March 17, 1942. G. KENNEDY ET AL 2,276,783

FLUID OPERATED MOTOR FOR DEEP WELL PUMPING EQUIPMENT

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Fig. 1

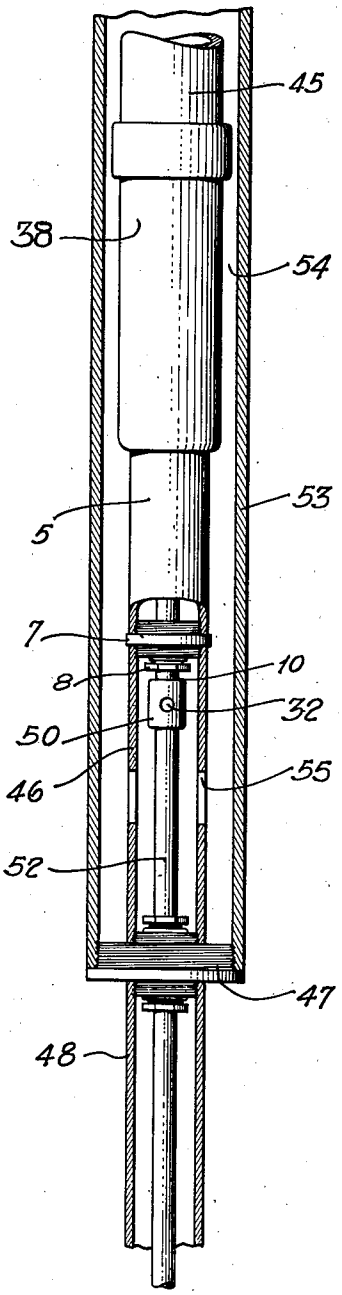
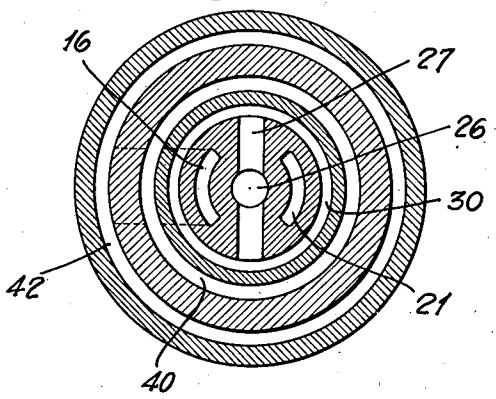


Fig. 4



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Fig. 3

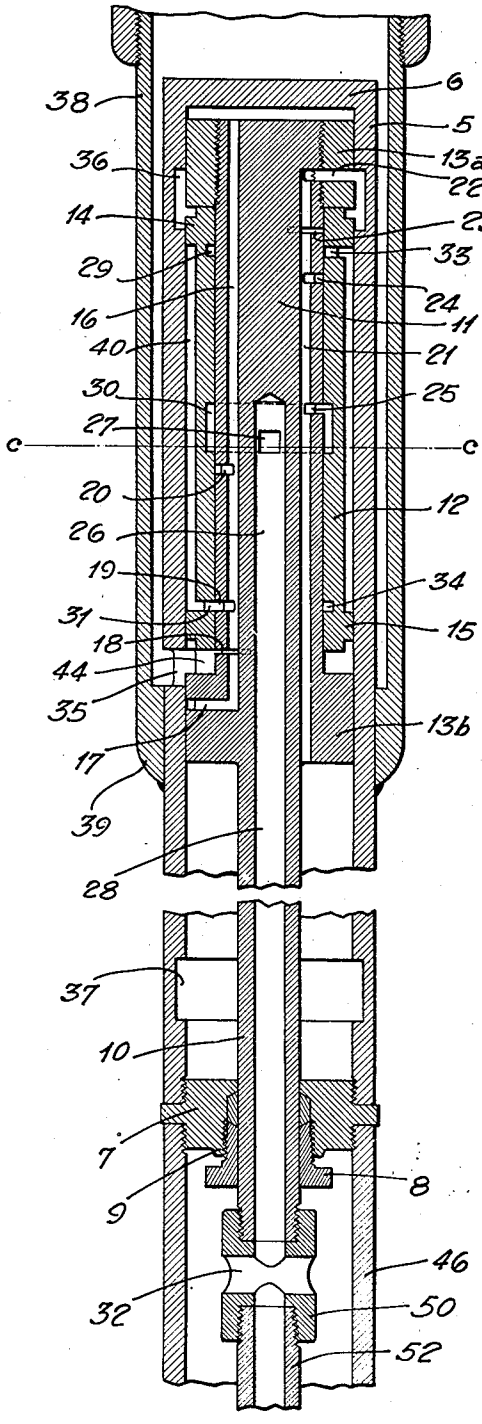
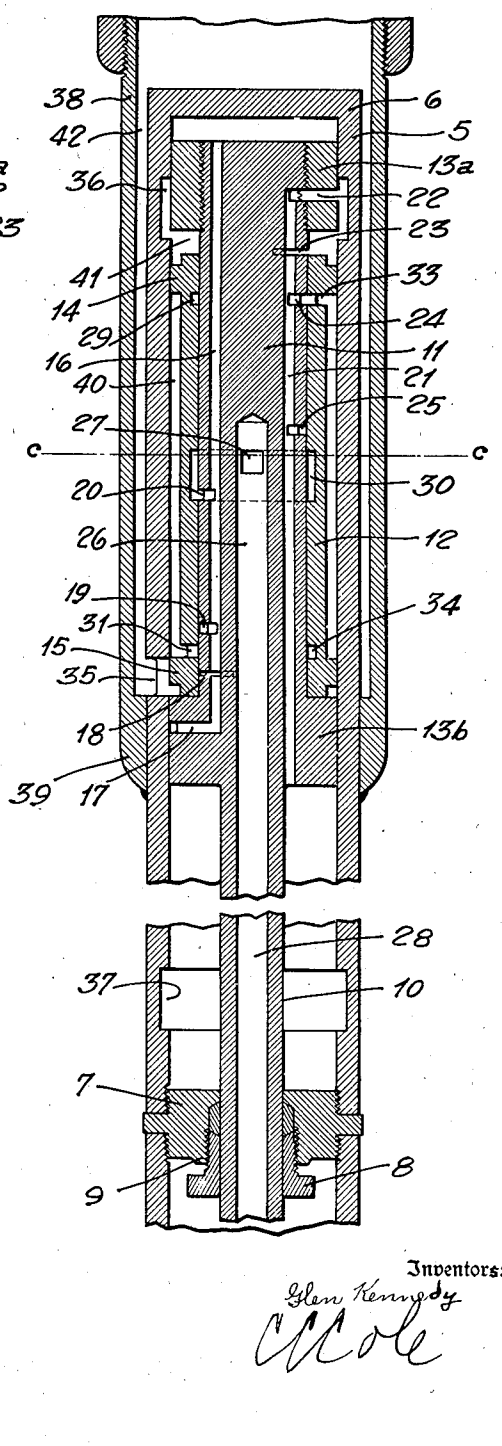


Fig. 2



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FLUID OPERATED MOTOR FOR DEEP WELL PUMPING EQUIPMENT

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Application November 7, 1938, Serial No. 239,258

6 Claims. (Cl. 121—123)

This invention relates in general to fluid motors and in particular to a fluid motor adapted to be positioned in a well bore for operating a deep well pump which may be associated with it. The pump preferably being of the double acting type.

While this motor may be applied to pumps used for many purposes, it is particularly adapted to the operation of deep oil well pumps. When utilized for this purpose, the motor, having the pump associated with it, is suspended from the lower end of a string of production tubing extending downwardly in the well bore. A string of pressure tubing, preferably disposed inside the production tubing, conducts a motive fluid from a surface pressure pump to the motor. The production tubing serving to conduct to the surface the discharge of the pump and the exhaust fluid from the motor.

It is an object of this invention to provide a fluid operated motor of a highly simplified design which consequently may be easily and economically manufactured and is comparatively free from mechanical breakdown in operation.

It is a further object of this invention to produce a fluid motor having but two moving parts, a piston and a control valve, which is positive in operation and which cannot get on dead center.

It is still another object of this invention to provide a fluid motor in which the two moving parts, a piston and a control valve, are both disposed in the piston chamber whereby the wearing surface is materially reduced under that of motors of a similar character which require separate chambers to receive the valves.

The essence of this invention which renders the foregoing and other objects possible of accomplishment resides in the concepts and in the methods of closing off the supply of fluid from the supply port to the piston chamber while the valve is being shifted by the fluid under pressure; of discharging fluid from the valve space; of starting the piston in the reverse direction as the valve completes its movement relative to the piston; in carrying the valve by the piston, and in the cooperative relationships which exist between the various elements of the mechanism and their respective fluid passages as follows:

1. Between fluid passages provided by the chamber wall and fluid passages provided by the piston.

2. Between fluid passages provided by the chamber wall and, respectively, the valve and valve fluid passages.

3. Between the piston fluid passages and, respectively, the valve and valve fluid passages.

Other objects and advantages of this invention will be made apparent in the description which follows and in the accompanying drawings.

In these drawings:

Fig. 1 is a diagrammatic view showing the motor of this invention attached to a pump.

Fig. 2 is a vertical sectional view of the motor of this invention, showing the valve in #1 control position.

Fig. 3 is similar to Fig. 2, except that the valve is shown in its other or #2 control position.

Fig. 4 is a horizontal sectional view taken on the line C—C—C of Figs. 2 and 3.

Referring to Fig. 1, a method of connecting the motor of this invention to a pump is shown. A string of pressure tubing **45** communicating with a source of operative fluid under pressure is threadably attached to the outside shell **38** of the motor. Shell **38** providing a passage to the motor supply port as will be explained later. Motor piston chamber threadably engages one end of head **7**, the opposite end of head **7** being threadably received by one end of connecting sleeve **46**. Head **47** serves as shown to threadably connect sleeve **46** and pump **48** and to threadably receive the lower end of a string of production tubing **53**.

Motor piston rod **10** and pump rod **52** are connected by rod connector **50**. Rod connector **50** provides opening **32** in communication with motor exhaust, as will be explained later, and with the discharge from the pump. Pump rod **52** is provided with a passage adapted to receive pump discharge. Opening **55** connects motor exhaust and pump discharge to space **54** between production tubing **53** and pressure tubing **45**.

Surface high pressure pumps for supplying motive fluid and methods of installation and operation in the well bore of fluid operated motor pumps are matters which have been described in the patent literature and are well understood by oil field workers. They will, therefore, not be made subjects for discussion here.

Referring to Fig. 2, a preferred construction of the motor is shown in detail. A cylindrical piston chamber **5** is closed at one end with a head **6** and is provided at the other end with a head **7** which provides a gland **8** and a stuffing box **9** adapted to receive the hollow piston rod **10**. The piston rod is attached to and substantially integral with the piston **11**. A sleeve control valve **12** and the piston are telescopically assembled; the valve being retained in place on the piston

by heads 13a and 13b, head 13a being threadably attached to the piston, as shown. It will be observed that heads 14 and 15 provided by the valve and piston heads 13 and 14 are in slidable and substantially fluid-tight contact with the inside chamber wall.

The piston, as shown, has formed therein a longitudinal primary passage 16, having primary, secondary, and tertiary and quaternary openings, designated as 17, 18, 19 and 20, respectively; and also a longitudinal secondary passage 21 having primary, secondary, tertiary and quaternary openings designated as 22, 23, 24 and 25 respectively; passage 16 connecting with the upper, and passage 21 connecting with the lower end of chamber 5. The piston further provides a longitudinal passage 26 connecting with a transverse passage 27 and passage 28 connecting with exhaust by opening 32, formed in piston rod 10. Since passages 27, 26, 28 and opening 32 constitute a passage leading to exhaust, hereinafter a connection to passage 27 will be termed as a connection to exhaust.

Valve 12 provides primary and tertiary openings 33 and 31 connecting respectively with annular channels 29 and 34 and furthermore provides a secondary passage 30 in the form of an annular channel in connection at all times with transverse passage 27. Channel 30 being wide enough to cover passage 27 with sleeve valve 12 in either one of its extreme positions.

The piston chamber 5 has formed in its inside wall primary and secondary channels 36 and 37 and a supply port 35, channels 36 and 37 being axially equidistant from supply port 35. A shell attached to the chamber at 39 provides a channel for conducting motive fluid to the chamber supply port 35.

It will be observed that piston heads 13a and 13b serve to limit the travel of valve 12, the distance of travel being that required to bring into proper registration the various cooperating ports and openings, as will be explained later.

It is also desired to point out that valve heads 14 and 15 in slidable contact with the inner surface of chamber 5 serve to define an annular passage 40.

With valve 12 in the position relative to the piston, as shown in Fig. 2, but with the piston slightly lower down in the chamber than shown, it will be apparent that a passage is established leading from supply port 35 through annular passage 40, through valve opening 33 and piston opening 24 into piston passage 21 and thence to the lower end of piston chamber 5. With shell 38 connected to a source of operative fluid under pressure fluid will flow through annular passage 42 to supply port 35 and thence through the passage as above described to the lower end of chamber 5 where it will act to force the piston in the upward direction. It should be noted that space 41 between valve head 14 and piston head 13a is connected with piston passage 21 by opening 23, consequently space 41 is filled with operative fluid under pressure whereby valve 12 is effectively held in its control position.

With the valve in the control position with respect to the piston, as above described, it will be clearly seen by referring to Fig. 2 that a passage for the exhaust of fluid from the upper end of chamber 5 is provided through piston passage 16 and opening 20 into sleeve valve passage 30 which connects to exhaust.

With piston 11 and valve 12 in the positions shown in Fig. 2 it will be apparent that valve head 15 has shut off the connection between supply port 35 and annular passage 40. Obviously, in this position no fluid can flow from supply port 35 to piston chamber 5; however, the full pressure of the operative fluid is applied against valve head 15 to move it in the upward direction.

As shown in Fig. 2, chamber annular passage 36 connects space 41 and piston opening 22 with piston in this position. Operative fluid pressure acting against valve head 15 causes the valve to move upwardly forcing fluid from space 41 through annular passage 36 and opening 22 thence through piston passage 21 into the lower end of chamber 5 closed off from exhaust at this time whereby the piston is caused to move upwardly, the upper end of chamber being open to exhaust. This movement of the piston continues until the valve has moved to the point where valve annular passage 30 connects opening 25 with exhaust passage 27 whereby a passage is set up from space 41 through annular passage 36, piston opening 22 and passage 21 to opening 25 then through valve annular passage 30, and, as already described, thence to exhaust.

It should be pointed out in a general way that in fluid motors of this character open exhaust passages must be maintained at all times as well as supply passages if the various fluid operated parts are to continue in motion and the motor is not to stall. It is therefore necessary to provide a slight overlapping of openings 20 and 25.

It will be seen that valve 12 in the course of its movement from control position #1 as shown in Fig. 2 to control position #2, as shown in Fig. 3 first closes opening 20 thus closing the passage established for the exhaust of fluid from the upper end of chamber 5 and just before opening 20 is completely closed valve passage 30 slightly laps opening 25 for reasons already stated. At this point openings 23 and 33 are closed, opening 31 is slightly lapping opening 19 and not until valve 12 has substantially completed its movement is opening 18 which is made narrow for this purpose connected to supply port 35. Opening 18 is a starting port and provides in part a passage for the flow of fluid to start the piston in the reverse direction as will be explained later. It thus becomes apparent that the piston moves the valve into operative relation with supply port 35 and passage 36, that at this point the supply of operative fluid is closed off from the piston chamber by valve head 15 and therefore the valve is maintained in operative relation with supply port 35 and passage 36 until it has completed its movement. Obviously it is impossible for the piston or valve to get on a dead center. It will be noted that the movement of the piston due to valve movement in either direction is very slight, due to the fact that fluid is forced against the piston head during only ½ of the total movement of the valve, during the last ½ of valve movement a passage to exhaust is provided, furthermore, the effective area of a valve head is much less than the working area of a piston head and the total movement of the valve relative to the piston is small.

Referring now to Fig. 3 it will be noted that valve 12 is in control position #2, that is, it is in its extreme upward position and passages have been established for the exhaust of fluid from the lower end of chamber 5 and for the supply of fluid to the upper end of chamber 5 to effect the downward movement of piston 11.

In the position of piston 11 and valve 12 shown

in Fig. 3 it is apparent that a passage for the supply of fluid has been established from supply port 35, through opening 18 and thence through piston passage 16 to the upper end of chamber 5. As piston 11 moves a slight distance in the downward direction valve head 15 will connect supply port 35 with annular passage 40; the passage for the supply of fluid to the upper end of piston chamber 5 will then be from supply port 35, through annular passage 40, through openings 31 and 19 and thence along piston passage 16. It will be noted that supply port 35 is sufficiently wide to permit valve head 15 to pass it without being closed and that fluid pressure is maintained in space 44 through opening 18, thus holding valve 12 in position.

As shown in Fig. 3 a passage for conducting fluid from the lower end of chamber 5 to exhaust is set up as follows: through piston passage 21 to opening 25, thence through valve passage 30 to exhaust.

With valve 12 in the position relative to piston 11 as above described and shown in Fig. 3, the piston will travel downwardly until the fluid filled space 44 is connected to piston passage opening 17 by passage 37 and valve head 43 closes off supply port 35 from the established passage leading to the upper end of chamber 5, the situation being entirely analogous to that shown in Fig. 2 and already described.

Fluid pressure acting against valve head 14 moves valve 12 downwardly. During the first ½ of the valve movement fluid from space 44 is forced through passage 37, and opening 17 along piston passage 16 and thence into the upper end of piston chamber 5 whereby the piston is moved downwardly a slight distance, at this time the upper end of piston chamber being closed off from exhaust and the lower end open thereto. As valve 12 completes its movement, valve passage 30 connects opening 20 to exhaust, whereby a passage from space 44 to exhaust is provided through opening 18 and along passage 16 to opening 20.

With the piston in its extreme downward position and with valve 12 having completed its movement valve 12 is now in a position with respect to the piston, as shown in Fig. 2 and with a passage to exhaust set up as previously described. However, valve head 14 has supply port 35 closed off from annular passage 40. Opening 23 being connected to supply port 35 fluid flows through opening 23 and passage 21 to the lower end of chamber 5 causing the piston to start moving in the upward direction. As valve head 14 passes supply port 35 a supply passage is set up as first described and the piston continues to move in the upward direction to the position shown in Fig. 2. Thus the cycle is completed. Obviously, with a continuous supply of operative fluid the piston will continue to reciprocate.

It will be apparent that valve 12 in shifting from control position #2 to control position #1 moves in a manner analogous to the shift from position #1 to position #2. In the course of the first ½ part of valve movement from position #2 to position #1 openings 25, 19 and 18 are closed. As the valve continues its movement, opening 20 is connected to exhaust by passage 30, there being, as previously explained, a slight overlapping of openings 20 and 25, passage 30 being sufficiently wide to effect this; opening 24 registers with opening 33 and just before valve movement is completed opening 23 is connected to supply port 35. As explained with regard to opening 18, opening 23 is made narrow to insure that before it is connected to supply port 35 valve movement will be substantially completed.

Since openings 18 and 23 act as starting ports, there is therefore no possibility of the piston starting in the reverse direction from either one of its extreme positions before valve movement is completed.

It should be noted that although for the sake of clarity a somewhat lengthy and detailed description of valve action has been given valve movement is actually relatively rapid. The rapidity of action, of course, being dependent on the rate at which motive fluid is supplied to the motor.

Thus it will be seen that a motor, operative by oil as the motive fluid, has been produced, the valve action of which is rendered positive at all times by the foregoing described arrangement of passages and ports. By first connecting the space ahead of the valve to a piston chamber end closed off from exhaust and subsequently, in consequence of valve movement, providing a connection to exhaust provision is made for the complete exhaust of fluid trapped ahead of the valve and the maintenance of live fluid pressure against the other end of valve throughout its entire course of travel without possibility of a connection between supply and exhaust occurring at any time. Obviously in a motor operated by an incompressible fluid such as oil any fluid trapped ahead of the valve would block its action.

We claim:

1. In a fluid operated motor: a motor body providing a chamber; a piston slidable in said chamber providing a valve space, a valve in said space, a port opening through one end of said piston, another port opening through the opposite end of said piston, one of said ports cooperating with a suitable passage provided by the chamber at one extreme limit of piston travel and the other of said ports cooperating with another chamber passage at the opposite extreme limit of piston travel to set up a passage in each case for the discharge of fluid from said valve space into that end of said chamber closed off from exhaust at that time.

2. In a fluid operated motor the combination of: a body providing a chamber and passages; a piston providing a valve space; a fluid operated valve slidably assembled in said space; said piston providing primary and secondary longitudinal passages opening through and extending back from opposite ends of said piston, said passages each providing: a primary opening adapted to cooperate with one of said chamber passages to conduct fluid from said valve space to end of said chamber closed off from exhaust during first part of valve shift, a secondary opening, valve controlled and arranged to open as said valve reaches an extreme limit of travel, tertiary and quaternary openings arranged to cooperate with passage means provided by said valve to control the supply and exhaust of fluid to and from said chamber.

3. In a fluid operated motor the combination of: a motor body providing a chamber and passages; a piston comprising two heads and a connecting body portion of reduced diameter thereby providing a valve space; a sleeve-like valve providing supply ports and an exhaust passage slidably assembled on said body portion between said two heads; said piston providing primary and secondary longitudinal passages opening through and extending back from opposite ends of said piston, said passages each having lateral

openings as follows: a primary opening through a piston head opposite to that end of the piston from which its respective passage extends, said opening being adapted to cooperate with a chamber passage to conduct fluid from said valve space, a secondary opening through said piston body, valve controlled and arranged to open as said valve reaches an extreme limit of travel, a tertiary opening through said piston body adapted to cooperate with one of two supply ports provided by said valve and a quaternary opening controlled by an exhaust passage formed in said valve in communication with exhaust at all times, said piston providing a passage leading to exhaust having a lateral opening through said piston body covered by said valve exhaust passage at all times.

4. In a fluid operated motor: a motor body providing a chamber and passages in the wall thereof and intermediate said passages a supply port; a piston in said chamber providing a valve space and a longitudinal pasage opening through the first end of said piston and laterally through said piston adjacent its second end, another similar passage opening through said piston second end and laterally through said piston adjacent its first end; a fluid operated valve slidable in said valve space and providing means to control the supply of fluid from said supply port; one or the other of said chamber passages being adapted as said piston approaches one or the other of its extreme limits of travel to connect one end of said valve space with the piston passage lateral opening in communication with the end of said chamber closed off from exhaust at that time at substantially the same time that said fluid supply port registers with the other end of said valve space and control means provided by said valve close off the communication between said supply port and said chamber whereby the shifting of said valve is permitted and effected.

5. In a fluid operated motor the combination of: a motor body providing a chamber and in its side fluid passage means adjacent each end and intermediate thereof a supply port; a piston comprising two heads and a connecting body portion of reduced diameter thereby providing a valve space; a sleeve-like valve providing supply ports and exhaust passage slidably assembled on said body portion between said two heads; said piston providing primary and secondary longitudinal passages opening through and extending back from opposite ends of said piston, said passages each having lateral openings as follows: a primary opening through a piston head opposite to that end of the piston from which its respective passage extends, said opening being adapted to cooperate with a chamber passage to conduct fluid from said valve space at extreme limits of piston travel, a secondary opening through said piston body, valve controlled and arranged to open as said valve reaches an extreme limit of travel, a tertiary opening through said piston body adapted to cooperate with a valve fluid supply port and a quaternary opening controlled by said valve exhaust passage; said piston providing a passage leading to exhaust having a lateral opening through said piston body covered by said valve exhaust passage at all times; said valve constructed with a flange adjacent each end thereof and adapted to cooperate with said chamber fluid supply port to close off the supply of fluid to said piston chamber ends during the time fluid is supplied to a valve space end to effect valve movement.

6. In a fluid operated motor the combination of: a motor body providing a chamber, a supply port and two passage means; a piston slidably mounted in said chamber, and providing a valve space; a valve in said space; said piston providing an exhaust passage and fluid passage means in alternate valve controlled communication with said exhaust passage for conveying fluid to and from opposite ends of said chamber to actuate said piston comprising a longitudinal passage opening through and extending from the end of the first piston head to and opening laterally through the second piston head and another longitudinal passage opening through and extending from the end of the second piston head to and opening laterally through the first piston head; as said piston approaches an extreme limit of travel, one of said body passages is adapted to provide a connection between the lateral opening in communication with that end of chamber closed off from exhaust at that time and one end of said valve space whereby initially, a passage is established for the discharge of fluid from said valve space end into said chamber end and subsequently in consequence of valve travel a passage is provided leading to exhaust; the complete shifting of said valve thereby being permitted and connection between supply and exhaust prevented.

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