United States Patent

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[73] Assignee Owatonna Tool Company

[54] **AIR-DRIVEN HYDRAULIC PUMP**
10 Claims, 4 Drawing Figs.

[52] U.S. Cl. 417/400, 91/227
[51] Int. Cl. F04b 17/00, F01l 21/02
[50] Field of Search 417/400, 398, 399, 401; 91/222, 224, 225, 227, 229

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ABSTRACT: A fluid-actuated hydraulic pump of the type having an air motor driving the pump. The air motor includes a reciprocal piston which is driven in one direction by fluid under pressure and is returned by a spring. A control valve is utilized to control the application of fluid under pressure to the piston and for venting the piston for the spring return. The control means for the control valve are arranged to trap a column of fluid behind a fluid pressure receiving surface of the control valve during the return of the piston by the spring to thereby positively hold the control valve in a position that will vent the piston to exhaust during return by the spring.

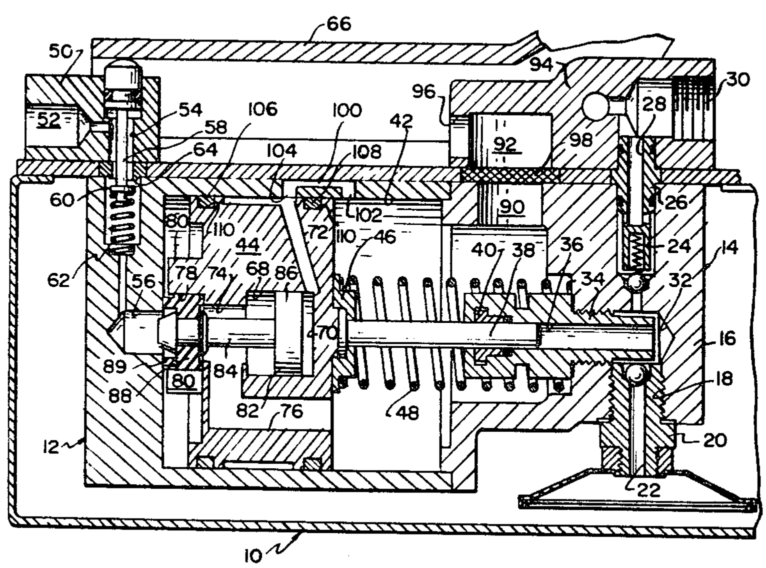

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FIG.1

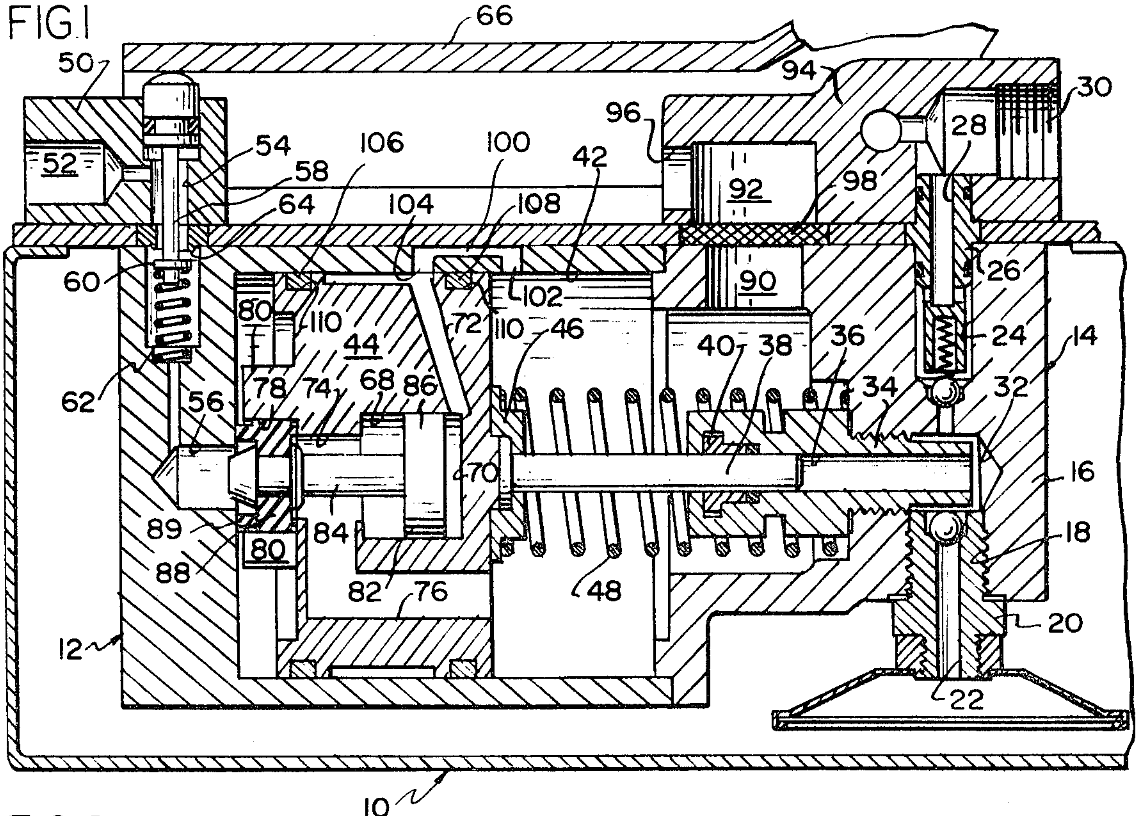

FIG.2

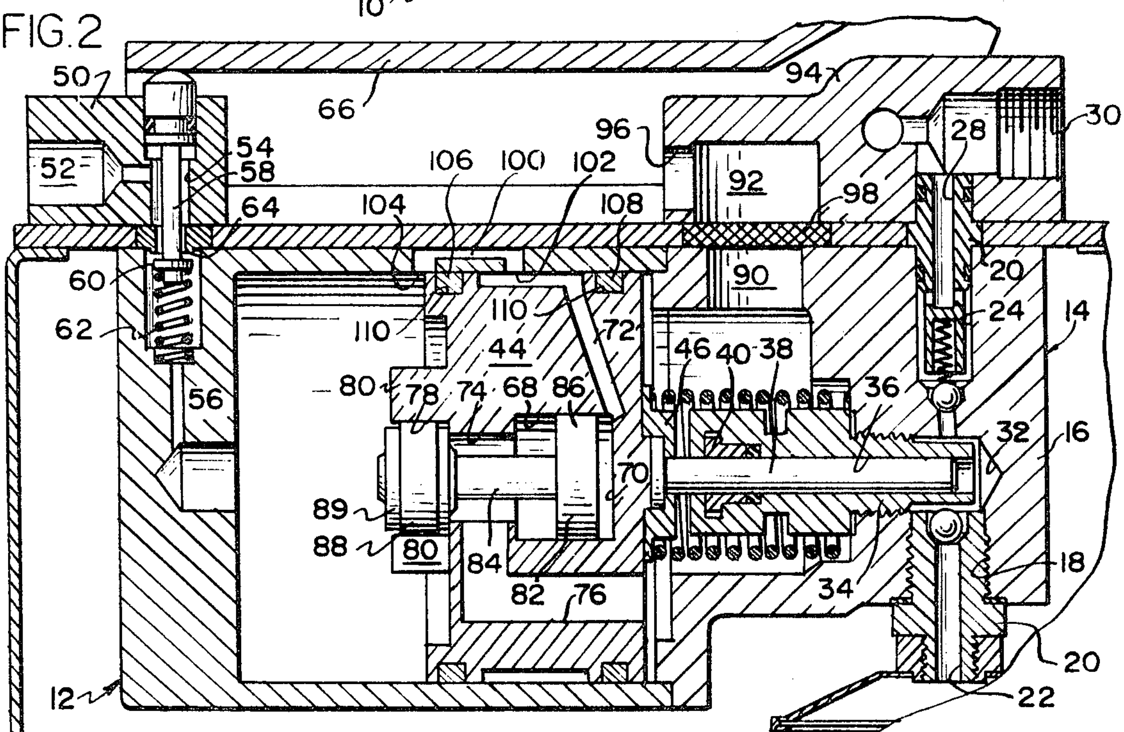

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FIG. 3

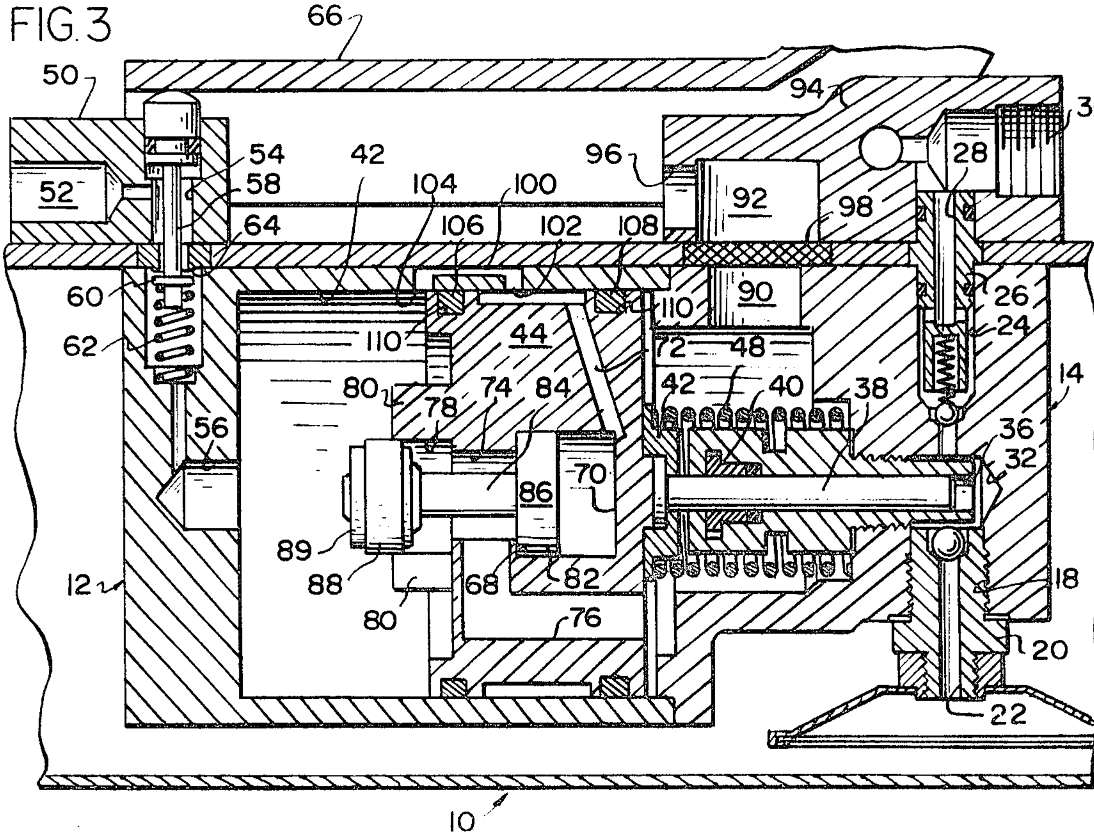
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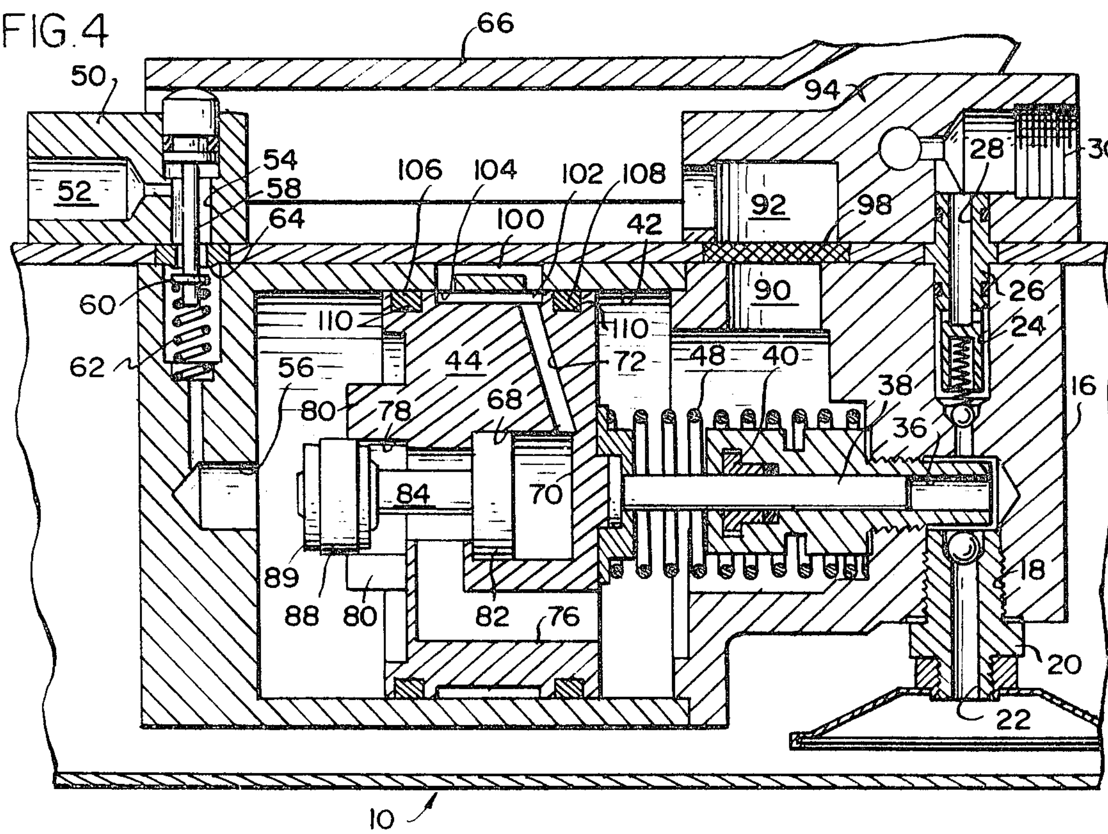
FIG. 4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AIR-DRIVEN HYDRAULIC PUMP

BACKGROUND OF THE INVENTION

Recent years have seen an increase in the number of applications wherein hydraulic power tools are extremely desirable. Many such applications utilize complex and expensive motor-driven pump systems providing hydraulic fluid under pressure to the hydraulic tool. In many such cases, the expense of the equipment required is well justified.

However, there are a number of lesser applications wherein the expense of such pumping equipment can not be justified and yet where it is nonetheless desirable to provide a motor-driven source of hydraulic fluid under pressure in lieu of a hand pump or the like.

As a result of this need, there have been a number of proposals for fluid-actuated hydraulic pumps which utilize a reciprocal air motor for driving a reciprocal hydraulic pump and which merely require a source of fluid under pressure. Such pumps find extensive use, for example, in service stations or the like where there is an existing source of fluid under pressure and where hydraulic fluid under pressure could be used when operating jacks or rams used for straightening, bending and raising.

Prior art proposals of fluid-actuated hydraulic pumps have had a number of drawbacks. Quite frequently, the same are fairly bulky and thereby needlessly occupy a significant amount of space. Furthermore, the proposed constructions of the prior art are not particularly efficient.

For example, all utilize an air-driven piston in the cylinder which, when being driven by air, reciprocates a reciprocal hydraulic pump member through a power stroke. In order to provide a return, the air motors employed customarily utilize a return spring. During the power stroke, air under pressure is applied to the piston and during the return stroke, the piston is vented to exhaust. In order to control the application of fluid under pressure and the exhausting of the piston, the prior art constructions utilize one or more control valves.

In some constructions, the control valve is mounted in an end of a bore while in others, the control valve is mounted for movement with the piston. Various porting arrangements which may include the use of pilot valves are utilized to shift the control valve.

Such constructions have proved to be relatively inefficient due to the inertia of the control valve member and the reciprocating action of the air-driven piston. In those constructions wherein the control valve member is mounted for movement with the piston, when the piston is returned under the influence of the associated spring, the rapid change in the direction of movement of the same and the inertia of the control valve member will tend to close off the ports venting the piston to exhaust. As a result, the rate of return of the piston will be diminished to increase the length of the operating cycle and decrease the amount of fluid under pressure deliverable by the pump. By the same token, in those constructions wherein the control valve is mounted in the end of a cylinder containing the bore, the reaction of the spring against the housing when pressure is released on the piston will tend to cause movement of the housing in a manner that will similarly limit the porting area of the control valve. Accordingly there will be the attendant inefficiency mentioned previously.

SUMMARY OF THE INVENTION

The principal object of the invention is to provide a new and improved fluid-actuated hydraulic pump. More specifically, it is an object of the invention to provide such a pump that is extremely compact and wherein inertia problems encountered with the control valve are overcome by positively holding the control valve in a piston-venting position until the return stroke of the piston under the influence of a spring is completed.

The exemplary embodiment of the invention contemplates the use of a bore receiving a reciprocally mounted piston which is connected to a reciprocally operating member of a hydraulic pump. One end of the bore is connected to a source of fluid under pressure while the other end of the bore is connected to an exhaust vent or fluid outlet.

A control valve is mounted for movement within a chamber formed in the piston itself and is movable between a first position wherein the inlet end of the bore is vented to permit the venting of the piston and the spring return of the same and a second position wherein no fluid communication from the inlet end of the bore to the vent is permitted so that the fluid under pressure will drive the piston through a power stroke.

Additionally, means are provided for positively holding the control valve in the first position during the return stroke of the piston by the spring so that inertial effects cannot diminish the porting area thereby decreasing the motor's efficiency. In the exemplary embodiment, the positive holding means include a means for trapping a column of fluid behind a control surface of the control valve from the beginning of the return stroke until the end thereof. This is accomplished by porting one end of the control valve to the side of the piston in such a way that for all locations of the piston within the bore between the end of the power stroke and the position of initiation thereof, the fluid behind the control valve cannot escape.

In order to shift the control valve, the bore includes a channel which opens into the bore at two spaced locations so that at the end of a power stroke, fluid under pressure is applied against the previously mentioned surface of the control valve to shift the same to the piston-venting position and also to vent the control valve surface thereby relieving the trapped column of fluid when the piston is fully returned by the spring so that the control valve may be closed in readiness for the initiation of another power stroke. In this connection, the piston itself is utilized as a valve member to control the flow of fluid through the channel. To this end, sealing means carried by the piston and in sealing engagement with the bore flank the porting to the side of the piston of the control valve chamber.

Other objects and advantages will become apparent from the following specification taken in conjunction with the accompanying drawings.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a vertical section of a fluid-actuated hydraulic pump made according to the invention illustrating the pump configuration at the initiation of a power stroke;

FIG. 2 is a vertical section of a fluid-actuated hydraulic pump illustrating the configuration of the same just prior to the completion of the power stroke;

FIG. 3 is a vertical section of a fluid-actuated hydraulic pump showing the configuration of the same at the termination of the power stroke; and

FIG. 4 is a vertical section of a fluid-actuated hydraulic pump during the return stroke.

DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference to FIG. 1, an exemplary embodiment of a fluid-actuated hydraulic pump made according to the invention is seen to comprise a housing, generally designated **10**, in which is located an air motor, generally designated **12**, and a hydraulic pump, generally designated **14**. Turning first to the hydraulic pump **14**, the same is seen to comprise a casting **16** including a threaded bore **18** which receives a ball valve member **20** which is operative to permit hydraulic fluid to be admitted to the pump **14** during the return stroke of the motor **12** through a passage **22** adapted to be connected to any suitable source of hydraulic fluid. By the same token, the ball valve is operable to preclude the passage of hydraulic fluid during the power stroke of the motor **12** as will be seen.

The casting **16** further includes a bore **24** which receives a spring loaded check valve member **26** which has a passage **28** communicating with an outlet **30** through which hydraulic fluid under pressure may flow to a point of use.

The casting 16 further includes a bore 32 which is in fluid communication with both the valve 20 and the valve 26 and which threadingly receives a cylinder 34 having a bore 36 in which is reciprocally received a pump piston 38. Reciprocation of the pump piston 38 within the bore 36 to the right viewed in FIG. 1 will cause such fluid as may be located in the bore 36 and the bore 32 to open the spring loaded check valve 26 and pass, under pressure, to the outlet 30. Reciprocation of the piston 38 to the left as viewed in FIG. 1 will permit ball valve 20 to open and draw hydraulic fluid into the bore 32 and the bore 36.

Suitable packing 40 may be located about bore 36 to provide a seal.

The air motor 12 includes a central bore 42 in which is received a piston 44. The piston 44 is connected to the pump piston 38 by securing means 46 so that reciprocation of the piston 44 will result in the reciprocation of the pump piston 38 and the delivery of hydraulic fluid under pressure to the outlet 30.

A coil spring 48 bears against one side of the piston 44 and against the casting 16 in such a way as to normally urge the piston 44 to the left as viewed in FIG. 1. As will be seen, the spring 48 acts to return the piston 44 to the position illustrated in FIG. 1 after each power stroke.

Mounted on the housing 10 by any suitable means is a block 50 having a fluid inlet 52 which may be connected to a source of air under pressure or the like. The inlet 52 is connected by means of a conduit 54 in the block 50 and a conduit 56 in the air motor casing to the center of one end of the bore 42. Associated with the conduits 54 and 56 is a manually actuable valve member 58 including a valve element 60 which is normally urged by a spring 62 against a valve seat 64 to preclude fluid under pressure provided to the inlet 52 from travelling to the bore 42. A manual actuator 66 may be pivotally mounted to the housing 10 by any suitable means not shown and, when pivoted downwardly, is operative to move the valve element 60 away from the seat 64 and against the bias of the spring 62 so that fluid under pressure will be provided to the interior of the bore 42.

The piston 44 includes a valve chamber 68 having one end 70 communicating with the side of the piston 44 by means of a port 72. The valve chamber 68 also includes a central portion 74 of reduced diameter which is in fluid communication with the right-hand side of the piston 44 by means of a port 76. Finally, the chamber 68 includes a second end portion 78 defined by three guide prongs 80 extending from the left-hand side of the piston 44 so that, under circumstances to be seen hereinafter, fluid communication between the left-hand end of the piston 44 and the central portion 74 may be had.

Received within the chamber 68 is a control valve member in the form of a pilot-operated guided poppet valve 82. The valve 82 includes a central, reduced diameter portion 84 which has a diameter less than that of the reduced diameter portion 74 of the chamber 68. The valve 82 further includes an enlarged end within the chamber end 70 and an enlarged soft poppet 88 within the end portion 78. The surface area of the enlarged end 86 is made greater than the surface area of the poppet 88 so that when equal pressures are applied to both ends of the valve 82, the same will shift to the left as viewed in FIG. 3.

The poppet includes an annular seat 89 designed to seat against the end of the casting 12 about the point of emergence of the conduit 56.

The right-hand end of the bore 42 is normally connected to exhaust by means of a port 90 opening through the casting 16 to the end of the bore 42. The port 90 is in fluid communication with a port 92 which may be formed in a block 94 and which additionally may include a suitable mounting for the check valve 26 and the outlet 30. Through a small bore 96 in the block 94, the port 90, and thus the right-hand end of the bore 42, is vented to atmosphere. If desired, a muffler 98 may be interposed between the ports 90 and 92 to minimize noise due to exhaust fluid. However, an external muffler connected to the port 96 could be substituted therefor.

Located adjacent the bore 42 is a channel 100 which opens at spaced locations, as at 102 and 104, into the bore 42. If desired, the material separating the openings 102 and 104 can be omitted and the channel 100 formed merely as a groove in the wall of the bore 42. The conduction of fluid through the channel 100 is controlled by the position of the piston within the bore 42. The arrangement is also such that alternate ones of the ends of the channel may be in fluid communication with the port 72 associated with the right-hand end 70 of the valve chamber 68.

To preclude leakage at the interface of the piston 44 and the bore 42, the piston carries sealing means 106 and 108 in grooves 110 therein. The arrangement is such that the sealing means 106 and 108, which sealingly engage both the piston and the bore 14, flank the port 72 as it emerges from the interior of the piston 44 to the side thereof.

The operation of the device will now be described. Initially, the configuration of the various elements will be that shown in FIG. 1 and when it is desired to provide hydraulic fluid under pressure, the manual actuator 66 is depressed to shift the valve 58 thereby admitting fluid under pressure to the left-hand side of the piston 44. As a result, the same will move to the right against the bias of the spring 48. The resulting rightward movement of the piston 44 will cause similar rightward movement of the pump piston 38 thereby expelling any fluid in the bore 36 and the bore 32 through the check valve 26 to the outlet 30 from which it may be conveyed to a point of use.

As the piston 44 approaches its rightward limit of travel, the opening 104 of the channel 100 will be uncovered by the piston 44 so that fluid under pressure will be provided to the channel 100. At this time, the opening 102 will be in fluid communication with the port 72 in the piston so that fluid under pressure will be applied against the end 86 of the valve 82 by virtue of its conduction to the chamber end 70 by the port 72. While the pressure of the fluid applied against both the end 86 and the poppet 88 of the valve 82 will be the same, because of the larger effective area of the end 86, the valve 82 will shift to the left to result in the alignment of parts illustrated in FIG. 2. At this time, the fluid under pressure in the leftmost end of the bore 42 will be exhausted to atmosphere by virtue of the poppet 88 of the valve 82 unblocking the area between the prongs 80 and permitting fluid communication through the reduced diameter portion 84 of the valve 82 to the port 76, the port 90, the port 92 and the bore 96.

Such relieving of the pressure against the piston 44 will permit the spring 48, which had been compressed during the rightward movement of the piston 44 to initiate the return stroke and move the piston 44 to the left. Such leftward movement will also cause the pump piston 38 to be moved to the left thereby drawing a new charge of hydraulic fluid into the bores 36 and 32 through the ball valve 20 from the source of such fluid.

As best viewed in FIG. 3, almost immediately upon movement of the piston 44 to the left, the opening 104 of the channel 100 will be closed off by the piston 44 so that a column of fluid will be trapped behind the end 86 of the valve 82 within the end 70 of the chamber 68, the port 72 and the channel 100. This trapped column of fluid will serve to positively hold the valve 82 in the position illustrated in both FIGS. 3 and 4. And, as seen in FIG. 4, the trapped column of fluid will be maintained during the return of the piston 44 to the position illustrated in FIG. 1 by virtue of the sealing off of the port 72 while it is in communication with the channel 100 by the sealing means 106 and 108.

As best viewed in FIGS. 1 and 4, continued leftward movement of the piston 44 by the spring 48 will finally result in the sealing means 108 unblocking the opening 102 of the channel 100. At this time, the port 72 communicating with the chamber end 70 will be in fluid communication with the opening 102 of the channel 100. At about the time the opening 102 is uncovered, the poppet 88 will be near seating about the periphery of the conduit 56. Air under pressure flowing into the bore 42 through the conduit 56 will tend to be caught in the space defined by the annular seat 89 to quickly shift the valve to the right thereby closing the passageway to vent between the prongs **80**. Relative movement of the valve **82** to the right at this point will be permitted in that the trapped column of fluid behind the end **82** will be relieved to the port **90** by virtue of the fluid communication of the opening **102** with the right-hand interior of the bore **42**. As soon as the poppet **88** and the valve **82** have moved sufficiently to close off the passageway between the prongs **80**, full pressure will again be applied to the left-hand side of the piston **44** to shift the same once again to the right to repeat the cycle.

From the foregoing, it will be appreciated that a fluid-actuated hydraulic pump made according to the invention provides a number of advantages over those prior art constructions mentioned previously. For example, the mounting of the control valve **82** in the piston **44** itself does not require an extra thickness in a wall of the air motor **12** thereby diminishing space requirements. Similarly, the positive holding of the spool valve **82** in the venting position during the return stroke precludes partial shifting of the same due to inertial effects as the piston moves from its position at the end of a power stroke to a position at the end of the return stroke. Accordingly, the efficiency of the pump is significantly increased.

I claim:

1. In a fluid-actuated hydraulic pump including a hydraulic pump having a reciprocally operable pumping member; a fluid motor including a housing having a bore containing a reciprocal piston movable between a retracted position and an extended position and connected to said pumping member, a fluid inlet through which fluid under pressure may be admitted into the bore to drive the piston towards said extended position, spring means for driving the piston towards said retracted position, and a fluid outlet for exhausting fluid within the bore to permit the spring means to drive the piston towards said retracted position, a control valve alternately movable between a closed position wherein fluid under pressure from said inlet drives said piston toward the extended position and an open position wherein said bore is connected to said fluid outlet to permit movement of the piston to said retracted position by said spring to thereby reciprocate the pump member; and control means responsive to the piston in the retracted position for shifting the control valve to the closed position and responsive to the piston in the extended position for shifting the control valve to the open position; the improvement which comprises: means for positively holding said control valve in said open position when said piston is moving from said open position thereof to said closed position thereof.

2. A fluid-actuated hydraulic pump according to claim **1** wherein said control valve is fluid operated in moving from said closed position to said open position and includes a surface subjectable to fluid under pressure to move said control valve from the closed position to the open position, and said positive holding means comprises means for trapping a column of fluid behind said surface while said piston is moving from the extended position to the retracted position.

3. A fluid-actuated hydraulic pump according to claim **2** wherein said trapping means comprises port means in fluid communication with said surface and closeable by said piston when said piston is between said retracted and extended positions and openable by said piston when said piston is in the retracted position.

4. A fluid-actuated hydraulic pump according to claim **3** wherein said control valve is carried by said piston in a chamber therein and said port means includes a first channel extending from said chamber to a side of the piston and a second channel in said housing opening into said bore at two spaced points therein.

5. A fluid-actuated pump comprising:

a. a hydraulic pump having a reciprocally operated pumping member,
b. a housing
c. a bore within said housing,
d. a piston mounted for reciprocal movement within said bore and connected to said pumping member,
e. a fluid inlet in said housing and communicating with one end of said bore,
f. a valve associated with said inlet and operable to admit fluid under pressure to said bore,
g. a fluid outlet in said housing and communicating with the other end of said bore to exhaust fluid therefrom,
h. a spring bearing on said piston to urge the same toward said one end of said bore,
i. a valve chamber in said piston and having one end thereof ported to the side of said piston, the other end thereof ported to said bore one end, and a portion ported to said bore other end,
j. a control valve member movable within said chamber for alternatively allowing fluid communication between said portion and said chamber other end in one position thereof to establish fluid communication between the two ends of the bore and to preclude fluid communication between said portion and said chamber other end in another position thereof, said valve further including a fluid-operated surface facing said chamber one end, and
k. channel means associated with said bore for establishing fluid communication between said bore one end and said chamber one end when said piston approaches said bore other end.

6. A fluid-actuated hydraulic pump according to claim **5** wherein said channel means is arranged with respect to said bore so fluid communication is established between said chamber one end and said bore other end as said piston approaches said bore one end, and fluid communication with said chamber one end is precluded whenever said piston is not approaching either end of said bore to thereby trap a column of fluid behind said surface when said piston moves from said bore other end to positively hold said valve in a position establishing fluid communication between the ends of said bore when the piston is travelling from said bore other end toward said bore one end.

7. A fluid-actuated hydraulic pump according to claim **6** wherein said control valve is a spool valve having a reduced diameter central portion, with the spool end within said chamber one end having a larger surface area than the other spool end, said portion of said chamber having a reduced diameter larger than the reduced diameter of said spool portion, said chamber one end being ported to one side of said piston at about the midpoint thereof, and further including sealing means on said piston sealingly engaging said piston and said bore and flanking the port of said chamber one end, said channel means opening into said bore at spaced locations therein.

8. A fluid-actuated hydraulic pump comprising: a hydraulic pump having a reciprocally operable pump member; a fluid motor including a housing having a bore containing a reciprocal piston movable between a retracted position and an extended position and connected to said pumping member; a fluid inlet through which fluid under pressure may be admitted into the bore to drive the piston towards its extended position; spring means for driving the piston towards its retracted position; a fluid outlet for exhausting fluid within the bore to permit the spring means to drive the piston towards said retracted position; a valve chamber in said piston; a fluid-actuated control valve within said chamber alternately movable between a closed position wherein fluid under pressure from said inlet drives said piston toward the extended position and an open position wherein said bore is connected to said fluid outlet to permit movement of the piston to the retracted position by said spring means to thereby reciprocate the pump member; and control means responsive to the piston in the retracted position for shifting the control valve to the closed position thereof and responsive to the piston in the extended position to shift, by fluid under pressure, the control valve to the open position thereof, said control means including a port within said piston communicating with the side thereof and with said valve chamber, and port means in said housing and opening into said bore whereby the side of said piston acts as a valve to

control the application of fluid under pressure to said control valve through said port to control the position thereof.

9. A fluid-actuated hydraulic pump according to claim 8 further including sealing means carried by the piston and engaging the bore, said sealing means being located on said piston so as to flank both sides of the opening of said port to the side of said piston.

10. A fluid-actuated hydraulic pump according to claim 9 wherein said port means is arranged to establish fluid communication between said inlet and said valve chamber when said piston is in said extended position and between said outlet and said valve chamber when said piston is in said retracted position.