

Oct. 8, 1957

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2,808,812

FLUID PRESSURE ENERGY TRANSLATING DEVICE

Filed Sept. 13, 1956

3 Sheets-Sheet 1

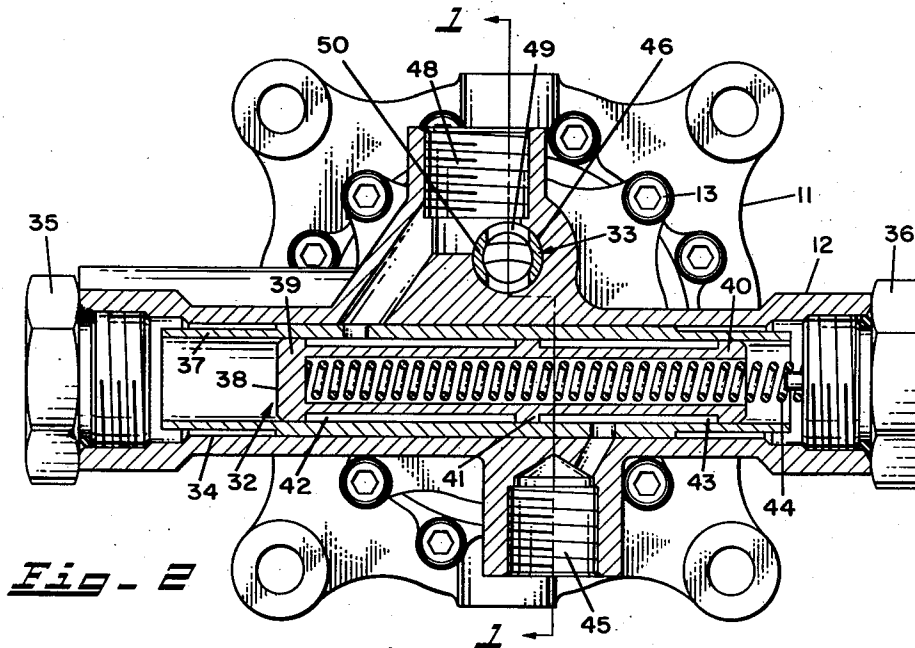


**Fig. 2**

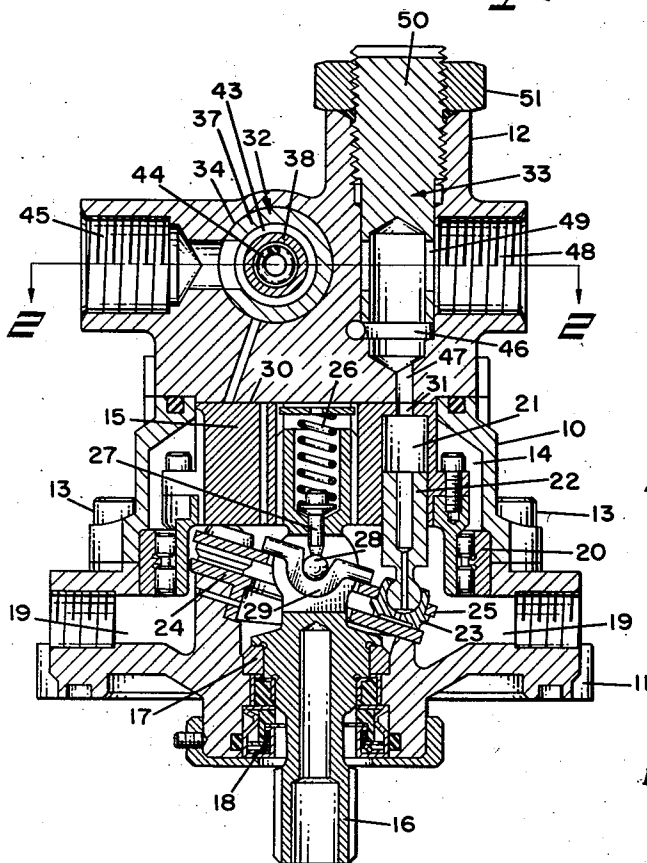


**Fig. 1**

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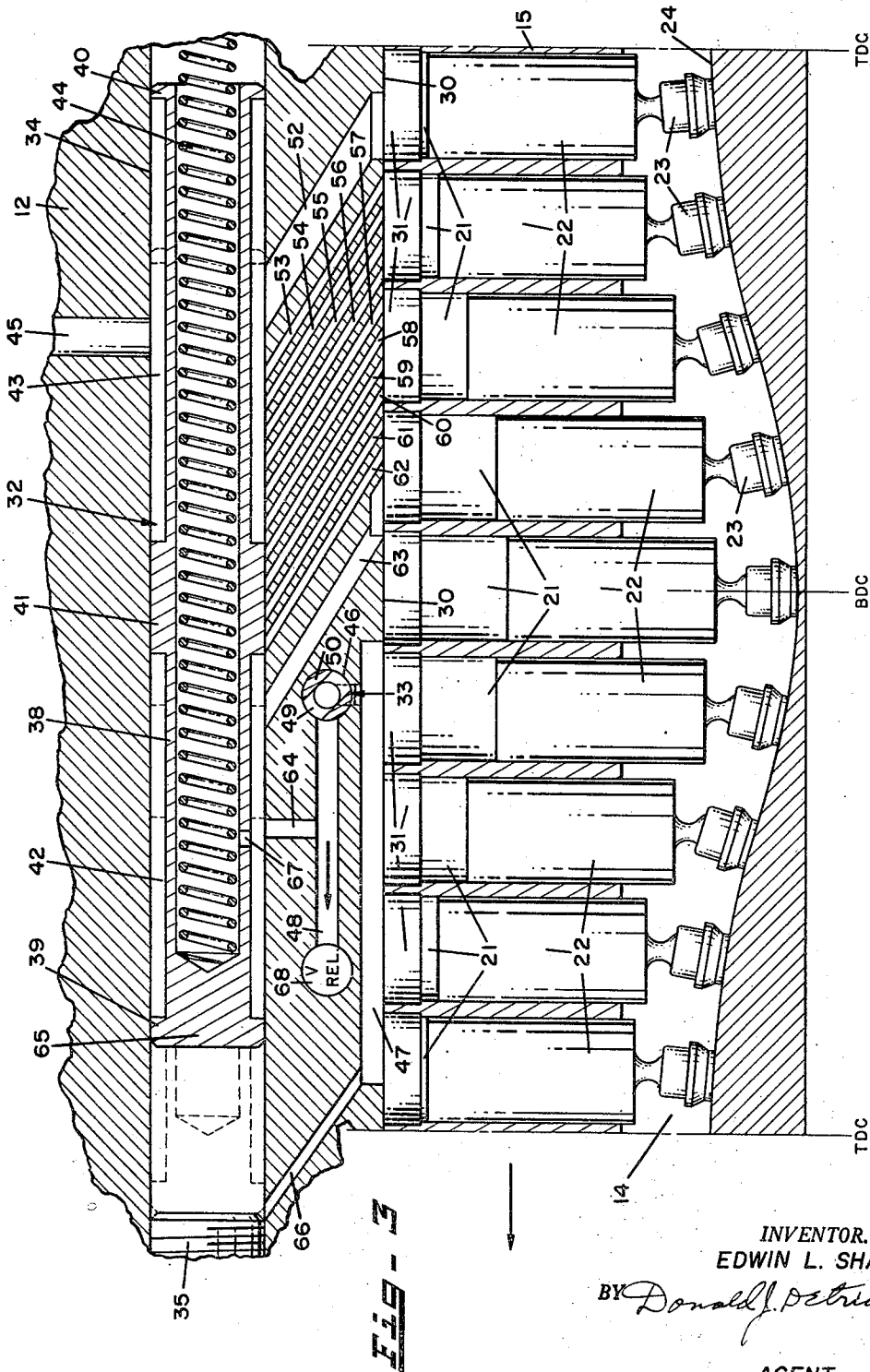
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3 Sheets-Sheet 2



**Oct. 8, 1957**

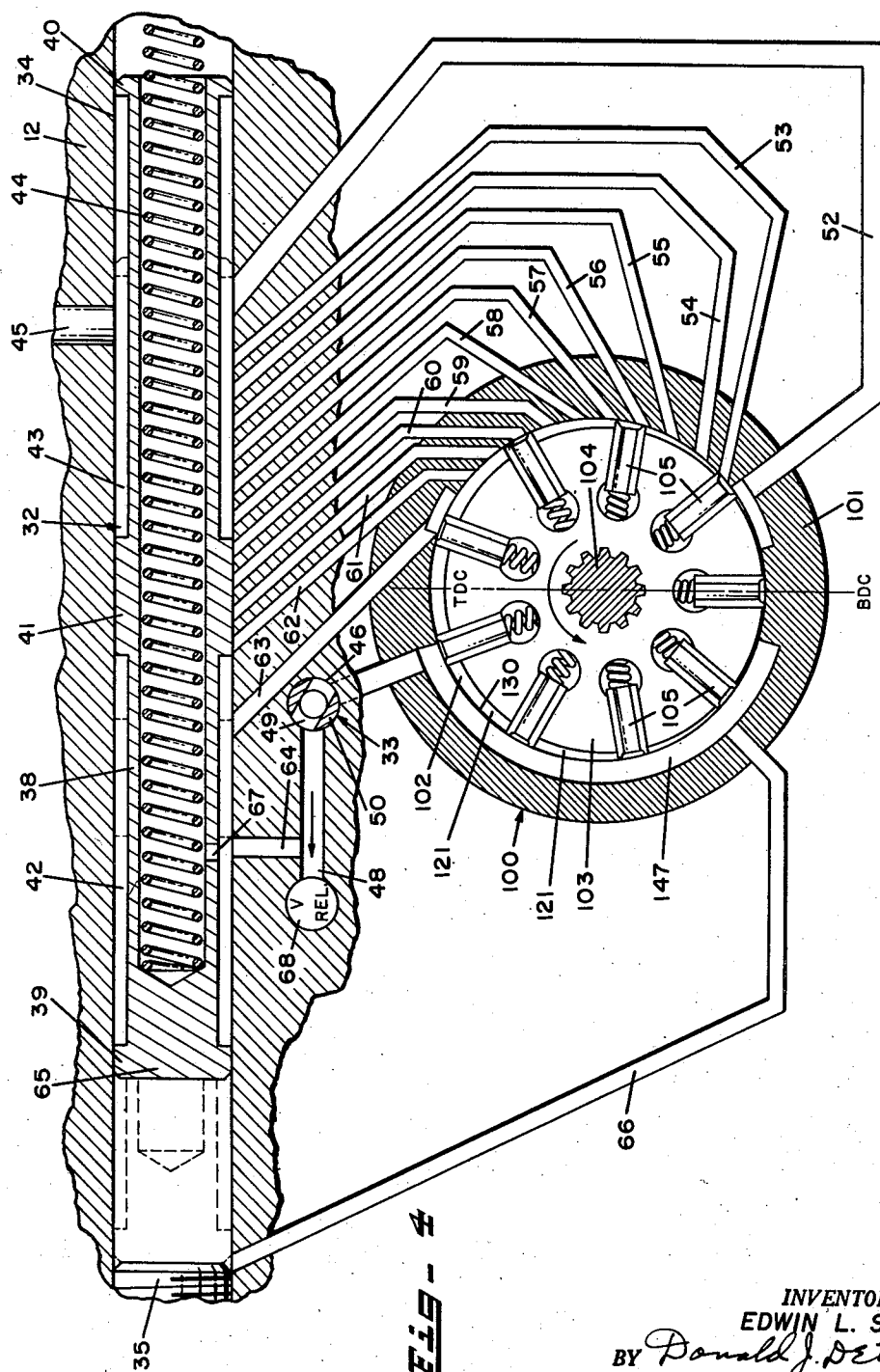
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# FLUID PRESSURE ENERGY TRANSLATING DEVICE

Filed Sept. 13, 1956

**3 Sheets-Sheet 3**



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2,808,812

## FLUID PRESSURE ENERGY TRANSLATING DEVICE

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Application September 13, 1956, Serial No. 609,690

17 Claims. (Cl. 121—62)

This invention relates to fluid pressure energy translating devices, and one of its objects is to provide an improved fluid pressure energy translating device such as a motor or pump which includes improved control means that may be operated manually or automatically as preferred to predetermine the operating characteristics of the translating device.

Another object of the invention is to provide an improved fluid pressure energy translating device such as a motor or pump which includes a plurality of chambers the volumetric capacities of which expand and contract cyclically as the device operates to receive and discharge or exhaust fluid and in which device valve means and passages are provided for interconnecting the chambers when they are expanding and contracting to permit and control by-passing or recirculation of fluid therebetween.

Another object of the invention is to provide an improved fluid pressure energy translating device which may be operated at a substantially constant speed regardless of variations in work load against which the device is operating.

Another object of the invention is to provide an improved fluid pressure energy translating device of the type set forth in the preceding object which includes a plurality of chambers the volumetric capacities of which expand and contract cyclically to receive and discharge or exhaust fluid as the device operates and in which device fluid may be supplied selectively from different sources to said chambers during different portions of the expansion of said chambers thereby to control the operational characteristics of the device.

In carrying out the foregoing object, it is a more specific object of the invention to provide an improved fluid pressure energy translating device which includes a plurality of chambers that expand and contract as the device operates thereby changing their volumetric capacities and which chambers are brought into successive registration with a plurality of fluid port or passage means, the device also including means, such as a valve, for progressively connecting and disconnecting certain of the fluid port or passage means whereby fluid may be supplied to said chambers from different sources while the chambers are expanding thereby to maintain the speed of operation of the device relatively constant even though the work load against which the device is operating may vary.

A more specific object of the invention is to provide a fluid pressure operated motor which includes a plurality of chambers which expand and contract as the device operates thereby changing their volumetric capacities and which chambers are brought successively into registration with a plurality of fluid ports or passage means, the device also including means, such as a valve, operative to disconnect progressively certain of the ports or passages means which admit fluid to said chambers as the latter increase in volumetric capacity from a source of fluid under pressure and for progressively connecting certain of the disconnected ports or passage means to receive fluid from a source of low pressure, and said means being operative to reverse the order of connections set

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forth thereby to maintain the speed of operation of the motor substantially constant regardless of variations in work load against which the motor is operating.

In carrying out the foregoing objects, it is a still more specific object of the invention to provide the improved motor set forth with a pressure responsive valve means operative to make the connections mentioned either in response to a back pressure or a pressure differential created in the port or passage means which conducts exhaust fluid from said chambers.

It is still another object of the invention to provide the improved motor set forth in the foregoing objects with a pressure responsive valve means operative to make the connections mentioned either in response to a back pressure or a pressure differential created in the port or passage means which conducts exhaust fluid from said chambers and to connect certain of the ports or passage means which have been disconnected from the source of fluid under pressure to receive fluid from the said exhaust port or passage means whereby said chambers, while expanding in volumetric capacity will receive fluid during a part of their expansion period from said source of fluid under pressure and during another part of their expansion period from said exhaust passage means.

Further objects and advantages of the invention will be apparent from the following description, reference being had to the accompanying drawings wherein preferred embodiments of the invention are clearly shown.

In the drawings:

Fig. 1 is a view in section of an axial piston type fluid motor including the features of the invention, the section being taken on line 1—1 of Fig. 2;

Fig. 2 is a view, partly in section and partly in elevation, of the motor seen in Fig. 1, the section being taken on line 2—2 of Fig. 1;

Fig. 3 is a diagrammatic showing of parts of the motor seen in Figs. 1 and 2 and in which the cylinder barrel, cam plate, etc. have been shown in a plane; and

Fig. 4 is a diagrammatic showing of the invention as applied to a vane type motor.

My invention relates to fluid pressure energy translating devices which may be in the form of motors or pumps and it is herein shown in an axial piston type translating device which is herein described as a motor, but which is also capable of functioning as a pump.

In the drawings, Figs. 1 and 2 show the above mentioned motor as having a body, casing or housing formed by a hollow generally cylindrical center portion or section 10, an end cap 11 and a valve block or body 12 which are secured together by a plurality of cap screws 13 to provide a chamber 14 in which a cylinder barrel 15 is housed.

The cylinder barrel 15 includes a central axially extending bore provided with splines by which it is connected for axial movement on and in driving relation with the splined inner end of a drive shaft 16. Shaft 16 extends through the end cap 11 and is carried for rotation therein in a bearing 17. Suitable oil seals 18 are provided for preventing the loss of oil from the chamber 14 through the cap 11 along the shaft 16. Oil is drained from the chamber 14 through either of two passages 19 formed in the end cap 11.

As clearly seen in Fig. 1 of the drawings, the cylinder barrel 15 carries or supports the upper or inner end of the shaft 16 and it is mounted for rotation upon its central axis by a roller bearing 20 located at the lower end of the cylinder barrel and between it and casing section 10.

The cylinder barrel 15 also includes a plurality of cylinder bores or piston chambers 21 spaced equal distances apart in a circle concentric with the axis of rotation of the barrel 15. In each of these cylinder bores or piston chambers 21 there is a piston 22 the lower end of which is con-

nected for universal motion or movement by a ball and socket joint with a piston shoe 23 which is held in engagement with a cam plate or cam ring 24 which surrounds the shaft 16 and is fixed upon a boss formed on the end cap 11. The upper surface of cam ring 24 which is engaged by the piston shoes 23 lies in a plane which intersects the axis of rotation of cylinder barrel 15 and shaft 16 at an angle whereby when said cylinder barrel 15 and shaft 16 rotate the pistons 22 will reciprocate in their respective cylinders 21.

The pistons 22 are hollow for the customary purpose of supplying oil under pressure from the cylinder bores 21 to pockets formed in the cam ring engaging surfaces of the shoes 23 to provide a film of oil between the shoes and the cam ring and for pressure balancing the pistons and shoes thereby to reduce friction between the shoes and cam ring.

The piston shoes 23 are retained in engagement with the cam ring or plate 24 by a hold-down ring or plate 25 which is resiliently urged toward the cam ring 24 by a compression spring 26 contained within the upper end of the shaft 16 and acting through a plunger 27 upon a ball 28 positioned within the drive shaft 16 and seated in the center of a yoke shaped cross bar 29 which extends through a slot in the drive shaft 16 and the ends of which engage the upper surface of the hold-down ring 25. The cross bar 29 can rotate about an axis extending at right angles to its longitudinal axis upon the ball 28 and also about its longitudinal axis upon the hold-down ring 25. It will thus be seen that there has been provided a simple universal joint mechanism between the plunger 27 and the hold-down ring 25 through which the energy of the spring 26 is transmitted to the hold-down ring 25 with a substantially constant force when the cylinder barrel 15 and hold-down ring 25 rotate.

Because the spring 26 also abuts a washer-like element which is held in the cylinder barrel 15, the cylinder barrel 15 is urged by the spring 26 into engagement with the bottom, port plate or valve plate surface 30 of the valve block 12.

The cylinder barrel 15 also includes a plurality of elongated, arcuate or sausage shaped ports 31, one for each of the cylinder bores or piston chambers 21, which like the cylinder bores or piston chambers 21 are spaced equal distances apart and are concentric with the axis of rotation of the cylinder barrel 15. It will be evident from the description which follows that these elongated ports 31 are actually elements of valving mechanisms which include the mating surfaces formed by the flat bottom, port plate or valve plate surface 30 and the upper end of the cylinder barrel 15 and ports in the port plate 30 which are brought successively into registration with the ports 31 in the cylinder barrel as the latter rotates. These described valving mechanisms operate to admit fluid to and permit its discharge from the cylinder bores or piston chambers 21 during the operation of the motor.

In addition to providing the port plate or valve plate surface 30, the valve block 12 also provides the body of a pressure responsive control valve 32 and the body of an orifice valve 33 the function of which is to provide an adjustable or variable orifice in the discharge conduit or passage 48 of the motor, the setting of which predetermines the speed of operation of the motor. Valve 33 may hereinafter be referred to as an orifice, variable orifice or orifice valve.

The pressure responsive control valve 32 includes a bore 34 which, as best seen in Fig. 2 of the drawings, extends entirely through the block 12 and is closed at its opposite ends by plugs 35 and 36. Bore 34 is provided with a liner sleeve 37 made of a hard wear-resistant material in which there is a valve element in the form of a hollow core or spool 38 having lands 39 and 40 and a center land 41 which are separated by two annular channels or grooves 42 and 43. The core or spool 38 is urged to the left as seen in Fig. 2 of the drawings

by a compression spring 44 contained within the core or spool 38 and abutting it and the plug 36.

Hydraulic fluid under pressure is supplied to the motor for operating it through an internally threaded inlet conduit, port or passage 45 in the block 12 which leads through a port in the wall of the sleeve 37 to the interior of the latter from which it is distributed, in accordance with the position of the core or spool 38, through conduits, ports or passages to various of the ports in the bottom, port plate or valve plate surface 30 of the block 12 as will be described in detail hereinafter with reference to the diagrammatic showing in Fig. 3 of the drawings.

The orifice valve 33 also includes a bore 46 which is connected through a conduit or passage with an elongated port or passage 47 formed in the bottom, port or valve plate surface 30 of block 12 and it is through this orifice valve 33 that fluid is discharged from the motor through an internally threaded conduit, port or passage 48. The adjustable orifice of the valve 33 is actually formed by a port 49 in a rotatably adjustable hollow core 50 which is threaded into the bore 46 which port co-operates with the inlet to the passage 48. Core 50 may be locked in its adjusted position by a nut 51 on an end of the core 50 which projects outwardly beyond the block 12.

The control structure and its operation as well as the operation of the motor are easily understood from the simplified showing of Fig. 3 of the drawings in which certain of the essential elements of the motor and the valve mechanisms thereof are shown schematically. From the description thus far given, it is understood that the ports 31, cylinders 21, pistons 22 and shoes 23 rotate bodily with cylinder barrel 15 and follow a circular path. In Fig. 3 of the drawings, this circular path as well as the port plate 30, the cylinder barrel 15 and cam ring or plate 24 are split on a plane TDC which passes axially through them at the top dead center position in the stroke of the pistons 22 as they rotate and these elements together with the pistons, etc. are laid out in a plane. As shown in this drawing, during each revolution of the cylinder barrel 15, the pistons 22 travel from the plane TDC at the right-hand side of the view to the same plane TDC at the left-hand side of the view, and the core or spool 38 of the pressure responsive control valve 32 is shown in dotted lines in the position which it occupies when the motor is inoperative, just starting, or when the entire volume of fluid under pressure being supplied to the motor is employed to drive it.

In operation, when the motor is to be started, the core or spool 38 is in the dotted line position mentioned and hydraulic fluid under pressure is supplied to the pressure responsive control valve 32 through the inlet conduit, port or passageway 45 from which it passes into the bore 34 and to the annular chamber formed by the channel or groove 43 in core or spool 38 and the bore 34. From this annular chamber, channel or groove 43, hydraulic fluid enters conduits 52 through 63 which form ports in the bore 34 and lead to the ports in the bottom, port plate or valve plate surface 30 of block 12 which ports are brought successively into registration or communication with the elongated ports 31 in the cylinder barrel 15 as the latter rotates.

Persons skilled in the art will readily understand that the cam ring or plate 24 causes the pistons 22 to reciprocate with a sine motion in the cylinders 21 as the cylinder barrel 15 rotates whereby the chambers formed by the cylinders 21 and pistons 22 will successively increase and decrease in volumetric capacity and also that the conduits or passageways 52 through 63, when the core or spool 38 is in the position shown in dotted lines in Fig. 3, will admit fluid under pressure to these piston chambers 21 while their volumetric capacities are expanding or increasing thereby forcing the pistons 22 outwardly in the cylinders 21 to cause rotation of the cylinder barrel 15 and shaft 16.

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It will be noted that each piston chamber 21 will begin to receive fluid under pressure from the control valve 32 as it crosses the top dead center position TDC where its port 31 begins to open or come into register with the elongated port in the port plate 30 formed in connection with the conduit or passage 52 and that said cylinder 21 will continue to receive fluid from the control valve 32 while its port 31 travels across the ports in the port plate 30 formed by the conduits or passages 53 through 63 until it reaches that position in its circular path of travel where the trailing end of the port 31 closes or moves out of registration with the port in port plate 30 formed by the conduit or passage 63. As the ports 31 of the cylinder bores or piston chambers 21 move out of registration with the valve port formed by the conduit or passageway 63, they are brought into registration or are placed in communication with the long port or passage 47 through which the fluid in the cylinders is discharged from the motor as the pistons 22 are moved inwardly in said cylinders to reduce their volumetric capacities.

If the speed of operation of the motor tends to exceed any rate of speed which has been predetermined by the adjustment or setting of the orifice valve 33, then the core or spool 38 of valve 32 will be moved to the right, as seen in Fig. 3 of the drawings in the manner hereinafter described, to reduce the rate of speed of the motor to the predetermined rate. In Fig. 3, the core or spool 38 is shown in full lines in a position wherein it is controlling the speed of operation of the motor.

It is pointed out here that of the conduits or passages 52 through 63 the conduits or passages 53 through 62 are substantially identical and are spaced equal distances apart at their ends which form the ports in both the valve 34 and the port plate 30. It is preferred, as shown, that the lengths of each of the ports 31 and the center land 41 of core or spool 38 be such that each can span at least four of the passages 53 through 62, although their lengths may be changed to span more or less of these passages. It will be seen that the greater the number of passages which are spanned by the land 41 and ports 31 the smoother the control of the motor will be.

Still referring to Fig. 3 of the drawings, when the core or spool 38 of control valve 32 has been moved to the position shown in full lines, fluid under pressure can pass from the channel or groove 43 in valve 32 through the conduits 52 through 59 and since the length of each of the ports 31 is such that it can span and place four of the passages 53 through 62 in communication with its respective cylinder 21, after the rear or trailing end of each port 31 closes the port in the port plate 30 formed by the conduit or passage 55, the front or leading end of the port 31 opens the port in the port plate 30 formed by the passage 59 which is blocked or closed at the bore 34 by the center land 41 on core or spool 38. As the port 31 continues to move to the left as seen in Fig. 3, it will successively close the ports in the port plate 30 formed by the conduits or passages 56, 57 and 58 to disconnect the port 31 and its respective piston chamber 21 from the supply of fluid under pressure and its leading end, after port 59 has been closed, will successively open the ports in the port plate 30 formed by the passages 60, 61, 62 and 63 of which passages 60, 61 and 62 are also blocked or closed at the bore 34 by the land 41. Passage 63 is open to the bore 34 and channel 42 to permit fluid exhausted from the cylinders 21 to be re-circulated in a manner and for a purpose hereinafter set forth.

As the port 31 begins to travel across the port in the port plate 30 formed by the passage 63, the piston 22 in the piston chamber connected with said port 31 is nearing the outer limit of its travel, i. e. its shoe 23 is approaching the bottom dead center position indicated by the plane BDC. During this period of time fluid exhausted from the piston chambers to the channel 42 flows through the passage 63 into the piston chamber and, as said port 31 crosses the dead center position BDC, the

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port 31 is closed by the port plate 30. Upon travelling across the bottom dead center position BDC, the port 31 comes into registration with elongated port 47 in port plate 30 and the piston 22 in the piston chamber 21 connected with said port 31 begins its inward stroke in said cylinder to reduce the volumetric capacity thereof and of exhaust fluid through the ports 31 and 47, the variable orifice valve 33 and the exhaust conduit, port or passage 48. A conduit or passage 64 connects the exhaust conduit 48 with the annular chamber in control valve 32 formed by the channel or groove 42 in core or spool 38 and the bore 34 whereby hydraulic liquid may be re-circulated in the motor from exhaust passage 48 through passages 64 and 63. The piston 22 will continue to exhaust fluid from its cylinder 21 through the port 47 until it reaches the top dead center position TDC in its circular path of travel.

As mentioned previously, the control valve 32 is a pressure responsive valve and its core or spool 38 is shifted axially in the bore 34 by differences in pressure at opposite sides of its solid end or head 65. The orifice valve 33 functions to cause this pressure difference by creating a back pressure in the port 47 which is communicated to the left-hand end of the piston 38 through a conduit or passage 66 which leads from the port 47 to one end of the valve bore 34 and between the plug 35 and said piston head 65. The low pressure or exhaust side of the orifice valve 33 is connected to the opposite or spring loaded side of the piston head 65 through the passages 48 and 64 and an opening or port 67 in the core or spool 38.

When the motor is operating, the volume of fluid discharged from the piston chambers 21 into the port 47 is directly proportional to the speed of rotation of the cylinder barrel 15 and, of course, substantially all of this fluid must pass through the orifice valve 33 to escape from the port 47. One of the functions of the orifice valve 33 is to provide an adjustable means whereby the speed of operation of the motor, that is, the speed of rotation of its cylinder barrel 15 and shaft 16 may be predetermined and this is accomplished by adjusting it to restrict the flow of fluid from port 47 through the port 49 thereby to create the back pressure in port 47 which is reflected through passage 66 to bore 34 to cause the core or spool 38 of control valve 32 to be moved to the right against the spring 44 and the lower pressure within the core or spool 38 from the exhaust or discharge side of the orifice valve 33. Should the speed of rotation of the cylinder barrel 15 increase and cause the pressure in port 47 to increase, core or spool 38 will be moved to the right, as seen in Fig. 3, and as said core or spool moves to the right its center land 48 will function to close the passages 59, 58, 57, etc. successively and to open the ports 62, 61, 60, etc. successively thereby cutting off the supply of fluid under pressure from the channel 43 to the piston chambers 21 before the latter have increased their volumetric capacities to the maximum and opening the channel 42 to the piston chambers whereby fluid will be bypassed or re-circulated in the motor from those piston chambers 21 whose volumetric capacities are being reduced to those piston chambers 21 whose volumetric capacities are still increasing but which have been cut off from the source of fluid under high pressure.

It will be seen that, when the orifice valve 33 is adjusted to predetermine the speed of operation of the motor at a speed less than its maximum possible speed that the core or spool 38 of valve 32 will be positioned in the bore 34 at some position to the right of that shown in the drawings and that should the torque load on the motor decrease and tend to permit the speed of operation of the motor to increase that the core or spool 38 will be moved further to the right to cause less of the expansion period of the cylinders to be utilized to drive the pistons 22 outwardly and more of the expansion period of said cylinders to receive fluid re-circulated from the cylinders

21 which are being exhausted thereby to maintain the speed of operation of the motor constant. It will, of course, be understood that should the torque load on the motor increase and tend to cause the speed of operation of the motor to decrease that the above described operation of the valve 32 will be reversed whereby fluid under pressure from the channel 43 will be supplied to the cylinders 21 for a greater portion of the period during which their volumetric capacities are increasing and simultaneously reducing the amount of fluid being re-circulated thereby maintaining the speed of operation of the motor constant. The motor will, therefore, tend to operate at a constant speed as predetermined by the setting of the orifice valve 33 even though the torque load upon the motor shaft 16 may vary.

It is pointed out here that the ports or passageway 52 remains open at all times. It is also pointed out that when the motor is employed in a hydraulic circuit wherein its exhaust port or conduit 48 is connected in such manner that little or no back pressure is created in the port or passage 48 that it is desirable to cause the hydraulic fluid flowing from said port or passage 48 to pass through a low pressure relief valve 68 whereby sufficient back pressure will be created in passage 48 to insure that adequate fluid will flow through the passages 63, 62, 61, etc. which may be functioning as recirculatory passages in the motor.

Fig. 4 of the drawings shows the invention as applied to a vane type fluid motor 100. Since this form of the invention includes the valves 32 and 33 and may, as shown, include the relief valve 68 and the conduits or passageways associated therewith, the valves, etc. carry the numerals applied to them in Figs. 1 through 3 of the drawings.

The vane type motor 100, with the exception of its porting, may be any of the typical types of such motors and the simple form of such motor herein employed to illustrate the invention includes a cam ring 101 having a circular interior cam surface which forms the peripheral wall 130 of a rotor chamber 102 in which a rotor body 103 is mounted. The rotor body 103 is mounted eccentrically within the chamber 102 upon a motor shaft 104 and it is rotated in the direction of the arrow seen in the drawing to drive the shaft 104. The rotor body 103 is provided with a plurality of equally spaced radially extending vane slots in each of which there is carried a vane 105. Each vane 105 is of such dimensions as to sealingly and slidably engage the opposite side walls, not shown, of the rotor chamber 102. Vanes 105 are urged radially outwardly against the wall 130 by springs.

In this vane type motor 100 the wall 130 is the full equivalent of the port plate or valve plate surface 30 of the piston motor described and shown in Figs. 1 through 3 of the drawings and the pockets or chamber 121 formed between the vanes 105 are the full equivalent of the piston chambers 21 of said piston motor.

As previously mentioned, the structure and operation of the valves 32, 33 and 68 are identical in each of the embodiments and therefore the description thereof need not be duplicated in connection with Fig. 4 of the drawings. It is pointed out, however, that in the operation of the vane type motor 100 the pockets or chambers 121 are rotated past the ports in the peripheral wall 130 formed in connection with the passages 52 through 63 and an elongated port 147 formed in connection with the conduit or passageway 66 and the orifice valve 33 and that the vanes 105 operate to form valve elements which correspond to the ports 31 in the piston type motor.

While the devices shown in the drawings have been described as motors, it is obvious that they are capable of operating as pumps if their rotor shafts are driven from a suitable prime mover. When the devices are employed as pumps, the relief valves 68 will not be used and the pumps will operate to deliver a constant volume of fluid

even though the rate of speed at which their rotors are driven may vary.

While the form of embodiment of the present invention as herein disclosed constitutes a preferred form, it is to be understood that other forms might be adopted, all coming within the scope of the claims which follow.

I claim:

1. A fluid pressure energy translating device including relatively movable means forming a plurality of chambers the volumetric capacity of each of which increases and decreases successively during operation of the device; means forming a plurality of separate ports; means for successively placing said separate ports in communication with each of said chambers while the latter move to increase their volumetric capacity; passage forming means for fluid, and valve means adjustable to connect progressively said ports and passage means.

2. A fluid pressure energy translating device including relatively movable means forming a plurality of chambers the volumetric capacity of each of which increases and decreases successively during operation of the device; means forming a plurality of separate ports; valve means for successively connecting and disconnecting said separate ports and each of said chambers as the latter move to increase their volumetric capacity; passage forming means for fluid, and valve means adjustable to connect progressively said ports and passage means.

3. A fluid pressure energy translating device including relatively movable means forming a plurality of chambers the volumetric capacity of each of which increases and decreases successively during operation of the device; means forming a plurality of separate ports; means for successively placing said separate ports in communication with each of said chambers while the latter move to increase their volumetric capacity; passage forming means for fluid, and pressure responsive valve means for connecting progressively said ports and passage means.

4. A fluid pressure energy translating device including relatively movable means forming a plurality of chambers the volumetric capacity of each of which increases and decreases successively during operation of the device; means forming a plurality of separate ports; valve means for successively connecting and disconnecting said separate ports and each of said chambers as the latter move to increase their volumetric capacity; passage forming means for fluid, and pressure responsive valve means for connecting progressively said ports and passage means.

5. A fluid pressure operated motor including relatively movable means forming a plurality of chambers the volumetric capacity of each of which increases and decreases successively during operation of the motor; a plurality of inlet passage means for successively admitting fluid to said chambers as the latter increase in volumetric capacity; exhaust passage means through which fluid is exhausted from said chambers as the latter decrease in volumetric capacity, and valve means for progressively connecting and disconnecting said inlet passage means and said exhaust passage means whereby some of the fluid exhausted from said chambers may be directed through said inlet passage means to said chambers as the latter increase in volumetric capacity.

6. A fluid pressure operated motor including relatively movable means forming a plurality of chambers the volumetric capacity of each of which increases and decreases successively during operation of the motor; a plurality of inlet passage means for successively admitting fluid to said chambers as the latter increase in volumetric capacity; exhaust passage means through which fluid is exhausted from said chambers as the latter decrease in volumetric capacity, and pressure responsive valve means for progressively connecting and disconnecting said inlet passage means and said exhaust passage means whereby some of the fluid exhausted from said chambers may be directed through said inlet passage means to said chambers as the latter increase in volumetric capacity.

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7. A fluid pressure operated motor including relatively movable means forming a plurality of chambers the volumetric capacity of each of which increases and decreases successively during operation of the motor; a plurality of inlet passage means for successively admitting fluid to said chambers as the latter increase in volumetric capacity; exhaust passage means through which fluid is exhausted from said chambers as the latter decrease in volumetric capacity; passage means for interconnecting said exhaust passage means and said inlet passage means; means for conducting fluid under pressure to said motor, and means including a valve for progressively connecting said inlet passage means with said fluid conducting means and progressively disconnecting said inlet passage means and said exhaust passage means.

8. A fluid pressure operated motor including relatively movable means forming a plurality of chambers the volumetric capacity of each of which increases and decreases successively during operation of the motor; a plurality of inlet passage means for successively admitting fluid to said chambers as the latter increase in volumetric capacity; exhaust passage means through which fluid is exhausted from said chambers as the latter decrease in volumetric capacity; passage means for interconnecting said exhaust passage means and said inlet passage means; means for conducting fluid under pressure to said motor, and means including a pressure responsive valve for progressively connecting said inlet passage means with said fluid conducting means and progressively disconnecting said inlet passage means and said exhaust passage means.

9. A fluid pressure operated motor including relatively movable means forming a plurality of chambers the volumetric capacity of each of which increases and decreases successively during operation of the motor; a plurality of inlet passage means for successively admitting fluid to said chambers as the latter increase in volumetric capacity; exhaust passage means through which fluid is exhausted from said chambers as the latter decrease in volumetric capacity; pressure responsive valve means for progressively connecting and disconnecting said inlet passage means and said exhaust passage means whereby some of the fluid exhausted from said chambers may be directed through said inlet passage means to said chambers as the latter increase in volumetric capacity, and means in said exhaust passage for creating a back pressure for operating said pressure responsive valve means as aforesaid.

10. A fluid pressure operated motor including relatively movable means forming a plurality of chambers the volumetric capacity of each of which increases and decreases successively during operation of the motor; a plurality of inlet passage means for successively admitting fluid to said chambers as the latter increase in volumetric capacity; exhaust passage means through which fluid is exhausted from said chambers as the latter decrease in volumetric capacity; passage means for interconnecting said exhaust passage means and said inlet passage means; means for conducting fluid under pressure to said motor; means including a valve for progressively connecting said inlet passage means with said fluid conducting means and progressively disconnecting said inlet passage means and said exhaust passage means, and means for creating a back pressure in said exhaust passage means for operating said pressure responsive valve means as aforesaid.

11. A fluid pressure operated motor including relatively movable means forming a plurality of chambers the volumetric capacity of each of which increases and decreases successively during operation of the motor; a plurality of inlet passage means for successively admitting fluid to said chambers as the latter increase in volumetric capacity; exhaust passage means through which fluid is exhausted from said chambers as the latter decrease in volumetric capacity; passage means for inter-

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connecting said exhaust passage means and said inlet passage means; means for conducting fluid under pressure to said motor; means including a valve for progressively connecting said inlet passage means with said fluid conducting means and progressively disconnecting said inlet passage means and said exhaust passage means, and means responsive to pressure in said exhaust passage means for operating said valve means as aforesaid.

12. A fluid pressure operated motor including relatively movable means forming a plurality of chambers the volumetric capacity of each of which increases and decreases successively during operation of the motor; a plurality of inlet passage means for successively admitting fluid to said chambers as the latter increase in volumetric capacity; exhaust passage means through which fluid is exhausted from said chambers as the latter decrease in volumetric capacity; pressure responsive valve means for progressively connecting and disconnecting said inlet passage means and said exhaust passage means whereby some of the fluid exhausted from said chambers may be directed through said inlet passage means to said chambers as the latter increase in volumetric capacity, said valve means including a bore; movable valve means in said bore; means urging said movable valve means toward a position wherein said exhaust passage means is disconnected from said inlet passage means, and means responsive to the pressure in said exhaust passage means for operating said valve as aforesaid.

13. A fluid pressure operated motor including relatively movable means forming a plurality of chambers the volumetric capacity of each of which increases and decreases successively during operation of the motor; a plurality of inlet passage means for successively admitting fluid to said chambers as the latter increase in volumetric capacity; exhaust passage means through which fluid is exhausted from said chambers as the latter decrease in volumetric capacity; pressure responsive valve means for progressively connecting and disconnecting said inlet passage means and said exhaust passage means whereby some of the fluid exhausted from said chambers may be directed through said inlet passage means to said chambers as the latter increase in volumetric capacity, said valve means including a bore; movable valve means in said bore; and means responsive to the pressure in said exhaust passage means for operating said valve as aforesaid.

14. A fluid pressure operated motor including relatively movable means forming a plurality of chambers the volumetric capacity of each of which increases and decreases successively during operation of the motor; a plurality of inlet passage means for successively admitting fluid to said chambers as the latter increase in volumetric capacity; exhaust passage means through which fluid is exhausted from said chambers as the latter decrease in volumetric capacity; pressure differential operated valve means for progressively connecting and disconnecting said inlet passage means and said exhaust passage means whereby some of the fluid exhausted from said chambers may be directed through said inlet passage means to said chambers as the latter increase in volumetric capacity; means in said exhaust passage for creating a pressure differential, and means for applying the different pressures of said pressure differential to said valve means to operate the same as aforesaid.

15. A fluid pressure energy translating device including relatively movable means forming a plurality of chambers and operating in a cycle during a portion of which said chambers increase in volumetric capacity and during another portion of which said chambers decrease in volumetric capacity; a plurality of passage means arranged to communicate successively with said chambers during one portion of said cycle; passage means arranged to communicate with said chambers during the other portion of said cycle, and means including a valve for progressively

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interconnecting the passage means forming said plurality of passages with the other mentioned passage means.

16. A fluid pressure energy translating device including relatively movable means forming a plurality of chambers and operating in a cycle during a portion of which said chambers increase in volumetric capacity and during another portion of which said chambers decrease in volumetric capacity; a plurality of passage means arranged to communicate successively with said chambers during one portion of said cycle; passage means arranged to communicate with said chambers during the other portion of said cycle, and means including a valve for progressively interconnecting the passage means forming said plurality of passages with the other mentioned passage means, said valve operating in response to pressure in one of said passage means.

17. A fluid pressure energy translating device including relatively movable means forming a plurality of cham-

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bers and operating in a cycle during a portion of which said chambers increase in volumetric capacity and during another portion of which said chambers decrease in volumetric capacity; a plurality of passage means arranged to communicate successively with said chambers during one portion of said cycle; passage means arranged to communicate with said chambers during the other portion of said cycle, and means including a valve for progressively interconnecting the passage means forming said plurality of passages with the other mentioned passage means, said valve operating in response to pressure in the last mentioned of said passage means.

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