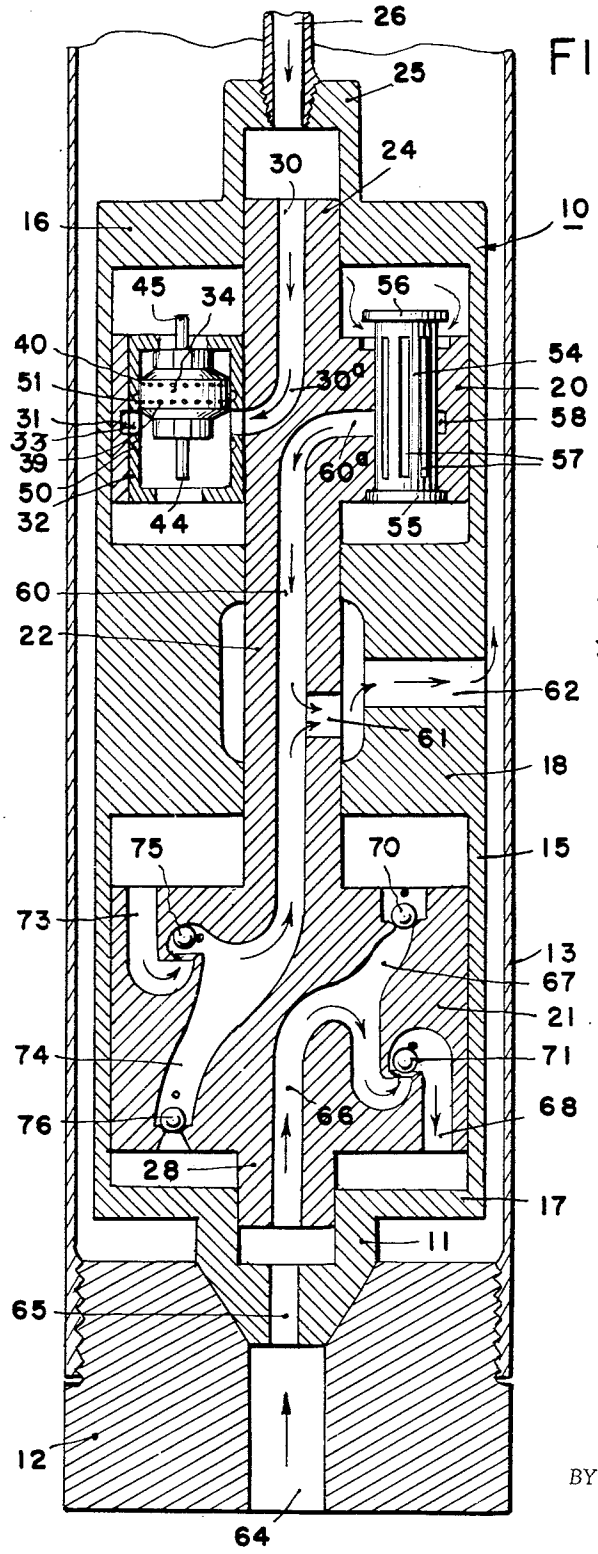
Dec. 20, 1955 C. D. RUSSELL 2,727,467

SUB-SURFACE PUMPING UNITS

Filed April 24, 1951

FIG. 1



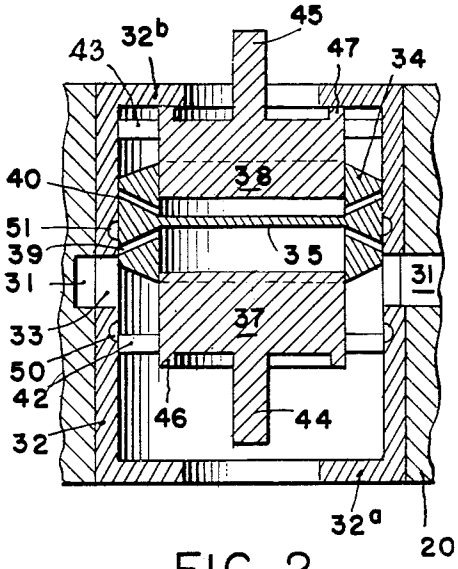


FIG. 2

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SUB-SURFACE PUMPING UNITS

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8 Claims. (Cl. 103—48)

This invention relates to improvements in sub-surface pumping units, and more particularly to an improved pumping unit of the type in which a hydraulic engine and a displacement pump are combined to provide a self-contained production unit capable of operating either as an insert pump or as a free-type pump.

A principal object of the invention is the provision of a sub-surface pumping unit as aforesaid, which is characterized by relatively inexpensive construction, low cost of installation and operation, and which is thoroughly dependable and efficient in operation.

A further aim of the invention is the provision of a sub-surface pumping unit capable of being built to reduced dimensions both axially and diameter-wise, as compared with prior pumping units of the same class.

Another object of the invention is the provision of a sub-surface pumping unit as aforesaid, characterized by a novel and simplified valving system.

Yet another object of the invention is the provision of a sub-surface pumping unit combining a double-acting hydraulic engine and a reciprocatory displacement pump, characterized in that the engine and pump pistons are directly connected and operate within a common cylinder member of simple construction, with all valves being carried by the respective pistons and all working and production fluid passages, with the exception of the pump intake and common exhaust passages, being formed in the pistons and in the middle or connection rod joining the same.

The above and other objects and advantages of a sub-surface pumping unit according to the invention will be seen from the following detailed description, taken with the accompanying drawings illustrating a preferred form of unit, in which:

Fig. 1 is a vertical section taken through a sub-surface pumping unit according to the invention, with the engine admission and exhaust valves in position as results in actuation of both engine and pump pistons in upward direction; and

Fig. 2 is a section taken through the engine admission valve illustrating its detailed construction.

Referring to the drawings, reference numeral **10** generally indicates the improved sub-surface pumping unit of the invention, shown in its bottom hole position within a well, with its bottom plug **11** resting on a seating shoe **12** to which the production tubing **13**, which may also function as the well casing, is affixed, as is conventional in insert pump installations. Such a pumping unit comprises a cylinder member **15** whose outer diameter is less than that of the production tubing so as to provide an annular space between cylinder and tubing for the upcoming production oil. The cylinder member is closed at its ends by heads **16**, **17** and has a transverse partition wall **18** which subdivides its interior space into upper and lower cylinders, of which the upper cylinder provides an engine cylinder and the lower a pump cylinder.

Operating in the engine cylinder is a power piston **20** and operating in the pump cylinder is a pump piston **21**. Said pistons are directly connected by a middle rod **22** which extends through the partition wall **18** and has sliding bearing therein. The power or engine piston **20** is formed with an upwardly extending, axial stem **24** having bearing in a tubular head plug **25** formed on the upper cylinder head **16**, into which is threaded a pipe **26** for supplying a working fluid, to be hereinafter referred to as power oil, to the engine. The pump piston **21** is formed with a downward axial stem **28** having sliding bearing in the aforesaid bottom plug **11**, which may be formed as an integral tubular extension of the lower cylinder head **17**.

The axial stem **24** of the engine piston is formed with an axial power-oil passage **30** extending into the body of the piston and terminating in a radial passage **30***a* which opens to an annular passage **31** formed in the piston body to encircle an open-ended cylindrical valve body **32** affixed in the piston so as to extend between the opposite faces thereof. The passage **30***a* communicates to interior of the valve body through the annular passage **31** and an inlet passage **33** formed in the valve body. Arranged within the valve body is an admission valve preferably of the automatic reversing type disclosed and claimed in my application Serial No. 215,950, filed March 16, 1951, now Patent No. 2,699,152, and which is shown in a position in which it is effecting admission of the power oil to the cylinder space below the under face of the engine piston **20**, with the result that the piston is moving on its upward stroke.

As explained in my aforesaid application, such a valve employs a sleeve-form valve element **34** having sliding clearance within the valve body **32**, and which is subdivided interiorly by a transverse wall **35** whereby it provides two oppositely disposed cups or cylinders for timing plungers **37**, **38** whose function and operation will be later explained. Power oil is supplied to one of the other of the plunger cylinders through the one of the two circular series of ports **39**, **40** then in registry with valve body inlet passage **33**, the ports of the series converging towards one another so that they open into said cylinders adjacent their relatively inner or closed ends. However, the outer ends of the ports **39**, **40** are spaced from one another a distance which is less than the width of the valve body inlet passage **33**, with the result that even though the sleeve element **34** is in its dead center position, one or the other series of ports **39**, **40** is in register with said inlet passage, and hence power oil will always pass to one or the other of the plunger cylinders.

The timing plungers **37**, **38** are oppositely arranged as shown and their skirt ends may be supported for reciprocatory travel within the valve body by spiders **42**, **43**, respectively. Said plungers are provided with axial stems **44**, **45** of length such that they protrude a calculated distance outwardly from the faces of the engine piston **20** when they are actuated to their outermost positions. The under faces of the plungers may be provided with circular sealing ribs **46**, **47** which are adapted to seal against the inner faces of radial end flanges **32***a*, **32***b* formed on the valve body **32**, when the plungers are in their aforesaid outermost position.

In its inner circumferential wall, the valve body **32** is provided with two circularly arranged exhaust channels **50**, **51** which open into the bore of the valve body and are spaced axially from the valve body inlet passage **33** by a predetermined small distance. Engagement of the sleeve element on one or the other of the inner surfaces of the valve body intervening between the exhaust channels **50**, **51** and the valve body inlet passage prevents the incoming power oil from being distributed in the wrong direction.

Briefly detailing the operation of the aforesaid ad-

mission valve, it is to be understood that the sleeve element **34** and the timing plungers **37**, **38** are shown in their relative positions (Fig. 2) to which they were actuated upon the engine piston **20** having earlier reached the lowermost limit of its travel. Upon the parts assuming such position, power oil from supply pipe **26** is admitted to the lower power space of the engine cylinder through the valve body **32** and underface of the engine piston **20**, resulting in actuation of the latter in upward direction.

As the engine piston approaches the uppermost limit of its stroke, the stem **45** of timing plunger **38** engages against cylinder head **16** and forces the plunger downwardly into its cylinder within the sleeve element **34**. Accordingly, the sleeve element is actuated downwardly by the fluid locked in the plunger cylinder by said plunger **38**, until its upper series of ports **40** registers with exhaust channel **51**, whereupon the plunger **38** collapses, i. e. moves freely into the sleeve element in response to final upward movement of the piston **20**, and engages against the transverse dividing wall **35** of the sleeve element. When such engagement occurs, the plunger **38** positively pushes the sleeve element **34** in downward direction the small amount required to register ports **40** with the inlet passage **33**, whereupon the power oil enters the space between the face of piston **38** and the sleeve partition **35**, and the piston now having fixed position, and forces the sleeve element downwardly to a position in which it permits free flow of power oil to the upper end of the valve body and thence to the upper power space of the engine cylinder. In addition, this final downward movement of the sleeve element results in timing plunger **37** being actuated to its outermost position in which its axial stem **44** projects from the under face of the piston.

Power oil is accordingly now distributed to the upper power space of the engine, namely, that above the upper face of the piston, whereupon the piston begins its downward travel which it continues until plunger stem **44** engages on the upper surface of the partition **18** which forms the lower head of the engine cylinder. Such initiates valve reversal and distribution through the lower face of the piston **20**, this cycle being repeated so long as the supply of power oil continues, which makes for simplified engine control through a valve located at the surface.

Also mounted in the piston **20** is an exhaust valve **54**, preferably of the spool type having a cylindrical body and enlarged diameter end flanges **55**, **56**. The exhaust valve slides in a cylindrical bore formed in the body of the piston and opening through both faces thereof, which is counterbored at both ends to provide seats for the large diameter end flanges **55**, **56** of the valve. The axial length of the exhaust valve is somewhat greater than the axial dimension of the piston so that it is actuated in one or the other direction upon the piston approaching the end of its stroke and its cylindrical body portion is provided on its surface with a plurality of "flats" **57** extending between the valve ends. Said flats provide communication between one or the other of the counterbores and an annular passage **58** formed in the piston body to encircle and communicate with the bore in which the valve operates. Said annular passage **58** communicates with the offset end **60***a* of an axial exhaust passage **60** extending downwardly through the piston body and in the middle rod **22** and opening to a radial exhaust port **61** in communication with an exhaust passage **62** provided in the partition wall **18**. As seen in Fig. 1, the inner end of the exhaust passage **62** is elongated vertically to provide for change in elevation of the port **61** due to the reciprocatory travel of the middle rod, and its outer end communicates directly with the annular space between cylinder member **15** and the production tubing **13**.

As the pump piston **21** is directly connected to the engine piston **20** by the middle rod **22**, the pump piston is driven so as to reciprocate in unison with the engine piston. Production oil is drawn into the pump cylinder through axial intake passages **64**, **65** formed in the bottom shoe **12** and cylinder bottom plug **11** respectively, and from thence through an axial passage **66** formed in the axial stem **28** of the pump piston and which extends into the body of the latter. At its upper end, the passage **66** connects with upper and lower intake branches **67**, **68**, the upper branch passage **67** opening through the upper face and the lower branch passage **68** opening through the lower face of the pump piston. Flow through the upper intake branch **67** is controlled by a valve **70** arranged on a seat which is upwardly disposed, and flow through the lower intake branch **68** is controlled by a valve **71** whose seat is also upwardly disposed.

The aforesaid passage **60** for the exhaust power oil from the engine is extended downwardly into the body of the pump piston **21**, being offset so as to have non-communicating relation with the aforesaid pump intake passage **66**. At its lower end, the exhaust passage **60** terminates in upper and lower exhaust branches **73**, **74**, of which the upper exhaust branch **73** opens through the upper face of the pump piston, and the lower exhaust branch **74** through the lower face thereof. Flow of oil through the upper exhaust branch is controlled by a valve **75** seating on an upwardly disposed seat, and flow through the lower exhaust branch **74** is controlled by a valve **76** whose seat is similarly upwardly disposed.

The operation of a sub-surface pumping unit as aforesaid is briefly as follows: Power oil is supplied to the engine through the pipe **26**, it being understood that such power oil may be crude oil drawn from a surface tank by a surface pump and delivered under pressure to the pipe **26**. The power oil operates the engine admission valve which in turn alternately distributes the power oil through the opposite faces of the engine piston **20**, resulting in reciprocation thereof. The exhaust from the engine passes through exhaust valve **54** and axial passage **60** to the annular space between cylindrical member **15** and the production tubing **13**.

Assuming the engine piston to be traveling in upward direction, pump piston **21** is also actuated in upward direction due to its direct connection with the engine piston. In the upward travel of the pump piston, its exhaust valve **75** and its intake valve **71** both are open and its intake valve **70** and its exhaust valve **76** are both closed, due to the difference in pressure effective on the opposite faces of the pump piston. Accordingly, production oil is drawn into the lower end and forced from the upper end of the pump cylinder, the latter oil exhausting through the upper branch passage **73** and thence to axial passage **60** wherein it combines with the power oil exhausting from the engine through the cylinder exhaust passage **62**. Upon reversal of reciprocatory travel of the engine piston **20**, pump piston **21** is now actuated in downward direction, with the result that pump intake and exhaust valves **70**, **76** open and the previously open intake and exhaust valves **71**, **75** close. Accordingly, oil is drawn into the upper end of the pump cylinder and forced from the lower end thereof, combining with the power oil from the engine and discharging through cylinder exhaust passage **62** as aforesaid.

Upon the production oil discharging to the annular space between cylindrical member and production tubing, it rises in said tubing, since the static head in the power oil column balances the head in the production column. It reaches the settling tank as crude oil and may be reemployed as power oil to drive the engine or to effect displacement of the production oil within the production tubing.

Without further analysis, it will be appreciated that a sub-surface production unit as aforesaid may be built to small dimensions both axially and diameter-wise in view of the fact that both the power oil admission and

exhaust valves of the engine and the intake and exhaust valves of the pump are built into their respective pistons, and this is true also for all power oil and production oil passages, with the exception of the common exhaust passage **62** which is provided in the cylinder partition **18**. Hence, a power unit according to the invention may be inexpensively constructed to small diameter and axial length. Its simplified construction lends itself to being run as an insert pump or as a free pump since its operation does not depend on whether it is attached to a bottom shoe, or whether it is hung free in the production tubing or well casing.

It will be understood that although packing and lubrication features have not been shown in the interest of simplified disclosure, such will be included in commercial pumping units built according to the invention. It is also to be understood that terms such as "upper," "lower," "upward direction," "downward direction," etc. are employed without limiting effect, since a pumping unit of the invention may be disposed on other than a vertical axis.

As many changes could be made in carrying out the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

I claim:

1. In a sub-surface pumping unit, the combination of a cylinder member having an interior partition subdividing it into an upper engine cylinder and a lower pump cylinder, interconnected engine and pump pistons mounted for reciprocatory travel in said engine and pump cylinders respectively, means for supplying a working fluid axially through the engine piston and thence alternately through the opposite faces thereof to the ends of the engine cylinder, means for exhausting the ends of the engine cylinder through the opposite faces and thence through the interior of the engine piston and thence through an exhaust passage extending to the interior of the pump piston, thereby to impart reciprocatory travel to both engine and pump pistons, an intake to the lower pump cylinder, the pump piston having valved intake passages opening through the opposite faces thereof and communicating with said intake and alternately with the ends of the pump cylinder, and valved exhaust passages similarly opening through its said opposite faces and communicating alternately with the opposite ends of the pump cylinder and with said exhaust passage, said exhaust passage being connected to a main exhaust passage extending to the exterior of the cylinder member.

2. A sub-surface pumping unit as set forth in claim 1, wherein the engine and pump pistons are interconnected by a rod having sliding bearing in the partition, said engine exhaust passage to the interior of the pump piston extends axially through the rod, and said main exhaust passage extends radially outward through said rod and partition.

3. In a sub-surface pumping unit, the combination of a cylinder member having an interior partition subdividing it into an upper engine cylinder and a lower pump cylinder, interconnected engine and pump pistons mounted for reciprocatory travel in said engine and pump cylinders respectively, means for supplying a working fluid axially to the interior of the engine piston, an admission valve mounted in and substantially contained within the axial dimension of said engine piston for effecting distribution of the working fluid alternately through the opposite faces of said piston to the cylinder ends, means for exhausting the one or the other engine cylinder ends not being supplied with working fluid through the engine piston and thence through an axial exhaust passage extending towards said pump cylinder, thereby to effect reciprocatory travel of both engine and pump pistons, an intake to the lower end of the pump cylinder, the pump piston having an axial intake passage communicating with said cylinder intake and with branch intake passages opening through its opposite faces respectively, intake valves contained within the pump piston for controlling flow from said intake through said branch passages alternately depending on the direction of travel of the pump piston, said pump piston also having branch exhaust passages opening through opposite faces thereof and communicating with an axial pump-exhaust passage extending toward said engine cylinder, exhaust valves also contained within the pump piston for controlling flow through said branch exhaust passages alternately and oppositely with reference to flow through the branch intake passages, said engine and pump exhaust passages connecting with one another and with a common exhaust passage in the cylinder.

4. A sub-surface pumping unit as set forth in claim 3, wherein the engine and pump pistons are interconnected by a rod, and said axial exhaust passages extend through said rod.

5. A sub-surface pumping unit as set forth in claim 3, wherein the engine admission valve includes a sleeve-form valve element mounted for limited axial movement within the piston and is actuable in part by the pressure of the working fluid.

6. A sub-surface pumping unit as set forth in claim 3, wherein the engine admission valve includes a sleeve-form valve element mounted for limited axial reversing movement within the piston, and means for initiating reversal of the valve element upon the engine piston approaching the limit of its stroke in either direction.

7. In a sub-surface pumping unit, the combination of a cylinder member having a partition subdividing it into an upper engine cylinder and a lower pump cylinder, interconnected engine and pump pistons mounted for reciprocatory travel in said engine and pump cylinders respectively, means providing working-fluid supply and exhaust passages which extend to the interior of and thence axially through the engine piston and which open to the opposite ends of the engine cylinder through the opposite faces of said engine piston, valving means mounted in said piston and being contained substantially within the axial dimension thereof and operative to supply working fluid through said passages to and exhausting it from said opposite ends of the engine cylinder alternately, means providing production-fluid inlet and exhaust passages which extend through the pump piston and open to the opposite ends of the pump cylinder through the opposite faces of said pump piston and valving means contained wholly within the pump piston for drawing production-fluid into and exhausting it from the opposite ends of the pump cylinder alternately.

8. A sub-surface pumping unit as set forth in claim 7, wherein the engine and pump exhaust passages are in communication with one another and wherein said cylinder partition is provided with means forming an exhaust passage to cylinder exterior into which said intercommunicating engine and pump exhaust passages open.

References Cited in the file of this patent

UNITED STATES PATENTS

389,725	Vanmeter	Sept. 18, 1888
2,156,537	Mathews	May 2, 1939
2,497,348	Ecker	Feb. 14, 1950
2,544,094	Knowles	Mar. 6, 1951
2,631,541	Dempsey	Mar. 17, 1953