US009518457B2

(12) United States Patent
Gronning

(10) Patent No.: US 9,518,457 B2
(45) Date of Patent: Dec. 13, 2016

(54) **DOWNHOLE TOOL FOR OPENING A TRAVELLING VALVE ASSEMBLY OF A RECIPROCATING DOWNHOLE PUMP**

(71) Applicant: **David Gronning**, Edmonton (CA)

(72) Inventor: **David Gronning**, Edmonton (CA)

(73) Assignee: **GLOBAL OIL AND GAA AUPPLIES INC.**, Beaumont, Alberta (CA)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 245 days.

(21) Appl. No.: **14/515,983**

(22) Filed: **Oct. 16, 2014**

(65) **Prior Publication Data**

US 2015/0107823 A1 Apr. 23, 2015

Related U.S. Application Data

(60) Provisional application No. 61/892,783, filed on Oct. 18, 2013.

(51) **Int. Cl.**

E21B 43/12 (2006.01)
F04B 47/02 (2006.01)
F04B 47/00 (2006.01)

(52) **U.S. Cl.**

CPC ***E21B 43/127*** (2013.01); ***F04B 47/02*** (2013.01); *E21B 43/12* (2013.01); *E21B 43/126* (2013.01); *F04B 47/00* (2013.01)

(58) **Field of Classification Search**

CPC E21B 43/127; E21B 43/12; E21B 43/126; F04B 47/00; F04B 47/02
USPC 417/554, 444
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,244,112	A	4/1966	Parkin	
4,781,847	A	11/1988	Madden	
4,907,953	A	3/1990	Hebert et al.	
5,382,142	A *	1/1995	Spears	E21B 43/127 137/515
5,533,876	A	7/1996	Nelson, II	
5,893,708	A	4/1999	Nelson, II	
7,051,813	B2	5/2006	Haynes et al.	
9,151,145	B2 *	10/2015	Scott	E21B 43/127
2006/0083646	A1	4/2006	Ford	
2013/0025846	A1	1/2013	Scott	

OTHER PUBLICATIONS

Dartt Valve. Dartt® Valve Co. Ltd., Flint, Texas, USA. http://www.darttsystems.com/valve.html (Date Unknown).
Sure Flow Valve. 2013. Dayzon Energy Solutions. www.dayzon.ca.

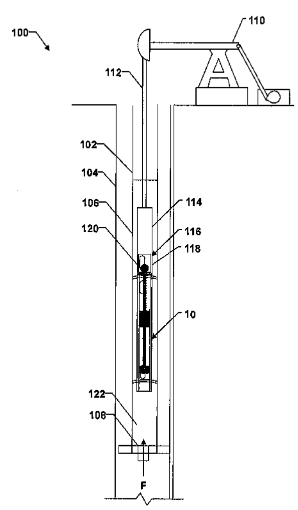
* cited by examiner

Primary Examiner — Jennifer H Gay
Assistant Examiner — George Gray
(74) *Attorney, Agent, or Firm* — Bennett-Jones LLP

(57) **ABSTRACT**

A downhole tool for opening a travelling valve assembly of a downhole pump is disposed with the travelling valve assembly within a pump barrel, and includes a substantially cylindrical housing and a piston. The housing defines an axial bore extending from a bottom opening for fluid communication with the pump barrel, a radial port for fluid communication between the axial bore and the pump barrel, and a channel formed in the outer surface of the housing for fluid communication between the radial port and the travelling valve assembly. The piston occludes the axial bore above the radial port, and in response to an upward pressure exerted by a production fluid below the piston, slides upwardly within the axial bore to engage and open a valve member of the travelling valve assembly.

20 Claims, 7 Drawing Sheets



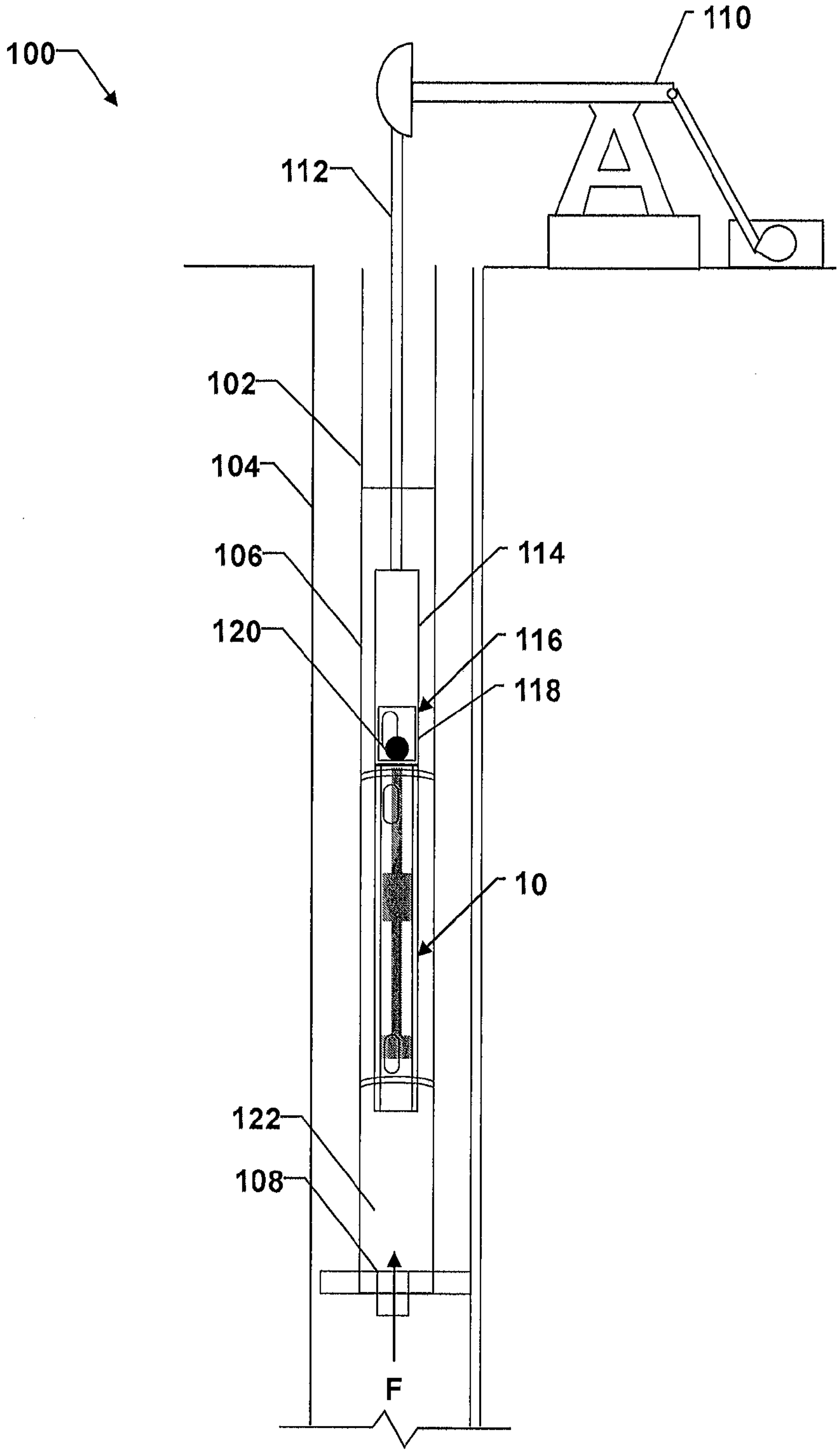


Fig. 1

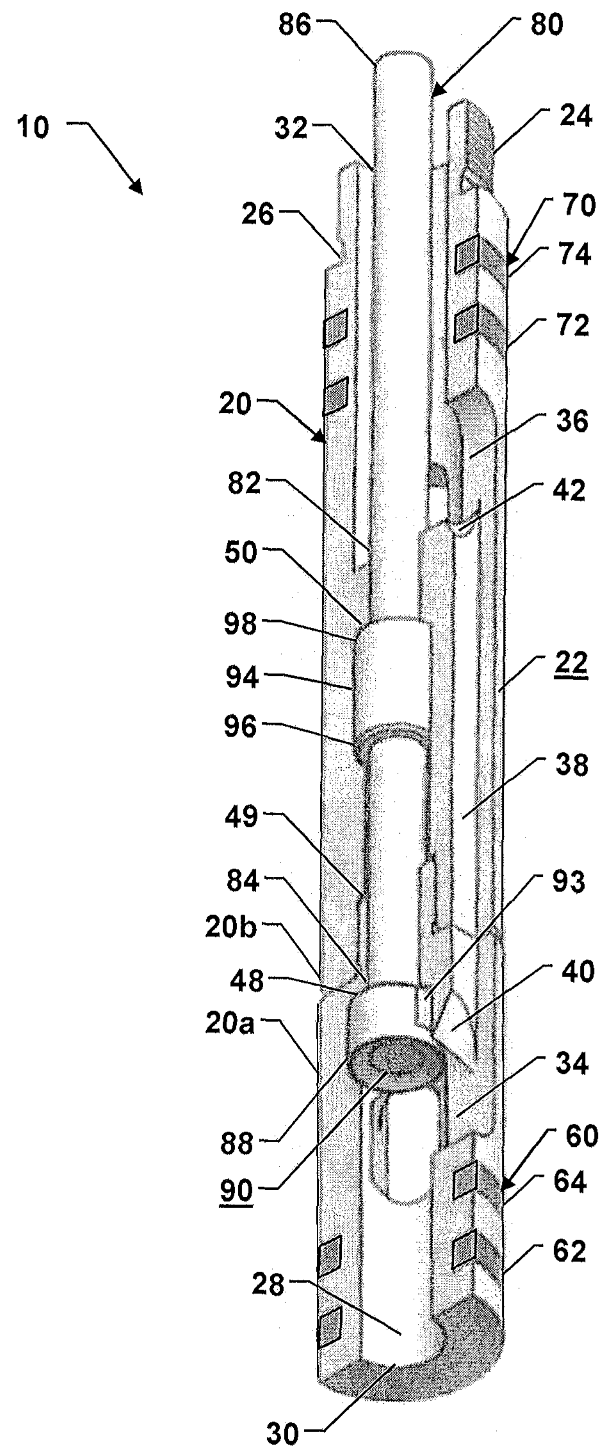

86
80
10
32
24
26
70
74
72
20
36
82
42
50
98
22
94
96
38
49
84
93
20b
48
40
20a
34
88
60
64
90
62
28
30

Fig. 2

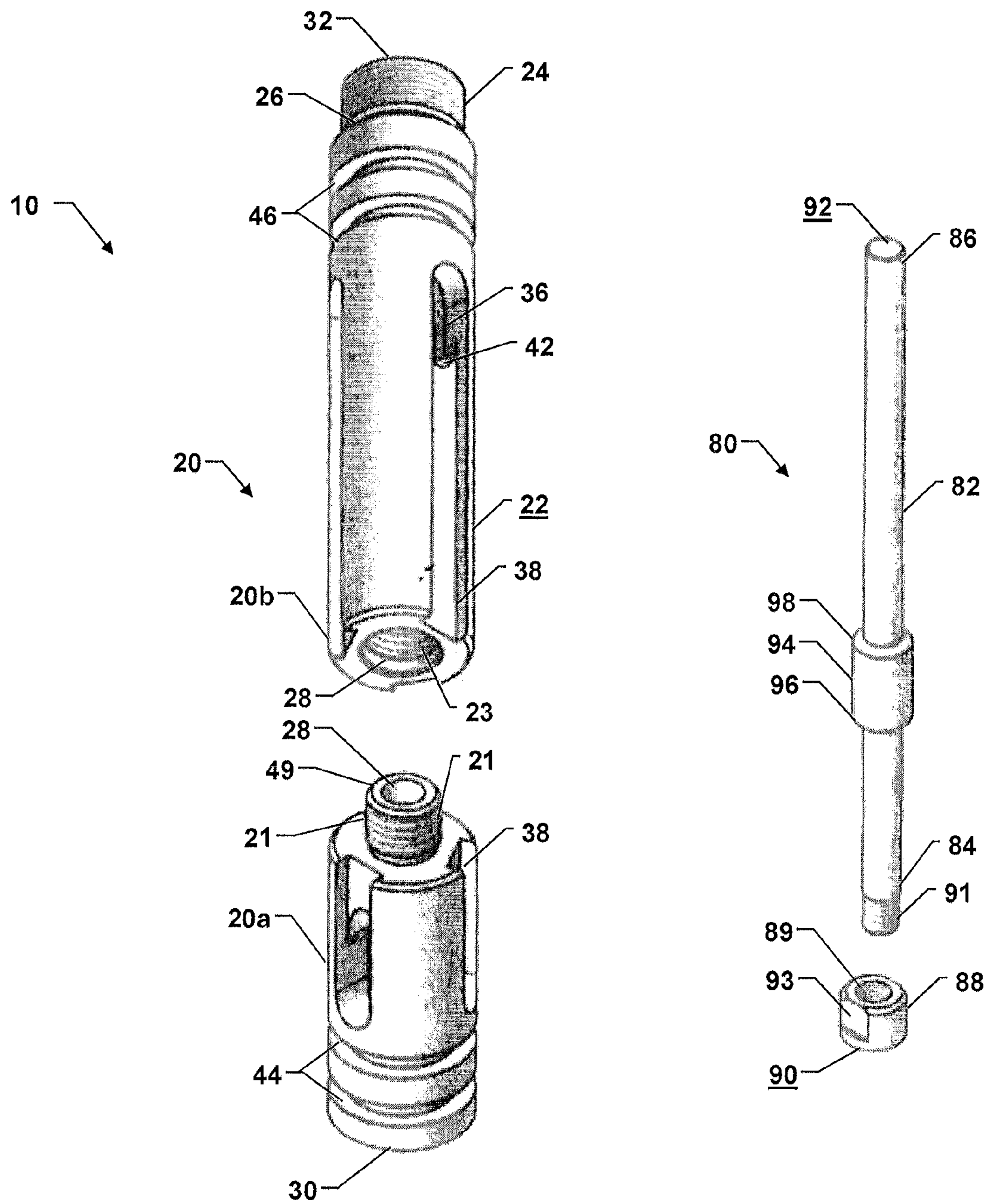

32
24
26
10
46
92
86
36
42
80
20
82
22
38
20b
98
94
96
28
23
28
49
21
21
38
84
91
20a
89
93
88
44
90
30

Fig. 3

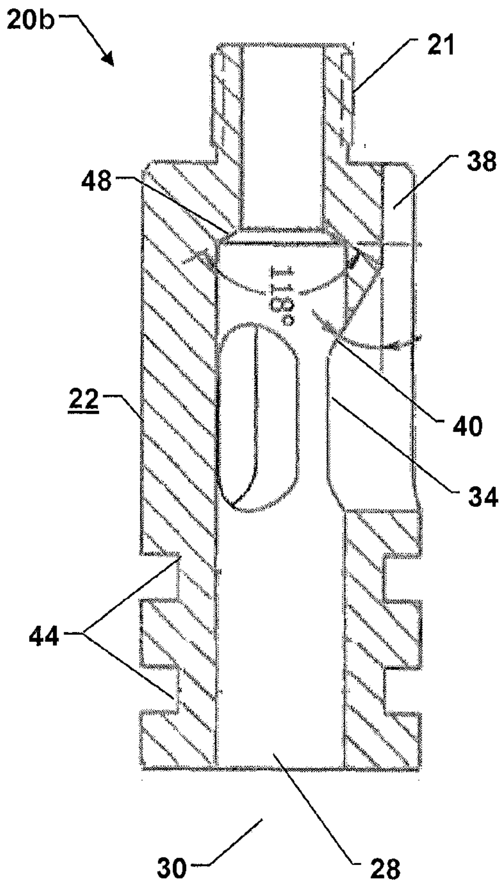

20b
21
38
48
118°
40
22
34
44
30
28

Fig. 4

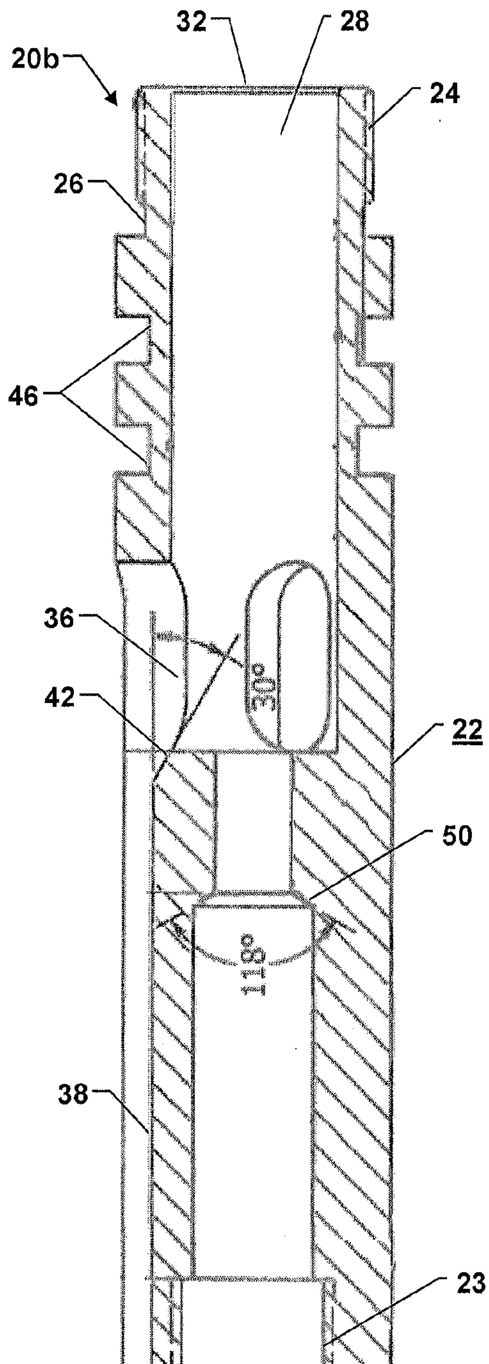

32
28
20b
24
26
46
36
30°
42
22
50
118°
38
23

Fig. 5

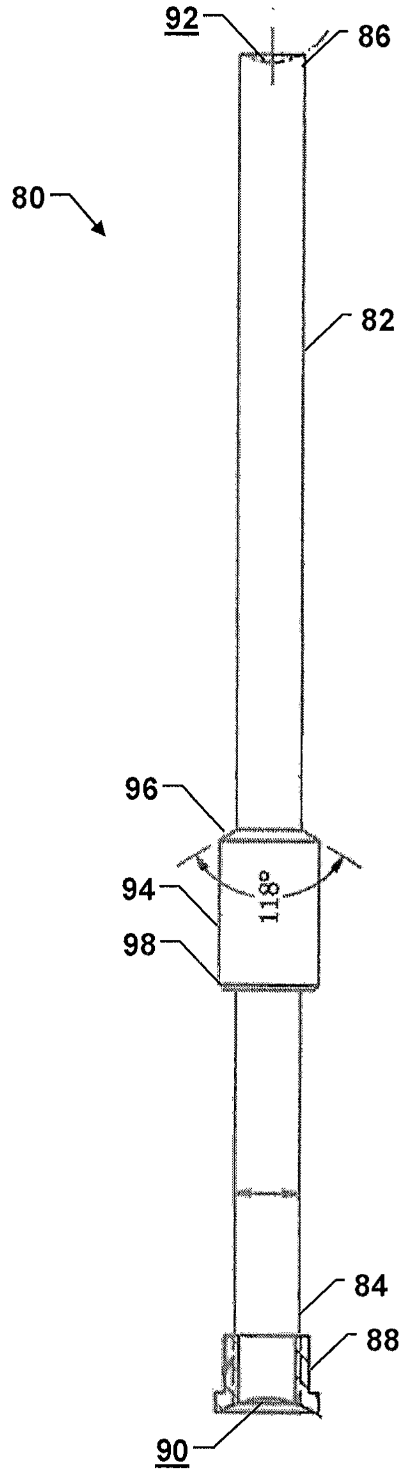


Fig. 6

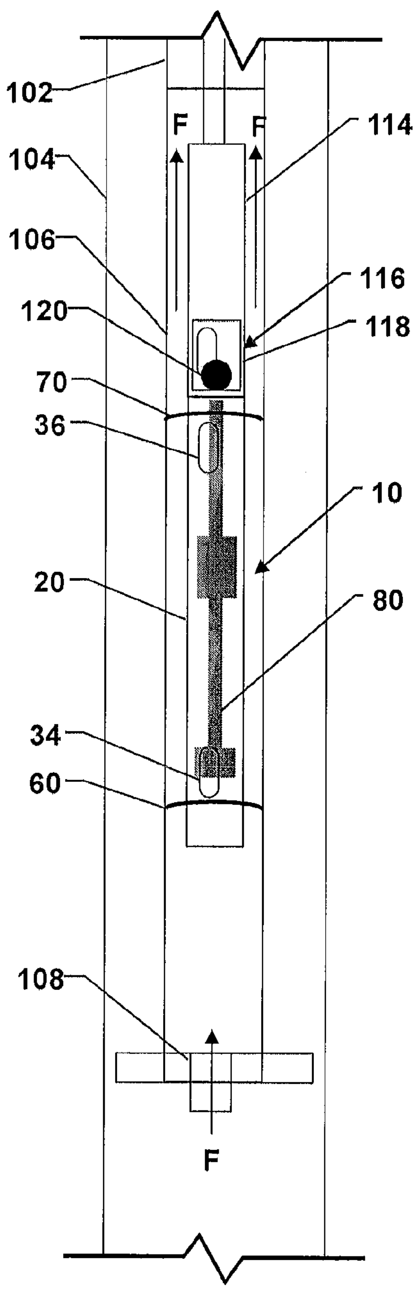

102
104
106
120
70
36
20
34
60
108
F
F
F
114
116
118
10
80

FIG. 7

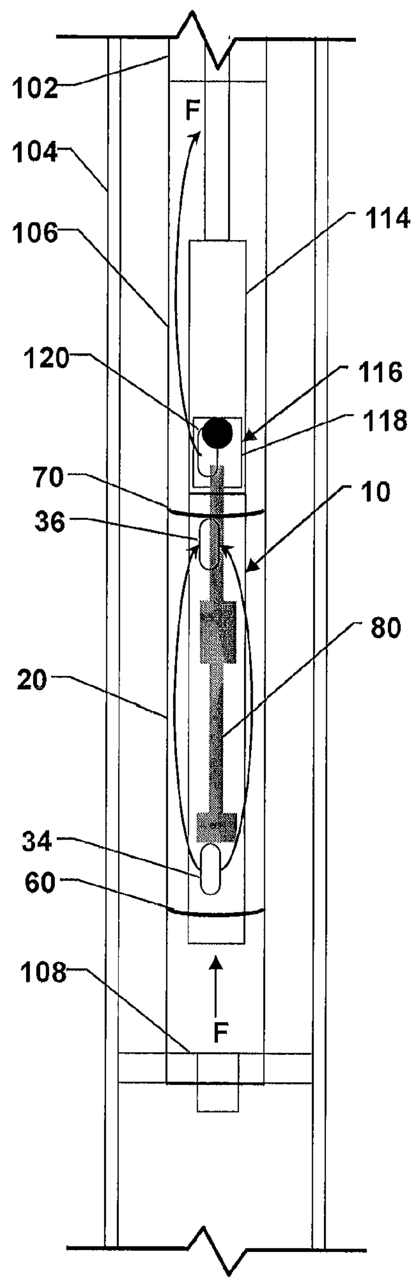

102
104
106
120
70
36
20
34
60
108
F
F
114
116
118
10
80

FIG. 8

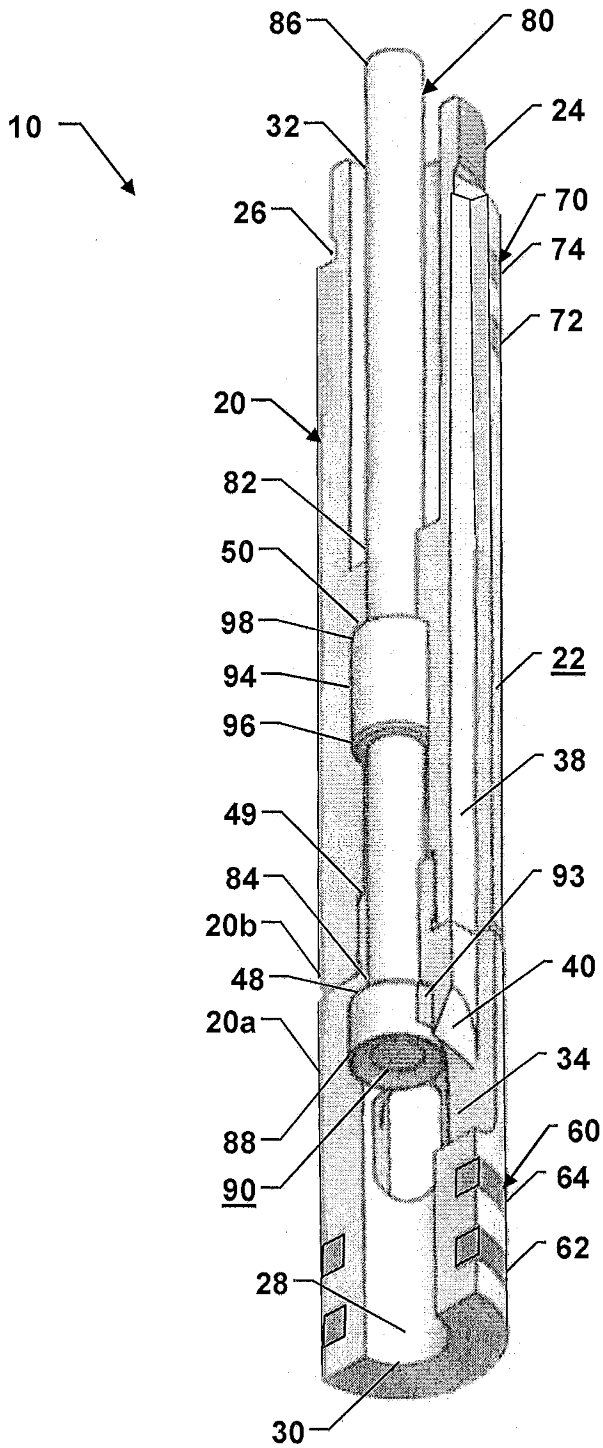

86
80
10
32
24
26
70
74
72
20
82
50
98
22
94
96
38
49
84
93
20b
48
40
20a
34
88
60
90
64
62
28
30

Fig. 9

DOWNHOLE TOOL FOR OPENING A TRAVELLING VALVE ASSEMBLY OF A RECIPROCATING DOWNHOLE PUMP

CROSS REFERENCE TO RELATED APPLICATION

This application claims the priority benefit of U.S. Provisional Patent Application No. 61/892,783, entitled "Downhole Valve Opening Tool" and filed on Oct. 18, 2013, the entire contents of which are incorporated herein by reference.

FIELD OF THE INVENTION

The present invention relates to a downhole tool for opening a travelling valve assembly of a reciprocating downhole pump.

BACKGROUND OF THE INVENTION

Reciprocating downhole pumps are used to elevate production fluids from a subterranean oil and gas well. Such pumps are typically driven by a motor, such as a pump jack, at the ground surface. A stationary standing valve is positioned at the bottom of a string of production tubing near the producing perforations of the well. A hollow cylindrical pump barrel is positioned above the standing valve and contains a traveling plunger with a traveling valve assembly. The plunger assembly is attached at its top end to a sucker rod which is actuated by the pump jack at the surface.

On the upstroke of the travelling plunger, the travelling valve assembly closes, so that each upstroke lifts a column of production fluid towards the surface. Meanwhile, the standing valve opens to charge the pump barrel below the travelling valve assembly with production fluid. On the downstroke of the travelling plunger, the travelling valve assembly opens to allow the production fluid to charge the pump barrel above the travelling valve assembly with a new column of production fluid for the next upstroke. Meanwhile, the standing valve closes to prevent the fluid drawn into the pump barrel below the plunger from flowing back into the production tubing.

The traveling valve assembly in such reciprocating pumps commonly consists of a ball and seat valve or a flapper valve. On the downstroke, the movement of the travelling valve assembly through the fluid and the incompressible nature of the liquid trapped between the traveling valve and the standing valve lifts the ball or the flapper from the valve seat thereby opening the valve. On the upstroke, the hydrostatic pressure of the fluid above the ball or the flapper, and the movement of the travelling valve assembly through the fluid forces the ball or flapper down onto the seat thereby closing the valve. Other types of valves employing similar actuating mechanisms on the up and downstrokes are employed, but in each instance, the consistent opening and closing of the traveling valve with the downstrokes and upstrokes of the plunger is essential to the efficient pumping of production fluid up the production tubing.

Although the reciprocating downhole pump described above is commonly used, there are circumstances that can render its use problematic and inefficient. For example, production fluids containing dissolved gases can result in an undesirable phenomenon known as "gas locking" if dissolved gases break out of solution. On the upstroke of the plunger, the gases flow upwards through the open standing valve into the pump barrel between the standing valve and the plunger. On the downstroke of the plunger, the plunger will compress the gases between the plunger and the closed standing valve. This is counterproductive to the effect of the production fluid in the pump barrel below the travelling valve forcing the valve member to its open position against the weight of the production fluid above the travelling valve. On the following upstroke, the compressed gas in the pump barrel between the traveling valve and the standing valve expands to fill the enlarged space. This prevents the upward flow of more production fluid from the production tubing through the standing valve and into the pump barrel. As such, the upstrokes and downstrokes of the pump simply result in the repeated compression and expansion of trapped gas between the standing valve and the traveling valve, and the pumping of fluid is prevented or decreased in efficiency. An associated problem is "fluid pounding" which occurs when the space in the pump barrel below the traveling valve is partially filled with fluid and partially with gas. The consequence of such a composition in the pump barrel is that the plunger forcefully enters the fluid level part way through the downstroke. This causes undesired vibrations, or "pounding", through the production string leading to mechanical failure and expedited wear.

Therefore, there is a need in the art for a tool that helps to ensure that a traveling valve assembly of a reciprocating downhole pump opens and closes as intended.

SUMMARY OF THE INVENTION

The present invention provides a downhole tool for opening a travelling valve assembly of a downhole pump, the tool and travelling valve assembly being disposed within a pump barrel, and the traveling valve comprising a valve member movable between an open position and a closed position. The tool comprises:

(a) a substantially cylindrical housing, wherein the housing comprises an outer surface and defines:
  (i) an axial bore extending from a bottom opening for fluid communication with the pump barrel;
  (ii) at least one radial port for fluid communication between the axial bore and the pump barrel;
  (iii) for each of the at least one radial port, a channel formed in the outer surface of the housing for fluid communication between the at least one radial port and the travelling valve assembly; and

(b) a piston slidably disposed within the axial bore and occluding the axial bore above the at least one radial port, wherein the piston is responsive to an upward pressure exerted by a production fluid below the piston to slide upwardly within the axial bore from a retracted position to an extended position in which the piston engages the valve member to move the valve member to the open position.

In one embodiment of the tool, the housing comprises a threaded connection for removable attachment to a complementary threaded connection of the travelling valve assembly.

In one embodiment of the tool, either the housing comprises a lower segment and an upper segment removably attachable to the lower segment, wherein the piston is removable from the housing when the upper segment is detached from the lower segment.

In one embodiment of the tool, the at least one radial port comprises a plurality of radial ports circumferentially spaced apart on the housing.

In one embodiment of the tool, the channel tapers inwardly towards the at least one radial port.

In one embodiment of the tool, the housing defines a pair of internal shoulders that engage the piston to limit sliding of the piston between the retracted position and the extended position.

In one embodiment of the tool, the piston comprises a cylindrical rod and an intermediate section attached to rod between the lower end of the rod and a top end of the rod, wherein the intermediate section engages an internal shoulder of the housing to occlude the axial bore above the at least one radial port.

In one embodiment of the tool, the piston comprises a cylindrical rod and a base attached to a lower end of the rod, wherein the base engages an internal shoulder of the housing to occlude the axial bore above the at least one radial port.

In one embodiment of the tool, the piston comprises a concave bottom surface.

In one embodiment of the tool, the valve member is a ball, and the piston comprises a concave top surface adapted to engage the ball.

In one embodiment of the tool, the tool further comprises a seal for sealing the outer surface to the pump barrel below the at least one radial port. The seal may comprise a sealing ring disposed circumferentially around the housing.

In one embodiment of the tool, the channel extends from the at least one radial port to an upper end of the housing.

In one embodiment of the tool:

(a) the axial bore extends from the bottom opening to a top opening for fluid communication with the travelling valve assembly;

(b) the at least one radial port comprises a lower radial port and an upper radial port; and

(c) the piston occludes the axial bore above the lower radial port and below the upper radial port.

The tool may further comprise a lower seal for sealing the outer surface to the pump barrel below the lower radial port, and an upper seal for sealing the outer surface to the pump barrel above the upper radial port. Each of the lower seal and the upper seal may comprise a sealing ring disposed circumferentially around the housing. The outer surface of the housing may define a lower circumferential groove for retaining the sealing ring of the lower seal, and an upper circumferential groove for retaining the sealing ring of the upper seal. The sealing ring may taper radially outwards from a top end to a bottom end.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described by way of an exemplary embodiment with reference to the accompanying simplified, diagrammatic, not-to-scale drawings. In the drawings:

FIG. **1** is a sectional schematic view of a reciprocating downhole pump incorporating one embodiment of the tool of present invention;

FIG. **2** is a cut-away sectional perspective view of one embodiment of the assembled tool of the present invention;

FIG. **3** is a perspective view of the embodiment of the tool as shown in FIG. **2**, when disassembled and without the lower seal and upper seal;

FIG. **4** is a half-sectional elevation view of the lower segment of the housing of the embodiment of the tool shown in FIG. **2**;

FIG. **5** is a half-sectional elevation view of the upper segment of the housing of the embodiment of the tool shown in FIG. **2**;

FIG. **6** is an elevation view of the piston of the embodiment of the tool shown in FIG. **2**, with the base shown in half-section;

FIG. **7** is a sectional schematic view of a reciprocating downhole pump incorporating one embodiment of the tool of present, during the upstroke of the pump;

FIG. **8** is a sectional schematic view of a reciprocating downhole pump incorporating one embodiment of the tool of present, during the downstroke of the pump; and

FIG. **9** is a cut-away sectional perspective view of another embodiment of the assembled tool of the present invention,

DETAILED DESCRIPTION OF THE INVENTION

The present invention provides for a downhole tool for opening a travelling valve assembly of a reciprocating downhole pump. When describing the present invention, all terms not defined herein have their common art-recognized meanings. To the extent that the following description is of a specific embodiment or a particular use of the invention, it is intended to be illustrative only, and not limiting of the claimed invention. The following description is intended to cover all alternatives, modifications and equivalents that are included in the spirit and scope of the invention, as defined in the appended claims.

To facilitate description of the tool of the present invention, FIG. **1** shows an embodiment of a reciprocating downhole pump **100** incorporating one embodiment of the tool **10**. The reciprocating downhole pump **100** includes production tubing **102** positioned inside the casing **104** of a well bore. The production tubing **102** is continuous with a cylindrical pump barrel **106** that is positioned above a standing valve **108**. A reciprocating motor **110** is attached to a sucker rod **112**, which is in turn attached to the top end of a travelling plunger **114**. The reciprocating motor **110** moves the plunger **114** axially up and down the pump barrel **106**. A travelling valve assembly **116** inside the plunger **114** has a valve **118** that allows production fluid F to flow into the pump barrel **106**. The valve **118** has a valve cage containing a ball **120** that alternately seats on and unseats from a valve seat to close and open the valve **118**. In other embodiments, not shown, the valve **118** may be a flapper valve. The tool **10** of the present invention is attached to the travelling valve assembly **116** and is disposed within the pump barrel **106**. The described embodiment of the reciprocating downhole pump **100**, its travelling valve assembly **116** and downhole configuration is only illustrative and not limiting of the present invention.

FIGS. **2-6** show one embodiment of the tool **10** of the present invention. Any dimensions of the parts of the embodiment of the tool **10** as shown in these Figures are provided only for illustrative purposes and are not limiting of the present invention. The tool **10** may be constructed in varying sizes for use with differing downhole environments, pump barrel sizes and types of traveling valve assemblies to meet the requirements of a particular application. Referring to FIG. **2**, the tool **10** generally includes a housing **20**, a lower seal **60**, an upper seal **70**, and a piston **80**.

The housing **20** may be made of any material that is sufficiently hard and durable to withstand wear in a downhole environment. In one embodiment, the housing **20** is made of stainless steel to minimize corrosion and wear.

The housing **20** has a substantially cylindrical shape. As used herein, the terms "axial" and "radial" in relation to the parts of the tool **10** refer to the directions substantially parallel with and substantially perpendicular, respectively, to the longitudinal axis of the housing **20**. When the tool **10** is in a vertical orientation, the "axial" direction coincides with the vertical direction and the "radial" direction coincides with the horizontal direction.

The outer diameter of the housing **20** is selected to be smaller than the inner diameter of the pump barrel **106** so that the housing **20** can slide axially within the pump barrel **106**. At the same time, the outer diameter of the housing **20** may be selected to be within a close tolerance of the inner diameter of the pump barrel **106** to minimize the annular space between the outer surface **22** of the housing **20** and the inner wall of the pump barrel **106**.

The housing **20** attaches to the travelling valve assembly **116** using any suitable means known in the art. The attachment may be either direct or indirect, and either removable or permanent. In one embodiment as shown in FIGS. **2-5**, the upper end of the housing **20** has a male threaded connection **24** for a direct and removable connection to a corresponding female threaded connection formed on the travelling valve assembly **116**. The housing **20** also has a neck profile **26** to facilitate removal of the travelling valve assembly **116** from the tool **10**.

The housing **20** defines an axial bore **28** that concentrically receives the piston **80** and allows the piston **80** to slide axially therein. The axial bore **28** extends from a bottom opening **30** to a top opening **32** of the housing **20**. The bottom opening **30** allows the production fluid F in the pump barrel **106** below the tool **10** to flow into the axial bore **28**. In one embodiment as shown in FIG. **2**, the top opening **32** allows the production fluid F in the axial bore **28** to flow into the travelling valve assembly **116** when attached to the upper end of the tool **10**, and the piston **80** to pass through.

The housing **20** defines at least one pair of vertically separated radial ports **34**, **36** to allow the production fluid F to flow between the axial bore **28** and the pump barrel **106**. In one embodiment as shown in FIGS. **2-5**, the housing **20** defines three pairs of radial ports **34**, **36**, equally circumferentially spaced apart from each other on the housing **20**. Each pair of radial ports **34**, **36** is associated with a channel **38** formed in the outer surface **22** of the housing **20**. The channel **38** allows the production fluid F to flow externally of the housing **20**, but internally of the pump barrel **106**, from the lower radial port **30** to the upper radial port **32**. In one embodiment as shown in FIGS. **2-5**, the part of the outer surface **22** defining the lower end **40** and the upper end **42** of the channel **38** taper radially inwardly towards the axial bore **28** to encourage a smooth flow of the production fluid F through the radial ports **34**, **36**. The channels **38** may be configured so that the cross-sectional area of the spaces defined between the channels **38** and the inner wall of the pump barrel **106** (the external area) relative to the cross-sectional area of the axial bore **28** immediately below the lower radial port **34** (the internal area) avoids undue flow restriction of the production fluid F, while still maintaining the pressure of production fluid F as it flows from the internal area to the external area. In embodiments, for example, the external area may be less than or equal to the internal area.

The lower seal **60** and the upper seal **70** provide a fluid-tight seal between the outer surface **22** of the housing **20** and the inner wall of the pump barrel **106**. The lower seal **60** is positioned below the pair of radial ports **34**, **36** while the upper seal **70** is positioned above the pair of radial ports **34**, **36**. The seals **60**, **70** may be made of any suitable material known in the art that is sufficiently, pliable, resilient and durable to withstand wear and friction with the inner wall of the pump barrel **106**. In one embodiment, the seals **60**, **70** are made of an elastomeric rubber.

In one embodiment as shown in FIG. **2**, the lower seal **60** is provided by a pair of sealing rings **62**, **64** and the upper seal **70** is provided by a pair of sealing rings **72**, **74**. In one embodiment as shown in FIG. **3**, the lower sealing rings **62**, **64** are retained by a pair of lower circumferential grooves **44** formed in the outer surface **22** of the housing **20**, while the upper sealing rings **72**, **74** are retained by upper circumferential grooves **46** formed in the outer surface **22**. In one embodiment, the sealing rings **62**, **64**, **72**, **74** have a tapered profile, being wider at the bottom than at the top, so that the combined effect of friction between the sealing rings **62**, **64**, **72**, **74** and the inner wall of the pump barrel **106** and the upward pressure of the production fluid F acting on the bottom face of the sealing rings **62**, **64**, **72**, **74** causes them to expand radially against the inner wall of the pump barrel **106** as the housing **20** slides axially downwards in the pump barrel **106**.

The piston **80** slides axially within the axial bore **28** to move the valve member **120** from the closed position to the open position. The piston **80** may be made of any suitable material known in the art that is sufficiently hard and durable to withstand wear in a downhole environment. In one embodiment, the piston **80** is made of stainless steel to minimize corrosion and wear.

In one embodiment as shown in FIGS. **2**, **3** and **6**, the piston **80** comprises an elongate cylindrical rod **82** extending from a bottom end **84** to a top end **86**. In one embodiment, the top end **86** of the piston **80** has a concave top surface **92** adapted to engage a valve member in the form of ball **120**. In other embodiments, the top surface **92** of the piston **80** may have a different shape.

The piston **80** further comprises a cylindrical base **88** with an enlarged diameter relative to the rod **82** to maximize the surface area of the piston **80** that is acted upon by the production fluid F below the tool **10**. The chamfered upper end of the base **88** is adapted to engage a complementary chamfered upper internal shoulder **48** of the housing **20** to occlude the axial bore **28** between the pair of radial ports **34**, **36**. Further, the base **88** has a concave bottom surface **90**, which helps to redirect upward flowing production fluid F back towards the lower radial port **34**.

The piston **80** further comprises a cylindrical intermediate section **94** with an enlarged diameter relative to the rod **82**. The intermediate section **94** has a lower end **96** adapted to engage a lower internal shoulder **49** of the housing **20**, and a chamfered upper end **98** adapted to engage a complementary chamfered upper internal shoulder **50** of the housing **20**. When the upper end **98** of the intermediate section **94** engages the upper internal shoulder **50** of the housing **20**, the intermediate section **94** occludes the axial bore **28** between the pair of radial ports **34**, **36**.

Each of the housing **20** or the piston **80** or both of them, may be made of several components to facilitate assembly, disassembly, and servicing of the tool **10**. In one embodiment as shown in FIG. **3**, the housing **20** is made of a lower segment **20*a*** and an upper segment **20*b***. The upper end of the lower segment **20*a*** has a male threaded connection **21** that is received by a corresponding female threaded connection **23** at the lower end of the upper segment **20*b***. Further, the base **88** of the piston **80** has a female threaded connection **89** that receives a male threaded connection **91** formed on the bottom end **84** of rod **82** of piston **80**. The base **88** is also provided with wrench flats **93** to facilitate assembly and disassembly of the rod **82** and base **88**.

The use and operation of the embodiment of the tool **10** as shown in the Figures FIGS. **2-6** is now described. To assemble the tool **10** as shown in FIG. **2**, the lower end **84** of the rod **82** is inserted downwardly into the axial bore **28** of the lower segment **20***a* of the housing **20**, while the upper end **86** of the rod **82** is inserted upwardly into the axial bore **28** of the upper segment **20***b* of the housing **20**. The lower segment **20***b* and the upper segment **20***b* are then screwed together by their corresponding threaded connections **21**, **23**, thus retaining the intermediate section **94** of the piston **80** between the lower internal shoulder **49** and upper internal shoulder **50** of the housing **20**. The base **88** and the rod **82** are screwed together by their corresponding threaded connections **89**, **91**. The housing **20** and travelling valve assembly **116** are screwed together using threaded connection **24**. The travelling valve assembly **116**, being part of the plunger **114**, is then lowered into the pump barrel **106** of the reciprocating pump **100**, as shown in FIG. **1**.

In operation, the pump **100** reciprocates axially, alternately between an upstroke and a downstroke, moving the tool **10** up and down within the pump barrel **106**. During the upstroke of the pump **100**, as shown in FIG. **7**, the weight of the piston **80** and the upward movement of the housing **20** causes the piston **80** to slide downwardly within the axial bore **28**, until the intermediate section **94** of the piston **80** engages the lower internal shoulder **49** of the housing **20**. In this retracted position, the upper end **86** of the piston **80** allows the ball **120** to come to rest on the valve seat. The pressure of the production fluid F above the ball **120** forces the ball **120** onto the valve seat, thus closing the valve **118** of travelling valve assembly **116**. As the plunger **114** continues to move upwardly within the pump barrel **106**, the plunger **114** lifts a column of the production fluid F in the portion of the pump barrel **106** above the tool **10**, as shown by the arrow lines, towards the surface. At the same time, the upward movement of the plunger **114** draws additional production fluid F through the open standing valve **108** into the portion of the pump barrel **106** below the tool **10**.

During the downstroke of the pump **100**, as shown in FIG. **8**, the lower seal **60** wipes downwardly against the inner wall of the pump barrel **106**, preventing any fluid to pass between the housing and the pump barrel **106**. This forces the production fluid F towards the standing valve **108**. However, as the standing valve **108** is now closed, the production fluid F in the portion of the pump barrel **106** below the tool **10** is forced to flow through the bottom opening **30** of the housing **20** and into the axial bore **28** below the piston **80**. This increases the pressure of the production fluid F acting on the bottom surface **90** of the base **88** of the piston **80**. Accordingly, the production fluid F urges the piston **80** to slide upwardly within the axial bore **28**, until the intermediate section **94** of the piston **80** engages the upper internal shoulder **50** of the housing **20**. In this extended position, the concave top surface **92** of the piston **80** pushes the ball **120** off of the valve seat, thus opening the valve **118** of travelling valve assembly **116** and prevents the ball **120** from returning to the valve seat.

In the extended position, the base **88** and intermediate section **94** of the piston **80** occlude the axial bore **28** between the radial ports **34**, **36**. Therefore, as shown by the arrow lines, the production fluid F in the axial bore **28** below the piston **80** flows through the lower radial port **34** and into the interior of the pump barrel **106**. In the pump barrel **106**, the combined effect of the seals **60**, **70** and the close tolerance of the outer surface **22** of the housing **20** and the inner wall of the pump barrel **106**, causes the production fluid F to flow in the channel **38**, through upper radial port **36** and back into the axial bore **28** above the intermediate section **94** of the piston **80**. The production fluid F continues to flow upwards in the axial bore **28**, through the top opening **32** and into the travelling valve assembly **116**. In the travelling valve assembly **116**, the production fluid flows through the open valve **118** and the valve cage, thus charging the portion of the pump barrel **106** above the tool **10** with production fluid F, which is lifted by the subsequent upstroke of the pump **100**.

FIG. **9** shows an alternative embodiment of the tool **10** of the present invention. This embodiment of the tool **10** differs from the embodiment of the tool **10** shown in FIG. **2**, in that the tool **10** does not have upper radial ports **36**, and that the channels **38** extend upwardly from the radial ports **34** to an upper end of the housing **20**. The use and operation of this embodiment of the tool **10** is the same as that of the embodiment of the tool **10** shown in FIG. **2**, except that the production fluid F flows from the channels **38** to the travelling valve assembly **116** in an alternative fluid passageway, rather than through the top opening **32** of the tool **10**. As will be apparent to those skilled in the art, various modifications, adaptations and variations of the foregoing specific disclosure can be made without departing from the scope of the invention claimed herein.

What is claimed is:

1. A downhole tool for opening a travelling valve assembly of a downhole pump, the tool and travelling valve assembly being disposed within a pump barrel, and the travelling valve comprising a valve member in a travelling valve housing, the valve member movable between an open position and a closed position, the tool comprising:

(a) a substantially cylindrical housing, wherein the housing comprises an outer surface and defines:

(i) an axial bore extending from a bottom opening for fluid communication with the pump barrel;

(ii) at least one radial port for fluid communication between the axial bore and the pump barrel;

(iii) for each of the at least one radial port, a channel formed in the outer surface of the housing for fluid communication between the at least one radial port and the travelling valve assembly; and

(b) a piston slidably disposed within the axial bore and occluding the axial bore above the at least one radial port, wherein the piston is responsive to an upward pressure exerted by a production fluid below the piston to slide upwardly within the axial bore from a retracted position to an extended position in which the piston engages the valve member in the travelling valve housing to move the valve member to the open position.

2. The tool of claim **1** wherein the housing comprises a threaded connection for removable attachment to a complementary threaded connection of the travelling valve assembly.

3. The tool of claim **1** wherein either the housing comprises a lower segment and an upper segment removably attachable to the lower segment, wherein the piston is removable from the housing when the upper segment is detached from the lower segment.

4. The tool of claim **1** wherein the at least one radial port comprises a plurality of radial ports circumferentially spaced apart on the housing.

5. The tool of claim **1** wherein the channel tapers inwardly towards the at least one radial port.

6. The tool of claim **1** wherein the housing defines a pair of internal shoulders that engage the piston to limit sliding of the piston between the retracted position and the extended position.

7. The tool of claim **1** wherein the piston comprises a cylindrical rod and an intermediate section attached to rod between the lower end of the rod and a top end of the rod, wherein the intermediate section engages an internal shoulder of the housing to occlude the axial bore above the at least one radial port.

8. The tool of claim **1** wherein the piston comprises a cylindrical rod and a base attached to a lower end of the rod, wherein the base engages an internal shoulder of the housing to occlude the axial bore above the at least one radial port.

9. The tool of claim **1** wherein the piston comprises a concave bottom surface.

10. The tool of claim **1** wherein the valve member is a ball, and the piston comprises a concave top surface adapted to engage the ball.

11. The tool of claim **1** further comprising a seal for sealing the outer surface to the pump barrel below the at least one radial port.

12. The tool of claim **11** wherein each of the seal comprises a sealing ring disposed circumferentially around the housing.

13. The tool of claim **12** wherein the outer surface of the housing defines a circumferential groove for retaining the sealing ring.

14. The tool of claim **13** wherein the sealing ring tapers radially outwards from a top end to a bottom end.

15. The tool of claim **1** wherein the channel extends from the at least one radial port to an upper end of the housing.

16. The tool of claim **1** wherein:

(a) the axial bore extends from the bottom opening to a top opening for fluid communication with the travelling valve assembly;

(b) the at least one radial port comprises a lower radial port and an upper radial port; and

(c) the piston occludes the axial bore above the lower radial port and below the upper radial port.

17. The tool of claim **16** further comprising a lower seal for sealing the outer surface to the pump barrel below the lower radial port, and an upper seal for sealing the outer surface to the pump barrel above the upper radial port.

18. The tool of claim **16** wherein each of the lower seal and the upper seal comprises a sealing ring disposed circumferentially around the housing.

19. The tool of claim **18** wherein the outer surface of the housing defines a lower circumferential groove for retaining the sealing ring of the lower seal, and an upper circumferential groove for retaining the sealing ring of the upper seal.

20. The tool of claim **18** wherein the sealing rings taper radially outwards from a top end to a bottom end.

* * * * *