July 20, 1965 T. S. REED ETAL 3,195,658

AIR RETURN SYSTEM FOR AIR FEED DRILL

Filed July 25, 1962 2 Sheets-Sheet 1

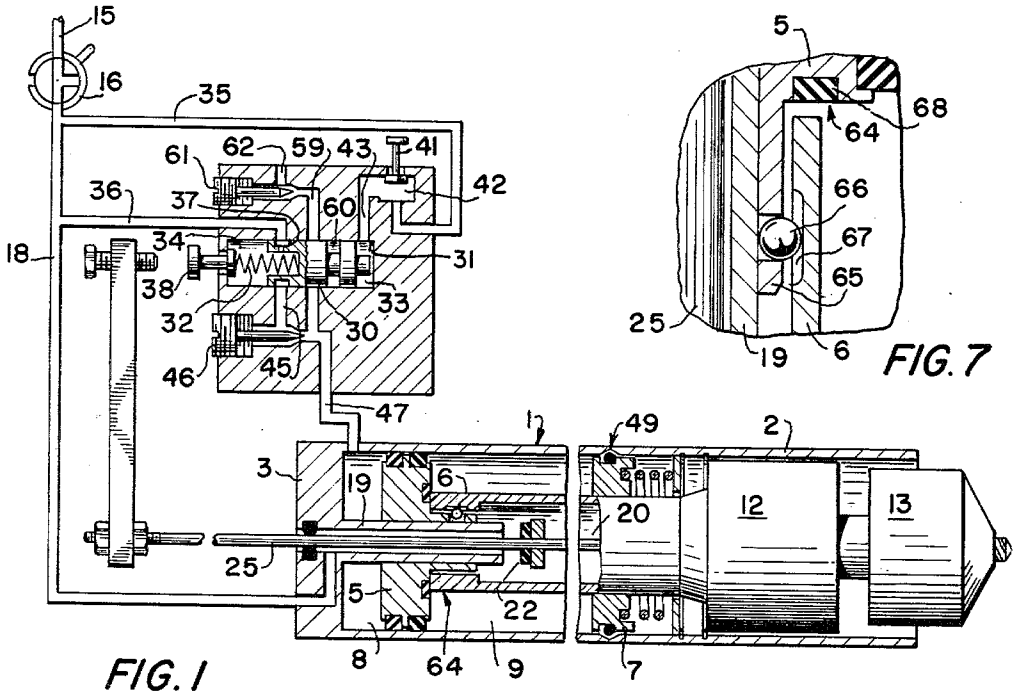


FIG. 1

FIG. 7

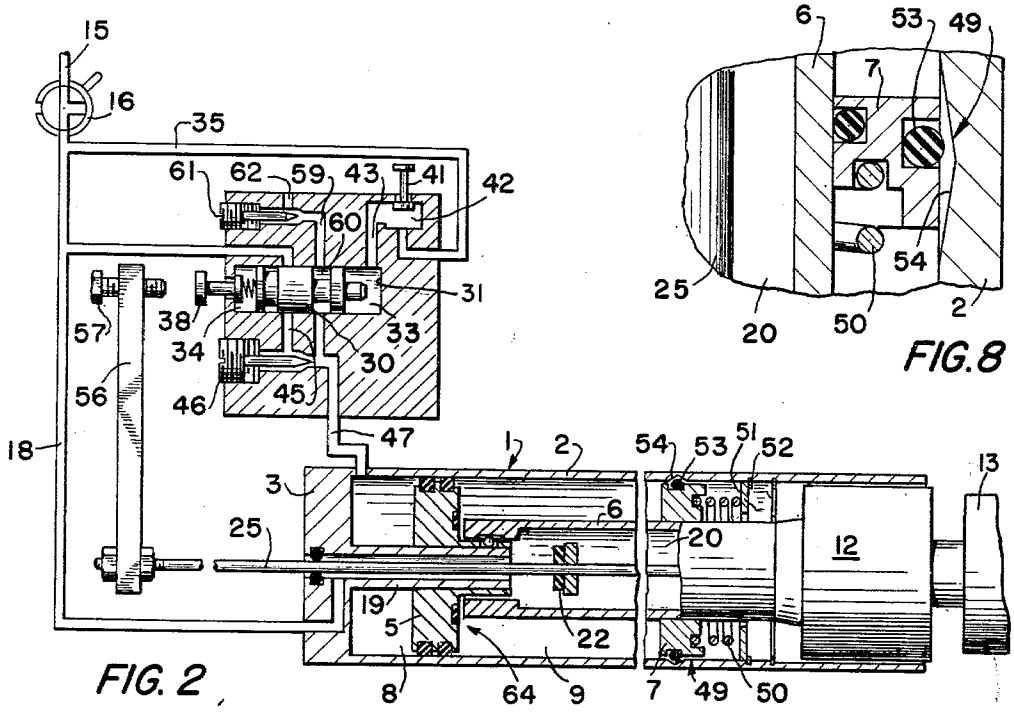


FIG. 2

FIG. 8

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AIR RETURN SYSTEM FOR AIR FEED DRILL

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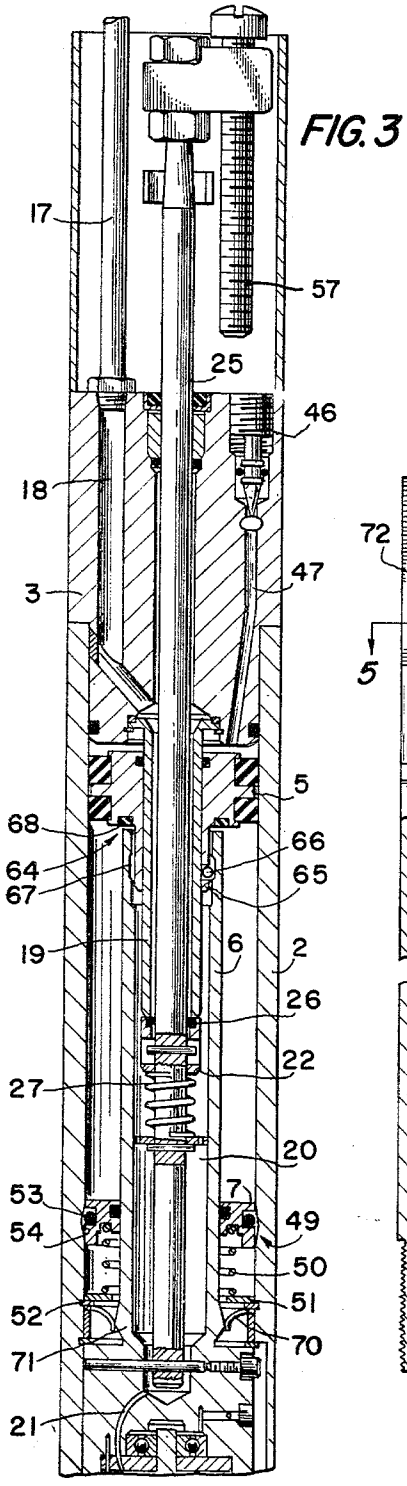


FIG. 3

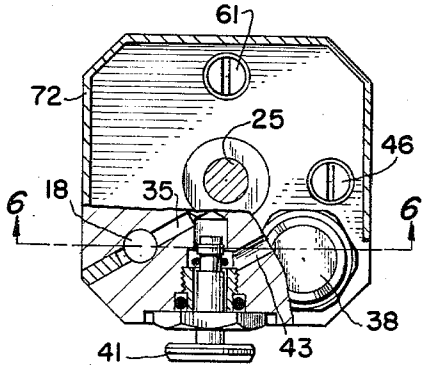


FIG. 5

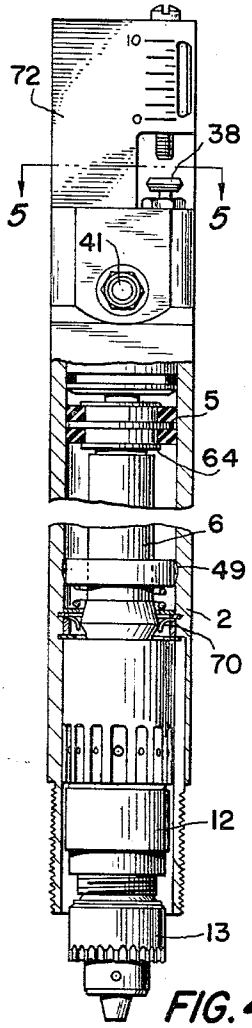


FIG. 4

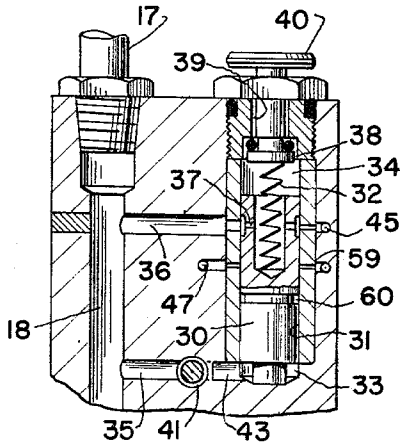


FIG. 6

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AIR RETURN SYSTEM FOR AIR FEED DRILL

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5 Claims. (Cl. 173—158)

This invention relates to fluid pressure-operated tools which simultaneously rotate and axially reciprocate a tool implement. An example of this type of tool is the "air feed drill" disclosed in the copending U.S. patent application of John M. Clapp et al., Serial No. 201,852, filed June 12, 1962, now abandoned.

Generally, it is desirable to connect an "air feed drill" to its pneumatic pressure source by a hose running to the back head or rear end of the drill where the hose is least likely to interfere with the use of the drill. This rear end location of the hose connection creates a problem in double-acting drills, which are reciprocated back and forth by alternately admitting fluid pressure into a pair of piston chambers in the tool, because it necessitates the provision of the tool with an air passage running to the front piston chamber around the piston. Heretofore, this front piston chamber passage generally has been located in the casing of the tool which is a disadvantage because it requires the thickness of the casing, and, consequently, the diameter of the tool, to be larger than it would be if the passage were eliminated and it creates manufacturing problems which are difficult to solve.

The principal object of this invention is to eliminate the need for the undesirable passage in the tool casing running to the front piston chamber and, therefore, to reduce the casing thickness and the overall diameter of the tool, thus rendering the tool smaller, easier to handle and to operate and more economical to manufacture.

Other important objects include: to provide a simplified valve mechanism for alternately admitting pneumatic pressure to the piston chambers of a double-acting air feed drill; to provide a double-acting air feed drill which is automatically retracted when air pressure is vented from its rear piston chamber; to provide a piston chamber vent valve which is effective to vent the piston chamber at low pressures and is actuated by high pressure to close and discontinue venting the piston chamber; and to provide an air feed drill which is double-acting and does not need or use a separate passage running from the rear end of the tool to the front piston chamber.

The invention is illustrated in the accompanying drawings wherein:

FIG. 1 is a diagrammatic view of the fluid control system of an air feed drill incorporating the features of this invention and shows the drill being fed forwardly;

FIG. 2 is similar to FIG. 1 and shows the control valve of the fluid control system in its alternate position, with the drill being retracted;

FIG. 3 is a longitudinal section of the rear half of the air feed drill;

FIG. 4 is a broken and cut-away elevational view of the air feed drill of this invention;

FIG. 5 is an enlarged section taken on line 5—5 in FIG. 4 and having portions cut-away;

FIG. 6 is a fragmentary section taken along the line 6—6 in FIG. 5;

FIG. 7 is an enlarged fragmentary view of a portion of FIG. 3; and

FIG. 8 is an enlarged fragmentary view of another portion of FIG. 3.

The air feed drill shown in the drawings comprises a body 1 formed by an elongate cylinder 2 which is open at its front end and closed at its rear end by a back head 3. A piston 5 is axially slidable in the cylinder 2 and includes a hollow piston rod 6 which extends forwardly from the piston 5 through an annular ring 7 mounted in the front end of the cylinder 2.

The foregoing structural arrangement forms two fluid-receiving chambers which are separated by the piston 5 and are adapted to alternately receive fluid pressure, such as pneumatic pressure, for feeding the piston 5 in alternate directions in the inner cylinder 2. The chamber located rearwardly of the piston 5 is designated the forward feed chamber 8 and the chamber located in front of the piston 5 is designated the retraction chamber 9.

The front end of the piston rod 6 is fixed to the rear end of a conventional vane-type air motor 12 which is slidably mounted in the front half of the forward portion of the cylinder 2. The air motor 12 carries a conventional drill chuck 13 projecting forwardly from the front end of the body 1. Normally, the drill chuck is driven through a set of planetary gears (not shown) which are located between the air motor 12 and the drill chuck 13 and reduce the rotary speed of the air motor 12 to a suitable value for driving the chuck 13. No attempt is made to describe the air motor and drill chuck further since these items are conventional and well known in the air feed drill art, as shown by the U.S. patents to Taylor, 2,674,098, Robinson, 2,857,789, and De Groff, 2,860,531.

From the foregoing, it will be obvious that the air motor 12 rotates its drill chuck 13 while the piston 5 axially feeds the motor 12 and chuck 13 through a reciprocatory cycle during a work operation. This reciprocatory cycle begins and terminates with the piston 5 resting at the rear end of its travel path and includes a forward stroke followed by a return stroke.

Motor fluid circuit

A simplified version of this circuit is shown in FIG. 1. In general, it includes a fluid pressure source (not shown) feeding a main line 15 connected to a conventional three-way valve 16. The valve 16 is connected by a hose 17 (shown in FIG. 3) to a fluid inlet passage 18 in the back head 3. The inlet passage 18 opens into a tube 19 which is fixed on the front of the back head 3 and extends forwardly through the piston 5 and the piston rod 6. The piston rod 6 is hollow and forms a central rod passage 20 which opens at its front end into the fluid inlet 21 of the air motor 12.

Access of the fluid pressure from the tube 19 into the central rod passage 20 in the piston rod 6 is determined by a motor valve 22 which is mounted in the central rod passage 20 and is located to seat on and close the front end of the tube 19 when the piston 5 is fully retracted. As the piston 5 starts its forward stroke, as shown in FIG. 1, the motor valve 22 is lifted off the front end of the fixed tube 19 and the fluid pressure in the tube 19 is free to flow into the rod passage 20 to the air motor 12, thereby driving the motor 12 and its chuck 13. This driving of the motor 12 continues throughout the remainder of the cycle and is only stopped when the piston 5 returns and seats the motor valve 22 once again on the front end of the fixed tube 19.

The specific construction and mounting of the motor valve 22 is shown in FIG. 3. A follower rod 25 is anchored at its front end to the front end of the piston rod 6 and extends axially rearwardly through the central rod passage 20, the fixed tube 19 and slidably through the back head 3 to project behind the back head a substantial distance. This follower rod 25 is smaller than the rod passage 20 and the interior of the fixed tube 19 so that fluid may pass therebetween. Suitable seals circle the follower rod 25 at the rear of the back head 3 to prevent the pressure fluid from leaking rearwardly from the fixed tube 19.

The motor valve 22 carries a resilient rear face 26 adapted to seat on the front end of the fixed tube, is slidably mounted on the follower rod 25 for limited movement and is spring-biased rearwardly by a spring 27 which is anchored at its front end to the follower rod 25. This arrangement insures that the motor valve 22 is firmly seated against the tube 19 when the piston 5 is retracted and compensates for any variation between the piston's position when it is fully retracted and when the motor valve 22 is seated. The foregoing structure is disclosed in the previously mentioned copending U.S. patent application of John M. Clapp et al.

Piston fluid circuit

FIG. 1 shows a portion of the back head 3 separate from the body 1 to simplify the illustration of the fluid circuits of the tool. It will be understood that FIG. 1 is merely a diagrammatic view and does not show the true construction or location of the back head 3 and its associated elements.

The back head 3 is provided with a two-position spool valve 30 which slides in a bore 31 formed in the back head 3. In one position, its front position shown in FIG. 1, the spool valve 30 feeds fluid pressure to the forward feed chamber 8 to drive the piston 5 on its forward stroke, and in its other position, its rear position shown in FIG. 2, the spool valve 30 exhausts the forward feed chamber 8 so that the piston 5 can be driven rearwardly through its return stroke.

The spool valve 30 is biased forwardly in the bore 31 by a spring 32. When the spool valve 30 is in its forward position, as shown in FIG. 1, the front and rear chambers 33 and 34 located at the opposite ends of the valve 30 are in communication with the fluid pressure in the inlet passage 18 by means of the intermediate passages 35 and 36. The front intermediate passage 35 is normally in direct communication with the front chamber 33 and the rear intermediate passage 36 communicates with the rear chamber 34 by means of a small port 37 in the spool valve 30.

When the spool valve 30 is in its forward position, the admission of fluid pressure into the inlet passage 18 results in the simultaneous admission of fluid pressure to both the front and rear chambers 33 and 34 of the valve, which prevents the creation of a differential pressure between the two chambers 33 and 34. Hence, the spool valve 30 remains in its forward position. The spring 32 normally moves and holds the spool valve 30 in its forward position when the fluid pressure is closed off from the tool.

After fluid pressure is admitted to both the front and rear valve chambers 33 and 34, the spool valve 30 is moved to its rear position by venting the rear chamber 34, thus creating a pressure differential between the two valve chambers tending to drive the valve rearwardly. This venting of the rear chamber 34 is accomplished by pushing inwardly on the poppet valve 38 located at the rear end of the bore 31 and projecting from the rear end of the back head 3. The poppet valve 38 is loosely mounted in its guide hole 39 so that when its head 40 is pushed inwardly off its seat, the fluid pressure in the rear chamber 34 freely escapes to the atmosphere along the clearance space between the valve stem and its guide hole. The poppet valve 38 is termed a reversing poppet valve since it actuates the spool valve 30 to its rear position, causing the piston 5 to move along its return stroke.

When the spool valve 30 is in its rear position, it is moved back to its forward position by exhausting the front valve chamber 33, allowing the spring 32 to drive the spool valve 30 forward. Exhausting the front chamber 33 may be accomplished by momentarily shutting off the the fluid pressure to the tool and exhausting the inlet passage 18 by means of the conventional three-way valve 16 shown in FIG. 1.

Exhausting the front valve chamber 33 may also be accomplished by a poppet valve 41, which is located on the side of the back head 3. The poppet valve 41 is similar to the poppet valve 38 and is mounted in the back head 3 to reciprocate in a cavity 42 which communicates with the chamber 33 through a passage 43. When the valve 41 is depressed, it simultaneously plugs the end of the passage 35, opening into the cavity 42, and exhausts the cavity 42 which is in communication with the front chamber 33. The poppet valve 41 is termed a manual recycle valve since it can be used to cause the tool to begin a cycle, as will be clear later.

Forward feed piston stroke

When the spool valve 30 is in its forward position as shown in FIG. 1, it allows pressure fluid to flow from the rear intermediate passage 36 to a forward stroke passage 45 running to a forward stroke needle valve 46. The needle valve 46 meters the fluid pressure and dumps it into a passage 47 leading into the forward feed chamber 8.

Also, in the forward position of the spool valve 30, the retraction chamber 9 is exhausted by a pressure-actuated vent valve 49 located at the front end of the chamber 9 and formed in part by the annular ring 7, as seen in FIG. 8. The annular ring 7 is slidably mounted in the cylinder 2 and rests against a spring 50 located between its front face and a washer 51 seated against a lock ring 52 fixed in the interior of the cylinder 2. Normally, the spring 50 prevents the ring 7 from moving forwardly beyond a predetermined position in the cylinder 2. The circumference of the ring 7 is encircled by an O-ring 53 and the interior of the cylinder 2 is formed with an annular groove 54 located to loosely contain the O-ring 53 when the ring 7 is in its normal predetermined position in the cylinder 2.

The vent valve 49 operates in the following manner. When the fluid pressure in the retraction chamber is relatively low, the ring 7 is held in its normal position wherein the O-ring 53 is spaced from the walls of the groove 54, resulting in the chamber 9 being vented to atmosphere past the O-ring 53 and out the front end of the cylinder 2. Sufficient space exists between the cylinder 2 and the air motor 12 to provide a vent path therebetween.

When the pressure in the retraction chamber is high, as in FIG. 2, the ring 7 is pressed forwardly to overcome the spring 50 and to press the O-ring 53 against a wall of the annular groove, thus closing the vent valve 49 and sealing the retraction chamber 9 from the atmosphere. In brief, when the pressure on the vent valve 49 is relatively low, it is open, and when the pressure is high, it is closed.

Return piston stroke

The follower rod 25 extending from the rear of the back head 3 carries at its rear end a bracket 56 containing a threaded bolt 57. As the piston 5 carries the follower rod 25 forwardly during the forward stroke of the piston, the bolt 57 eventually strikes and depresses the reversing poppet valve 38. The point in the forward stroke at which the reversing poppet valve 38 is depressed can be varied merely by adjusting the threaded bolt 57. Hence, the length of the forward piston stroke is adjusted by means of the bolt 57.

As previously explained, the depression of the reversing poppet valve 38 exhausts the rear valve chamber 34 to create a pressure differential between the front and rear valve chambers 33 and 34 and cause the spool valve to move to its rear position.

When the spool valve 30 is in its rear position as shown in FIG. 2, it exhausts the forward feed chamber via the passage 47. The passage 47 is placed in communication with a vent passage 59 by a peripheral groove 60 on the spool valve 30.

It will be noted that with the spool valve 30 in its rear position, it closes off the rear intermediate passage 36 with the forward stroke passage 45, and the exhaust of the forward feed piston chamber 8 bypasses and is

not metered by the forward stroke needle valve 46. Instead, the vent passage 59 is connected by a needle valve 61 to a vent port 62 and the needle valve 61 is used to adjust and meter the exhaust of the forward feed piston chamber 8.

When the forward feed chamber 8 is exhausted, pressure is automatically fed to the retraction chamber 9 by means of a "lost motion" valve 64 connecting the piston 5 to the piston rod 6, as seen in FIG. 7. The piston 5 includes a short nipple 65 projecting forward telescopically into the rear end of the piston rod 6 and held in the rod 6 by a lock ball 66 resting in a radial hole in the nipple 65 and in an annular groove 67 formed in the interior of the piston rod 6. The groove 67 is sufficiently wide to allow the rod 6 to slide back and forth on the nipple 65 for a short distance between a position wherein the rear edge of the rod 6 seats against a valve seat 68 mounted on the front face of the piston 5 and a position spaced from the seat 68.

The operation of the "lost motion" valve 64 should now be obvious. When the pressure in the forward drive chamber 8 is high, the piston 5 is biased forward to press the valve seat 68 against the end edge of the piston rod 6 thus closing the "lost motion" valve 64. When the pressure in the forward drive chamber 8 is exhausted, the high pressure existing in the passage 20 of the piston rod 6 forces the piston 5 rearwardly on the rod 6, thus lifting the valve seat 68 off the end of the rod 6 and opening the "lost motion" valve to allow the pressure in the central rod passage 20 to flow into the retraction chamber 9. Sufficient clearance is provided between the nipple 65 and the interior of the rod 6 to allow pressure to flow freely therebetween.

When the piston 5 reaches the end of its return stroke, it stops and remains in that position so long as the spool valve 30 remains in its rear position, as shown in FIG. 2. The spool valve 30 will remain in its rear position so long as fluid pressure is maintained in the front valve chamber 33.

In order to recycle or start another cycle of the tool, the front valve chamber 33 is exhausted using either the three-way valve 16 or the manual recycle poppet valve 41, as previously explained. The manual recycle poppet valve 41 is normally used when the operator is using the drill by itself, instead of in a gang of tools. When the tools are used in a gang, they are usually controlled by the valve 16 which momentarily shuts off the fluid pressure to the tools and exhausts the feeding hoses 17 leading from the valve 16 to the individual tools. This feature of being able to recycle the tools simply by interrupting the fluid pressure supply is highly desirable as it enables the use of only one hose for both supplying fluid pressure to and controlling the tools.

Miscellaneous structure

FIG. 3 illustrates as set of leaf springs 70 mounted in the cylinder 2 in front of the lock ring 52. These leaf or finger springs 70 extend radially inward and have their inner ends curving forwardly. The leaf springs 70 are adapted to engage ahead of an enlarged bulge 71 on the piston rod 6 to hold the piston 5 in its rearwardly retracted position when the tool is not energized with air pressure.

The projecting portion of the follower rod 25 and the bolt 57 which operates the reversing poppet valve 38 are surrounded and substantially enclosed within a sleeve-like guard 72 to prevent an operator from being accidentally injured by these moving parts.

Operation

Prior to the start of operation of the air feed drill, and prior to the admission of fluid pressure to it, the piston 5 is located at the rear end of its reciprocatory travel path and the spool valve 30 is resting in its forward position. Since the piston 5 is in its rearmost position, the motor valve 22 in the piston rod passage 20 is seated on and closes the fixed tube 19 extending axially forward from the back head 3.

Fluid pressure is fed to the tool simply by turning the valve 16 to the position shown in FIG. 1, thus introducing fluid pressure into the inlet passage 18 in the back head 3. This fluid pressure is simultaneously fed to both the front and rear chambers 33 and 34 of the spool valve 30, via the intermediate passages 35 and 36, causing the spool valve 30 to remain in its forward position.

In the forward position of the spool valve 30, the fluid pressure flows from the rear intermediate passage 36 past the spool valve 30 and into the forward stroke passage 45. The passage 45 dumps the fluid pressure into the forward stroke needle valve 46 which meters it and feeds it via the passage 47 into the forward feed piston chamber 8, resulting in the piston 5 being driven forward on its forward stroke. During the forward stroke of the piston 5, the retraction piston chamber 9 is exhausted by the vent valve 49 which is held in its rearmost position by the spring 50, i.e., the pressure in the retraction chamber 9 is not high enough to overcome the spring 50 and bias the valve 49 to a closed position.

During the initial portion of the forward stroke of the piston 5, the motor valve 22 is lifted off the end of the fixed tube 19 to allow fluid pressure to flow to the motor 12, which begins to drive the chuck 13 and whatever tool bit it may be holding. Hence, the chuck 13 is simultaneously rotated and fed axially forward on its forward stroke. The speed of the forward stroke may be controlled by adjusting the needle valve 46.

As the piston 5 moves on its forward stroke, the follower rod 25 carries the threaded bolt 57 forward until it eventually engages and depresses the reversing poppet valve 38. Depression of the valve 38 vents the rear chamber 34 of the spool valve 30 causing the pressure in the forward valve chamber 33 to drive the spool valve 30 to its rear position, as shown in FIG. 2.

In the rear position of the spool valve 30, it blocks the forward stroke passage 45 and exhausts the forward feed chamber 8 to atmosphere via the passage 47, the peripheral groove 60 in the spool valve 30, the vent passage 59, the needle valve 61 and the vent port 62. The needle valve 61 can be adjusted to vary the speed of the return stroke of the piston 5.

When the forward feed chamber 8 is exhausted, the fluid pressure in the central rod passage 20 acts to move the piston 5 rearwardly from the end of the piston rod 6, thus opening the "lost motion" valve 64 and admitting fluid pressure from the central rod passage 20 into the retraction chamber 9. The relatively high pressure (about 90 p.s.i.) of the fluid admitted to the retraction chamber 9 causes the vent valve 49 to close, thus sealing the retraction chamber from atmosphere, and drives the piston 5 on its return stroke.

As the piston 5 stops at the rear end of its return stroke, the motor valve 22 seats on and closes the front of the fixed tube 19 thus shutting off fluid pressure to the rotary motor 12 and stopping its operation. The spool valve 30 will thereafter remain in its rear position until it is desired to recycle the tool for another operation.

Recycling the tool can be accomplished in either of two ways, by depressing the manual recycle poppet valve 41 or by momentarily closing off the fluid pressure from the tool by operating the three-way valve 16. The use of either of these expedients results in the exhaust of fluid pressure from the front valve chamber 33, thus allowing the spring 32 to drive the spool valve 30 back to its forward position. Thereafter, when fluid pressure is again admitted to the tool by manipulating the three-way valve 16 or by closing the recycle poppet valve 41, the tool beings another forward stroke. The following operation of the cycle is identical with the description of the operation of the preceding cycle.

Although a preferred embodiment of the invention has

been illustrated and described in detail, it will be understood that the invention contemplates other embodiments and variations of the basic invention.

Having described our invention, we claim:

1. A fluid-operated tool for rotating and axially reciprocating a tool implement, said tool comprising: a tool body; a piston slidably mounted in said body for axially reciprocating movements therein and carrying a fluid-operated motor and a spindle on its front end; said tool body containing a pair of piston chambers separated by said piston and adapted to receive fluid pressure alternately for reciprocating said piston, said pair of piston chambers including a forward feed chamber and a retraction chamber; exhaust means operative to normally exhaust said retraction chamber when the pressure in the retraction chamber is low and operative to seal the retraction chamber when the pressure in the retraction chamber is high; and valve means connected to said piston chambers for admitting fluid pressure alternately into said piston chambers.

2. The fluid-operated tool of claim 1 wherein said valve means includes means operative to automatically admit pressure fluid into said retraction chamber in response to the exhaust of pressure fluid from said forward feed chamber.

3. The fluid-operated tool of claim 2 wherein: said piston includes a hollow piston rod connected to the motor and conveying fluid pressure to said motor; and said valve means includes a lost motion connection between said piston and piston rod which automatically opens to admit pressure from inside the piston rod to said retraction chamber when said forward feed chamber is exhausted.

4. The fluid-operated tool of claim 3 wherein said valve means includes: a first needle valve connected to the forward feed chamber and being adjustable to meter the fluid pressure being admitted to said forward feed chamber; and a second needle valve connected to said forward feed chamber and being adjustable to meter the fluid being exhausted from said forward feed chamber, whereby the needle valves control the speed of the forward feed stroke and the return stroke of the piston independently of each other.

5. The fluid-operated tool of claim 1 wherein said exhaust means for the retraction chamber includes: a valve body movably mounted in the retraction chamber and adapted to be moved in one direction from a normal position to an alternate position by pressure in the retraction chamber; a resilient means biasing the valve body in the other direction opposite to the pressure in said retraction chamber; and said tool body containing a vent which is open for exhausting said retraction chamber when said valve body is in its normal position and closed when the valve body is in its alternate position.

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