

# UNITED STATES PATENT OFFICE
# CERTIFICATE OF CORRECTION

**Patent No.** 3,625,288 **Dated** December 7, 1971

**Inventor(s)** GEORGE K. ROEDER

**It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:**

Column 5, line 42, after "wherein" insert --step--.

Insert Claim 11.

Claim 11. In a fluid operated pump assembly having an engine which actuates a pump means, wherein the assembly is positioned downhole within a borehole by means of a packer device, with a fluid producing formation causing liquid and gas to form within the borehole, the method of producing the liquid from the borehole while venting gas therefrom, comprising the steps of:

(1) forming a fluid flow path which extends from the surface of the earth downhole to the engine;

(2) pumping power fluid along the flow path of step (1) to cause the engine to actuate the pump;

(3) flow connecting the pump means to the liquid formed within the borehole;

(4) forming a fluid flow path which extends from the pump means, uphole to the surface of the ground so as to enable the pump means to produce the liquid formed within the borehole;

(5) forming a flow passageway which extends from a location underlying the packer, through the pump assembly, and uphole to the surface of the ground;

(6) venting gas which is formed by the fluid producing formation by flowing the gas along the flow path described in step (5).

Signed and sealed this 27th day of June 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents