United States Patent [19]

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[11] **3,776,665**

[45] **Dec. 4, 1973**

[54] **TWO STAGE FLUID PUMP**

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[22] Filed: **July 8, 1971**

[21] Appl. No.: **160,614**

[52] **U.S. Cl.**..... **417/252,** 417/397, 417/268

[51] **Int. Cl.**..... **F04b 3/00**

[58] **Field of Search** 91/290; 417/62, 252, 417/253, 287, 397, 268, 286

[56] **References Cited**

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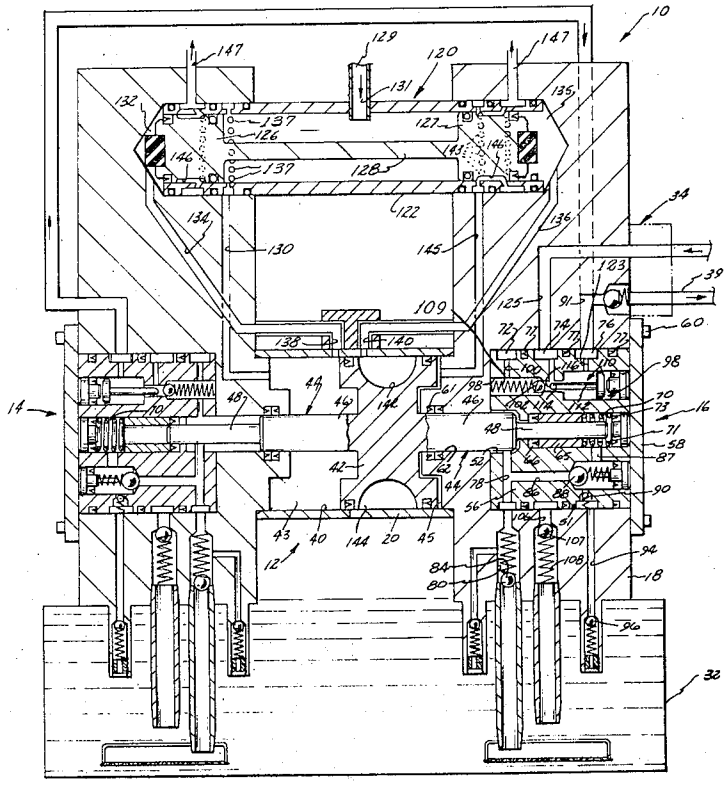
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[57] **ABSTRACT**

A fluid pump having a reciprocally mounted air driven piston including portions extending from opposite sides thereof with each piston portion extending into a pair of axially spaced pressure chambers such that when the air piston is reciprocated in one direction within the housing the piston portion at one end is in a compression stroke and compresses its associated chambers to discharge pressure fluid from the pump through an appropriate outlet portion, while the portion at the opposite end of the air piston is in an expansion stroke and expands its associated chambers to draw fluid therein from a reservoir. One pressure chamber associated with each of the piston portions has a valve means adapted to exhaust fluid pressure therein while closing communication with its associated chamber when the pressure in the same reaches a predetermined value. Actuation of the valve means is accomplished by an actuating mechanism responsive to a predetermined pressure build up as caused by the load being imposed upon the fluid user such that in the absence of a predetermined pressure being produced by the fluid user during each compression stroke fluid is discharged from the pump from both chambers at a first, relatively high, rate of flow and at a pressure less than the predetermined pressure, and upon the predetermined pressure being reached the spaced pressure chambers are fluidly disconnected, resulting in a decreased rate of fluid flow from the pump, while the pressure of the discharged fluid is increased. Valve means are provided to control the direction of flow of the fluid discharged from the pressure chambers on opposite sides of the air piston to either direct the fluid from each side of the pump to a single fluid user or to provide two sources of pressure fluid for separate fluid users.

5 Claims, 6 Drawing Figures



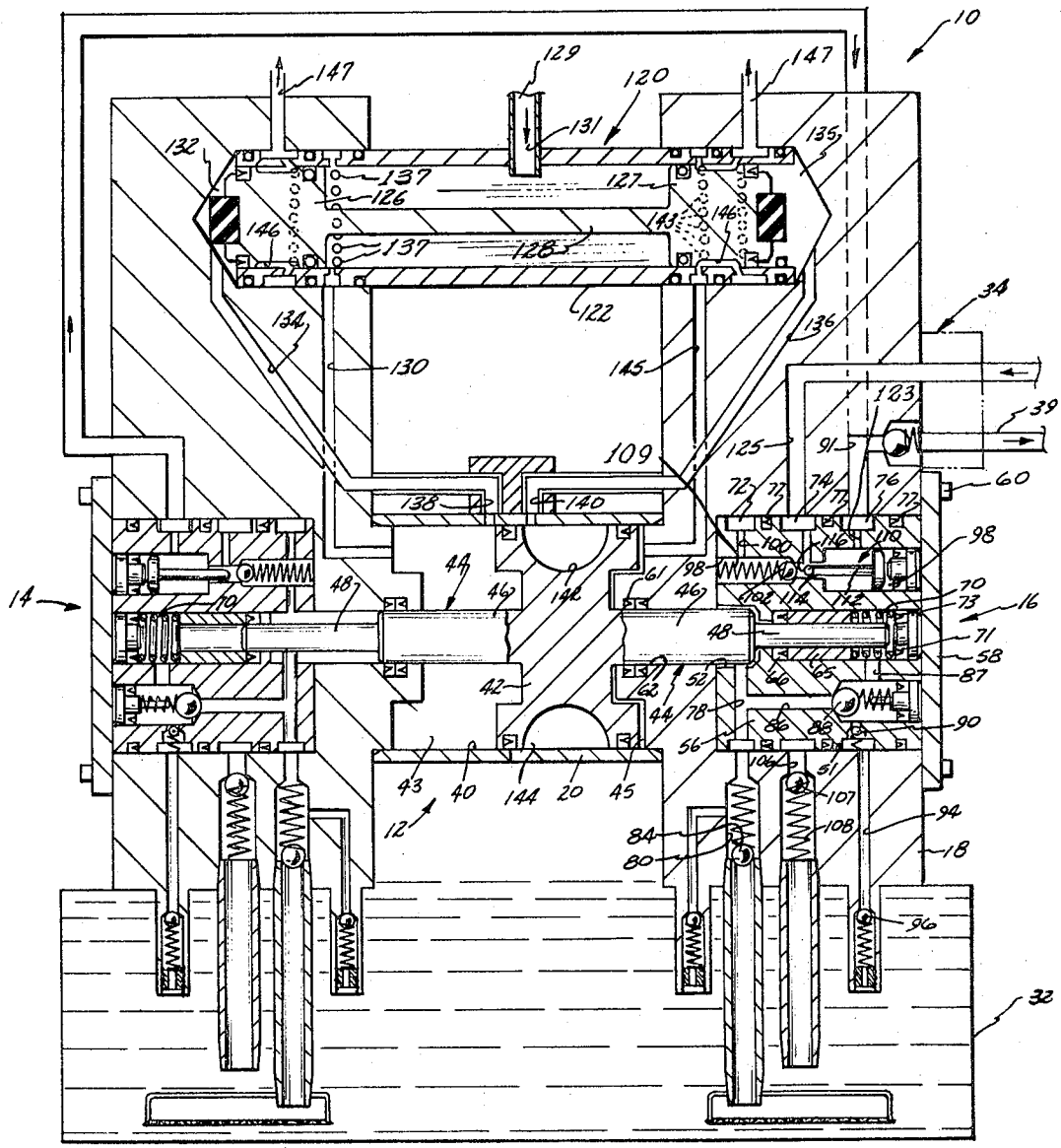


FIG-1

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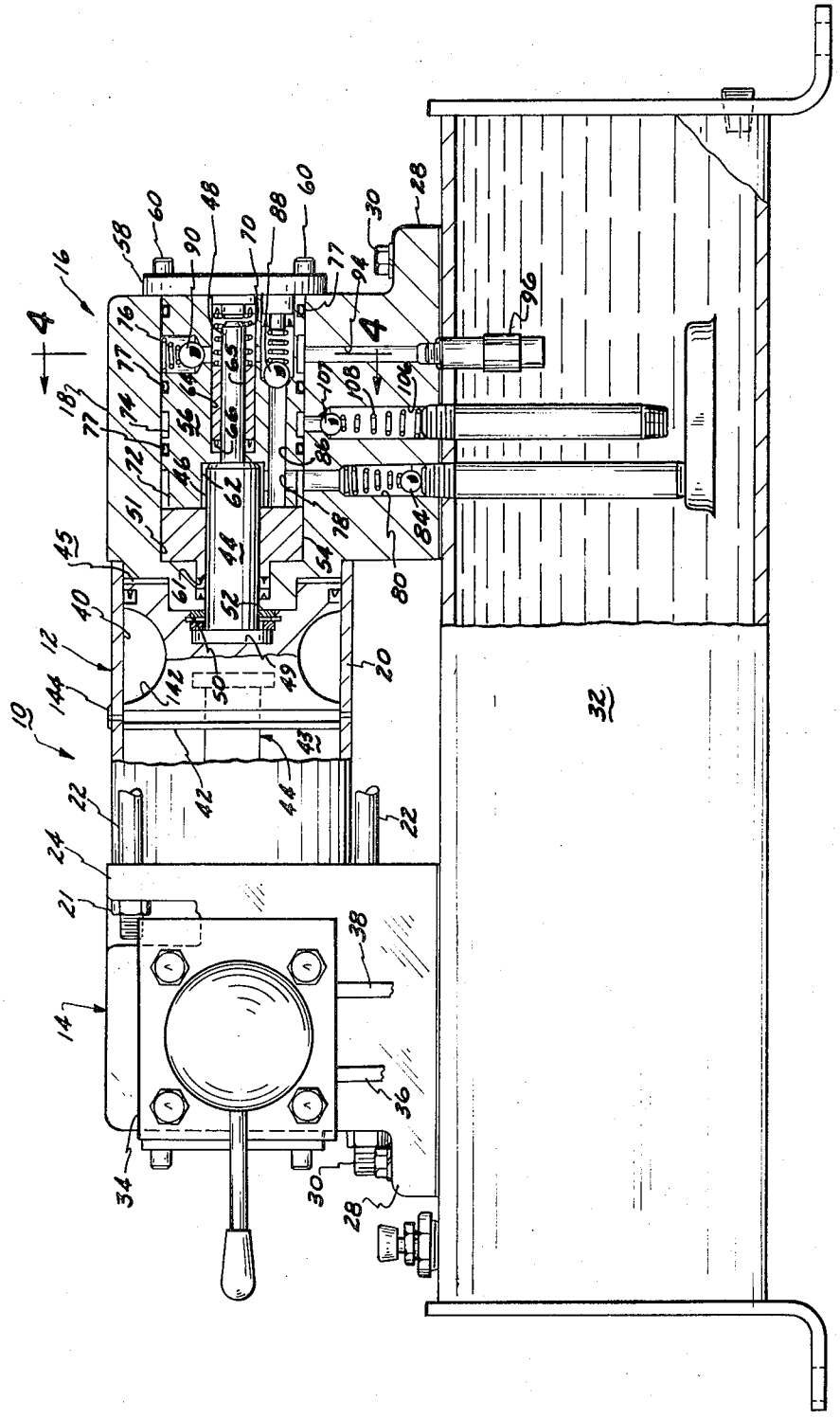


FIG-2

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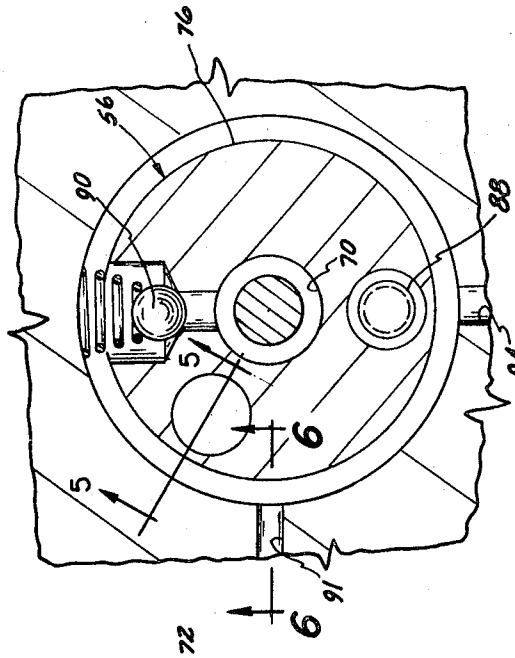


FIG-4

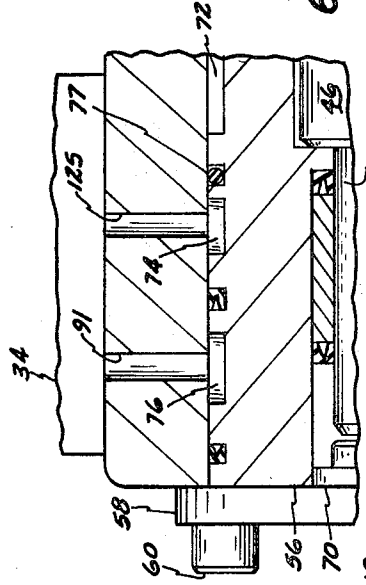


FIG-6

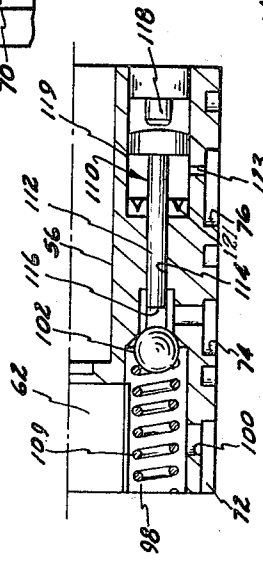


FIG-5

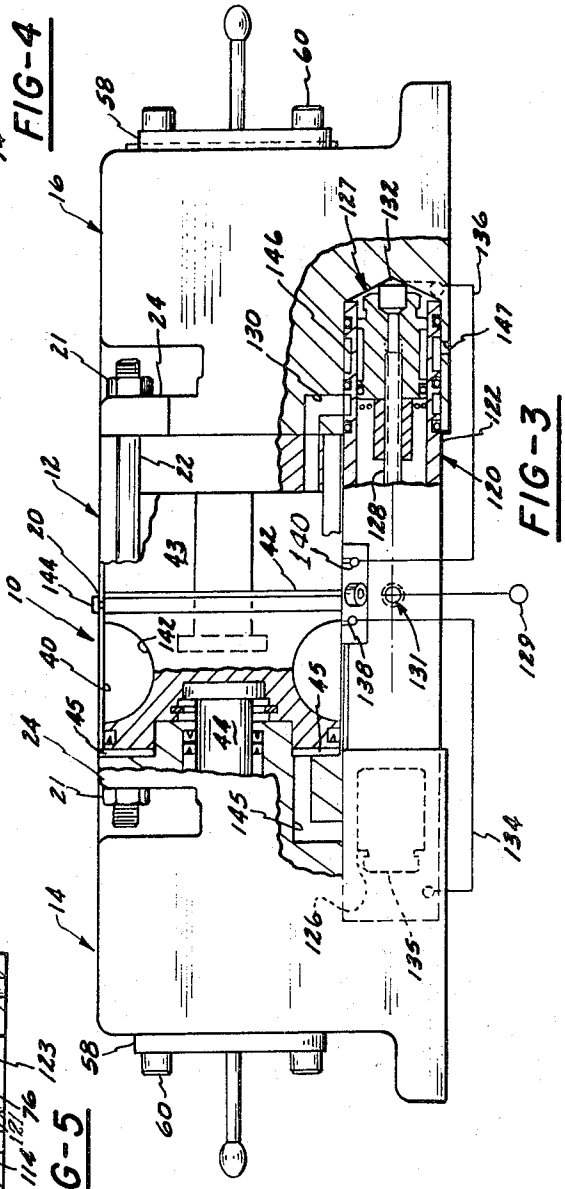


FIG-3

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TWO STAGE FLUID PUMP

BACKGROUND OF THE INVENTION

I. Field of the Invention

The present invention relates generally to pneumatically powered fluid pumps and, more particularly, to such a pump having a reciprocating piston-type pumping means and which is automatically operable to change from low pressure, high volume operation to high pressure, low volume operation upon a predetermined pressure being produced by the fluid user.

II. Description of the Prior Art

Pumps capable of automatically changing from a low pressure, high volume operation to a high pressure, low volume operation in response to the demands of the particular fluid user are not new. Such pumps are especially suitable for raising and lowering the landing gears of truck trailers and provide a means for lowering the gear at a relatively high rate of speed during initial operation of the pump and until the foot of the landing gear makes contact with the ground and begins to bear the weight of the trailer. At that point, the pressure of the fluid begins to increase and the pump automatically switches to a high pressure, low volume operation. Previously, however, such pumps have generally taken the form of electric driven two-stage axial pumps.

Such pumps to be commercially acceptable should be lightweight and compact. They should be of relatively low cost in their manufacture and they should be durable and rugged to withstand the abuse to which they may be subjected. At the same time, they must be efficient in operation and, when used as a means for raising and lowering truck landing gears, it is quite important that they be reliable and safe.

SUMMARY OF THE INVENTION

The present invention comprises a pump having an air powered piston which reciprocably drives a pair of double diameter pressure piston portions extending from opposite sides of the air piston. Each piston portion is adapted to expand and compress a pair of axially spaced pressure chambers to respectively draw in and pump out a fluid. Valving means interconnect the chambers such that during initial operation of the pump pressure fluid is discharged from the pump at a relatively high flow rate and at a relatively low pressure, but upon a predetermined pressure being produced because of the load being imposed upon the fluid user one of the chambers on each side of the pump is automatically exhausted back to the reservoir and the other chamber functions to discharge fluid from the pump at a decreased flow rate and at an increased pressure.

It is therefore an object of the present invention to provide an improved, lightweight, pneumatically actuated hydraulic pump of a compact, unitary and durable construction adapted to be produced at a low cost and which has internal valving means adapted to automatically change the output pressure and output flow rate of the pump.

Other objects, advantages, and applications of the present invention will become apparent to those skilled in the art of pneumatically powered pumps when the accompanying description of an example of the best mode contemplated for practicing the invention is read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The description herein makes reference to the accompanying drawings wherein like reference numerals refer to like parts throughout the several views, and in which:

FIG. 1 is a diagrammatic representation of the pump of the present invention;

FIG. 2 is a partially sectioned, front elevational view of a pneumatically powered pump constructed in accordance with the principles of the present invention;

FIG. 3 is a partially sectioned, rear elevational view of the pump illustrated in FIG. 2;

FIG. 4 is a fragmentary, cross-sectional view of the pump taken along line 4—4 of FIG. 2;

FIG. 5 is a fragmentary, cross-sectional view of the pump taken along line 5-5 of FIG. 4; and

FIG. 6 is a fragmentary, cross-sectional view of the pump taken along line 6—6 of FIG. 4.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1, there is illustrated diagrammatically a pneumatically powered pump 10 which is constructed in accordance with the principles of the present invention and which comprises an air motor portion 12 sandwiched between left and right hand pump portions 14 and 16, respectively.

As can best be seen in FIG. 2 in which the pump is shown as it is actually constructed in contrast to FIG. 1 where it is shown diagrammatically to aid in understanding the construction, each of the pump portions 14 and 16 comprises a housing 18, the opposing side walls of which support a tubular member 20 which forms the housing of the air motor portion 12. The housing 18 and the tubular member 20 are secured to each other by fasteners 21 and elongated rods 22 extending through radial flanges 24 on each housing 18. The lower section of each housing 18 has flanges 28 through which screws 30 extend into a threaded engagement with a reservoir 32 so as to secure the pump 10 thereto. As the pump 10 is illustrated in FIG. 2, each of the pump portions 14 and 16 is provided with directional control valves 34 which are respectively adapted to direct the fluid discharged from the pump portions 14 and 16 to outlet conduits 36 and 38, such that the high pressure fluid discharged from the pump portion 14 is directed through its associated valve 34 and conduit 36 (or 38) to a fluid user such as a fluid cylinder (not shown), while the other conduit 38 (or 36) receives low pressure fluid from the fluid user for return to the reservoir 32, as will be described hereinafter.

The high pressure fluid discharged from the pump portion 16 is directed through its associated directional control valve 34 to a second fluid user (not shown), while its associated valve 34 receives low pressure fluid from the second fluid user for return to the reservoir 32. It is to be understood, however, that a single directional valve 34 could be used as illustrated diagrammatically in FIG. 1 connected to both pump portions 14 and 16 to direct the outlet fluid to a single fluid user by way of a conduit 39.

Referring again to FIGS. 1 and 2, the tubular member 20 has an internal bore 40 within which is reciprocably mounted an air piston 42, the opposite sides of which each have coaxially aligned and oppositely extending double diameter pistons 44. Each piston 44 comprises

an enlarged piston portion 46 and a smaller piston portion 48 integrally joined to the end of the portion 46. As can best be seen in FIG. 2, each piston 44 is retained in a central recess 49 on each side of the air piston 42 by any suitable means, such as washer and retainer clip assemblies 50. The air piston 42 is reciprocated within the tubular member bore 40 by air pressure selectively communicated to air chambers 43 and 45 formed on the opposite sides of the air piston 42.

Since the left hand pump portion 14 is substantially identical to the right hand pump portion 16, only the right hand pump portion 16 will be described in detail; however, it is to be understood that the description of the right hand pump portion 16 is equally applicable to the left hand pump portion 14.

Still referring to FIG. 2, the housing 18 of the pump portion 16 has an axial bore 51 with an inner opening 52 coaxially aligned with the piston 44 and through which the piston 44 reciprocally extends. The enlarged piston portion 46 is supported by a bushing member 54 held in abutment with the end wall of the bore 51 by a porting member 56 which, in turn, is maintained in a proper axial position by an end plate 58 secured to the outer side wall of the housing 18 by screws 60 extending through the end plate 58 into threaded bores (not shown) in the housing 18. Suitable sealing elements are provided at 61 to prevent fluid leakage between the interior of the tubular member 20 and an expansible pressure chamber 62 formed in the face of the porting member 56 and into which the piston portion 46 is adapted to be stroked so as to expand and compress the pressure chamber 62. That is, as the piston portion 46 is stroked leftwardly as viewed in FIGS. 1 and 2, the pressure chamber 62 of pump portion 16 is expanded, while the same is compressed when the piston portion 46 is stroked rightwardly.

The porting member 56 has a bore 64 for receiving a bushing 65, the internal bore of which supports the smaller piston portion 48 for reciprocal movement. Suitable sealing means at 66 prevent leakage between the pressure chamber 62 and a second pressure chamber 70 axially spaced therefrom and formed between the bushing 64 and the end plate 58. A seal 71 (FIG. 1 prevents leakage from the pressure chamber 70 and a spring 73 applies pressure between the bushing 65 and the seal 71 to maintain the bushing 65, the seal 71 and the seal 66 in place. The pressure chamber 70 is expanded and compressed by the smaller piston portion 48 at the same time as the enlarged piston portion 46 expands and compresses the pressure chamber 62.

The peripheral surface of the porting member 56 has a plurality of axially spaced annular grooves 72, 74 and 76 which are fluidly separated from one another by seals 77 carried on the peripheral surface of the portion member 56. As can best be seen in FIG. 1 the annular groove 72 communicates the pressure chamber 62, via a radial passageway 78, to an inlet port connection 80 extending through the housing 18 for connection with the reservoir 32. A check valve 84, disposed in the passageway 80, permits fluid to be drawn in from the reservoir 32 through the passageway 78 and into the pressure chamber 62 of the pump portion 16 when the piston portion 46 is being stroked leftwardly as viewed in FIGS. 1 and 2, while at the same time the check valve 84 prevents fluid from being returned to the reservoir 32 through the passageway 80 when the piston portion 46 is being stroked rightwardly to compress pressure chamber 62.

Still referring to FIG. 1, a passageway 86, extending axially through the porting member 56, connects the radial passageway 78 and a port 87 to provide communication between the pressure chamber 62 and the pressure chamber 70. A spring biased check valve 88, disposed in the passageway 86, permits fluid flow communication between the pressure chambers 62 and 70 as long as fluid is being pumped by the portion 46. During the expansion stroke, check valve 88 will prevent a backflow of fluid from chamber 70 to chamber 62.

As can best be seen in FIG. 2, the pressure chamber 70 communicates through a second spring biased check valve 90 with the annular groove 76 which, in turn, communicates pressure fluid to both its associated directional control valve 34, via a passageway 91 FIG. 1, and to a passageway 94 connected to the reservoir 32 through a high pressure relief valve 96. The high pressure relief valve 96 is conventional in its construction and acts as a safety feature to limit the maximum operating pressure of the pump portion 16 to within designed limits. The check valve 90 permits the flow of pressure fluid from the chambers 62 and 70 to the directional control valve 34 when the piston 44 of pump portion 16 is being stroked rightwardly in a compression stroke, but prevents a backflow of fluid from the fluid user when the piston 44 is being stroked leftwardly in an expansion stroke.

As can best be seen in FIGS. 1, and 5, the annular groove 72 and thus the pressure chamber 62 is connected with a chamber 98 via a radial passageway 100. Chamber 98 communicates through a check valve 102 to the annular groove 74 which as shown in FIGS. 1 and 2 is in turn connected to the reservoir 32 by means of a radial passageway 106 and a second check valve 107. Check valve 107 is normally spring biased to a seated position by a spring 108, such that communication between the pressure chamber 62 and the reservoir 32 is normally closed.

Thus, as the piston portion 46 of the pump portion 16 is stroked rightwardly in FIG. 1 during a compression stroke to compress pressure chambers 62 and 70, the normal flow path of the fluid therein is from the chamber 62 through passageway 86, past the check valve 88, and from the pressure chamber 70, past the check valve 90, into the annular groove 76 and through the passageway 91 to the directional control valve 34. When the piston 44 of the pump portion 16 is being stroked leftwardly, that is during an expansion stroke, fluid will be drawn from the reservoir 32 through the check valve 84 into the pressure chamber 62 via radial passageway 78, while simultaneously fluid from the reservoir 32 will flow through axial passageway 86, past the check valve 88 and into the pressure chamber 70.

During the initial stages of operation of the pump and as long as the fluid user is not exerting a predetermined back pressure in annular groove 76, the check valve 102 is maintained in a seated position by a spring 109 and the pressure of the fluid in chamber 98, and thus the fluid in chamber 62 cannot be exhausted to the reservoir 32 until the check valve 102 is unseated.

The various passageways and chambers are illustrated diagrammatically in FIG. 1 as all lying in the same plane. This is only for the purpose of understanding the operation of the aid in understanding how the check valve 102 actually operates.

Referring again to FIG. 5, the check valve 102 is adapted to be unseated by an actuating mechanism 110, comprising a stem portion 112 slidably mounted within an axial bore 114 of the porting member 56. One end 116 of the stem portion 112 is adapted to engage the check valve 102 and unseat the same when the opposite end on which a guide member 118 is formed is subjected to pressure of sufficient magnitude to move the stem portion 112 against the bias of a spring 109. A chamber 119 communicates with the pressure chamber (FIG. 1) 70 through a radial passageway 123 and the annular groove 76. Thus, when the pressure in the chamber 119 exceeds a predetermined value, which is a function of pressure being produced by the load on the fluid user, the stem portion 112 will be shifted leftwardly to maintain the check valve 102 in an open position, thereby exhausting the fluid in pressure chamber 62 to the reservoir 32 via annular groove 74 and passageway 106.

A return passageway 125 (FIGS. 1 and 6) from the directional control valve 34 also communicates with the annular groove 74, such that fluid returned from the fluid user is piped directly to reservoir 32 via passageway 106.

From the description of the pump 10 to this point it is clear that it is capable of a two-stage operation and that it automatically shifts from one stage to the other. The first stage is a low pressure, high volume stage and the pump operates in this stage as long as the valve 102 is closed. With the valve 102 closed, fluid is delivered to the passage 91 and thus the fluid user from both sets of chambers 62 and 70. This would be the stage of operation, for instance, if the pump were used for landing gear operation when the legs were being extended out prior to the legs reaching the ground and assuming the weight of the trailer. This stage of operation would provide the high volume of fluid necessary to provide a relatively fast extension. High pressure fluid is not needed during this stage of operation as the system is performing very little work.

When the pressure builds as the landing gear begins to assume the weight of the trailer, the check valve 102 will be opened, exhausting fluid from chamber 62 to the reservoir 32. This produces automatic switching to the high pressure, low volume stage since as long as the valve 102 is opened fluid will be supplied to the user only from the chambers 70.

Referring again to FIG. 1, the air motor 12 is illustrated as including a shuttle valve 120 having a tubular member 122 sandwiched between the pump portions 14 and 16 and within which is slidably mounted a pair of spools 126 and 127 carried at opposite ends of a connecting rod 128. As best seen in FIG. 3 the interior of the tubular member 122 is connected to a source 129 of a usable compressed gas, such as compressed air or whatever may be convenient, through an inlet connection port 131, such that the opposing inner sides of the spools 126 and 127 are exposed to the compressed air. When the spool 126 is in the position illustrated in FIG. 1, pressurized air is comunicated to the air chamber 43 on one side of the air piston 42 through ports 137 and a passageway 130. The pressurized air in air chamber 43 acts against the air piston 42 to move it in a compression stroke into the pump portion 16 as illustrated in FIG. 1.

Still referring to FIGS. 1 and 3, the outer ends 132 and 135 of each spool 126 and 127 are communicated through suitable passageways 134 and 136 to port connections 138 and 140 respectively, which, in turn, communicate with the bore 40 of the tubular member 20, such that when the air piston 42 has been reciprocated to the end of a compression stroke in pump portion 16 the pressurized air in the air chamber 43 is communicated through the port 138 and the passage 134 to the spool end 132 and acts against the spool 126 to shift the same rightwardly as viewed in FIG. 1 and toward the position shown in FIG. 3. At the same time, the pressure at the spool end 135 is vented to atmosphere through the passageway 136, port connection 140, an annular groove 142 formed in the outer periphery of the air piston 42 and a vent port 144 in tubular member 20. As can best be seen in FIG. 1, when the spools 126 and 127 are shifted rightwardly, the source 129 of pressurized air is connected by ports 143 and a passage 145 to the air chamber 45 on the opposite side of the air piston 42 so as to stroke the air piston 42 in a compression stroke in pump portion 14 as shown in FIG. 3. At the same time the air in chamber 43 is vented to atmosphere through the passage 130, an annular groove 146 around the peripheral surface of spool 126 and a vent aperture 147.

As the air piston 42 again traverses the port connections 140 and 138, air pressure from the chamber 45 will be communicated through the port connection 140 to the spool end 135, while the other spool end 132 is vented via the port connection 138, air piston groove 142 and vent port 144, whereby the spools 126 and 127 are shifted from the position illustrated in FIG. 3 to the position illustrated in FIG. 1 wherein pressurized air is again communicated to the air chamber 43 through conduit 130 and the compression stroke of pump portion 16 is repeated.

As can be seen in FIGS. 1 and 2, as the air piston 42 is being stroked to the right to compress the chambers 62 and 70 of the pump portion 16, the fluid therein will be discharged from the associated directional control valve 34, while the pressure pistons within the pump portion 14 are in an expansion stroke, drawing fluid from the reservoir 32 in the manner hereinbefore described. When the air piston 42 is being stroked to the left, as viewed in FIGS. 1 and 2, the pressure pistons in pump portion 16 are in an expansion stroke, while the pistons in the pump portion 14 are in a compression stroke.

In operation, when the air piston 42 is in the position illustrated in FIG. 1 and the shuttle valve 120 is shifted so as to pipe pressurized air into the air chamber 45 on the right side of the air piston 42, the air piston 42 is shifted leftwardly to withdraw the piston portions 46 and 48 from their respective chambers 62 and 70 in pump portion 16, whereupon fluid is drawn from the reservoir 32 into the chambers 62 and 70 via passageways 79, 80 and 86. At the same time the piston portions 46 and 48 of pump portion 14 are in a compression stroke to compress the pressure chambers 62 and 70 in the pump portion 14 and to discharge pressure fluid therefrom. After the compression stroke in pump portion 14 is completed and the air piston 42 traverses the ports 138 and 140, the spool end 132 of the spool 126 is vented through the annular space 142 around the air piston 42, while pressurized air is communicated to the end 135 of the spool 127 to shift the same leftwardly from the position shown in FIG. 3 toward the position shown in FIG. 1 so as to provide communica-

tion between the air pressure source **129** and the air chamber **43.** Pressurized air communicated to the air chamber **43** acts against the air piston **42** to shift the same rightwardly toward the position shown in FIG. **1** to commence the compression stroke of the chambers **62** and **70** within the pump portion **16,** while at the same time withdrawing the pistons on the opposite side of the air piston **42** from the pump portion **14,** wherein fluid from the reservoir **32** replenishes the chambers **62** and **70** of the pump portion **14.**

As the piston portions **46** and **48** are stroked into their respective chambers to compress the fluid therein, the pressure in the chamber **62** acts against check valve **84** to maintain the same closed so that fluid does not flow back to the reservoir **32,** while at the same time the pressure in chamber **62** acting against check valve **88** maintains the same open so that the flow path is from the chamber **62** into the chamber **70,** through the check valve **90,** through conduit **76** to the directional control valve **34.** This operational stage will continue supplying high volume, low pressure fluid to the valve **34** until a sufficient back pressure is created by the work performed to open the valve **102** to exhaust the pressure fluid within chamber **62** back to the reservoir **32** via passageway **106.** As soon as this happens, fluid being discharged from the pump **10** will only be from the pressure chambers **70** and thus high pressure, low volume fluid will be delivered to the control valve **34.**

As shown in FIG. **2,** each pump portion **14** and **16** can be provided with a directional control valve **34** which enables the user to operate two separate fluid users, such as two hydraulic cylinders simultaneously at the same traverse speed, thereby eliminating the need for a separate flow device to insure that each cylinder piston travels at the same speed; however, it should be noted that both pump portions **14** and **16** may be piped together through one directional control valve, as shown in FIG. **1,** if a particular application so requires the combined and continuous flow output of both pump portions.

By properly sizing of the area of the air piston **42** and the pressure piston portions **46** and **48,** a favorable ratio may be obtained wherein a small amount of air pressure (such as shop air which is normally in the range of 100 psi) supplied to the air piston **42** may produce a substantial pressure output from the pressure chamber **70** associated with smaller piston portion **48.** In the preferred embodiment, the area ratio of the air piston **42** to the larger piston portion **46** is 15:1, while the area ratio of the air piston **42** to the smaller piston portion **48** is 80:1. Thus, when 100 psi air pressure is provided to the air piston **42,** the system has a maximum capability of 8,000 psi output pressure. During the initial stages of operation of the pump when both pressure chambers **62** and **70** are connected to outlet, the pump **10** will deliver a higher rate of flow, whereas when a predetermined pressure is reached, say 1,200 psi, and the actuating mechanism is shifted so as to exhaust the pressure chamber **62,** the pump will shift to a stage in which the flow rate will drop substantially. The output pressure will continue to increase up to the limit set by the high pressure relief valve **96.**

It can thus be seen that the present invention provides a pneumatically powered pump which is simple in design and which will supply low pressure fluid to a fluid user at a relatively high flow rate during initial operation of fluid user, and which will automatically shift to a high pressure, low volume operation when the fluid user begins to perform work.

Although only one form of the present invention has been disclosed, it is to be understood that other forms may be adopted, all coming within the spirit of the present invention and scope of the appended claims.

What is claimed is as follows:

1. A fluid pump adapted to be driven by a pressurized fluid, said fluid pump comprising:

a housing having a bore separated on opposite sides into first and second, cylindrically formed, axially spaced pressure chambers, said first pressure chambers being of a larger diameter than said second pressure chambers;

piston means carried in said bore and having cylindrical portions at each end extending into said first and second chambers, the portions of said piston means extending into said second chambers being of a smaller diameter than the portions of said piston means extending into said first chambers;

means for reciprocating said piston means;

a first port means for each of said first pressure chambers and respectively communicating said first pressure chambers to a source of fluid;

a second port means for respectively exhausting said first pressure chambers;

valve means normally closing communication between said first pressure chambers and their associated second port means;

outlet port means communicating with said first and second pressure chambers;

means responsive to a predetermined outlet pressure to actuate said valve means to open communication between said first chambers and said second port whereby fluid in said first chamber is exhausted through said second port means and fluid is thereafter delivered to said outlet port means only from said second pressure chambers;

said means for reciprocating said piston means comprising a piston having a pressure responsive area substantially exceeding the effective area of each of the portions of said piston means said piston and said piston means being reciprocally mounted in said housing on a coextensive axis,

means for automatically supplying the pressurized gas to opposite sides of said piston to reciprocate said piston means;

said last mentioned means comprising a source of pressurized air; a shuttle valve connected with said source of pressurized gas and operable in a first position to direct pressurized gas to one side of said piston and to exhaust the opposite side of said piston, and in a second position to exhaust said first mentioned side of said piston and to direct pressurized gas to the opposite of said piston;

valve means automatically moving said shuttle valve between said first position and said second position to automatically reciprocate said piston;

said valve means comprising means delivering pressurized gas from the sides of said piston to the ends of said shuttle valve in response to said piston being moved to limit positions in each direction.

2. The pump defined in claim **1** wherein said valve means comprises:

a bore in said housing communicating said first pressure chamber with said exhaust port means, a valve seat formed at one end of said bore;

a valve member resiliently biased into engagement with said seat to normally close communication from said first pressure chamber through said bore passageway;

said actuating means comprises:

a second bore in said housing having a rod slidably mounted therein;

said rod projecting toward said valve means;

means communicating the pressure fluid within said second pressure chamber to the end of said rod whereby said rod engages said second valve member to unseat the same when the pressure in said second pressure chamber exceeds said predetermined amount to thereby exhaust said first pressure chamber.

3. The pump defined in claim **1** wherein the effective area of said first piston exposed to said first pressure chamber substantially exceeds the effective area of said second piston.

4. The pump defined in claim **1** wherein the ratio of the effective area of the portions of said piston means extending into said first pressure chamber to the effective area of the portions of said piston means extending into said second pressure chamber is at least 80:1.

5. The pump defined in claim **1** wherein said second piston is a coaxial integral extension of said first piston.

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