July 29, 1969 H. E. FISCHER ETAL 3,457,873

PUMPING CHAMBER DECOMPRESSION

Filed March 20, 1967 2 Sheets-Sheet 1

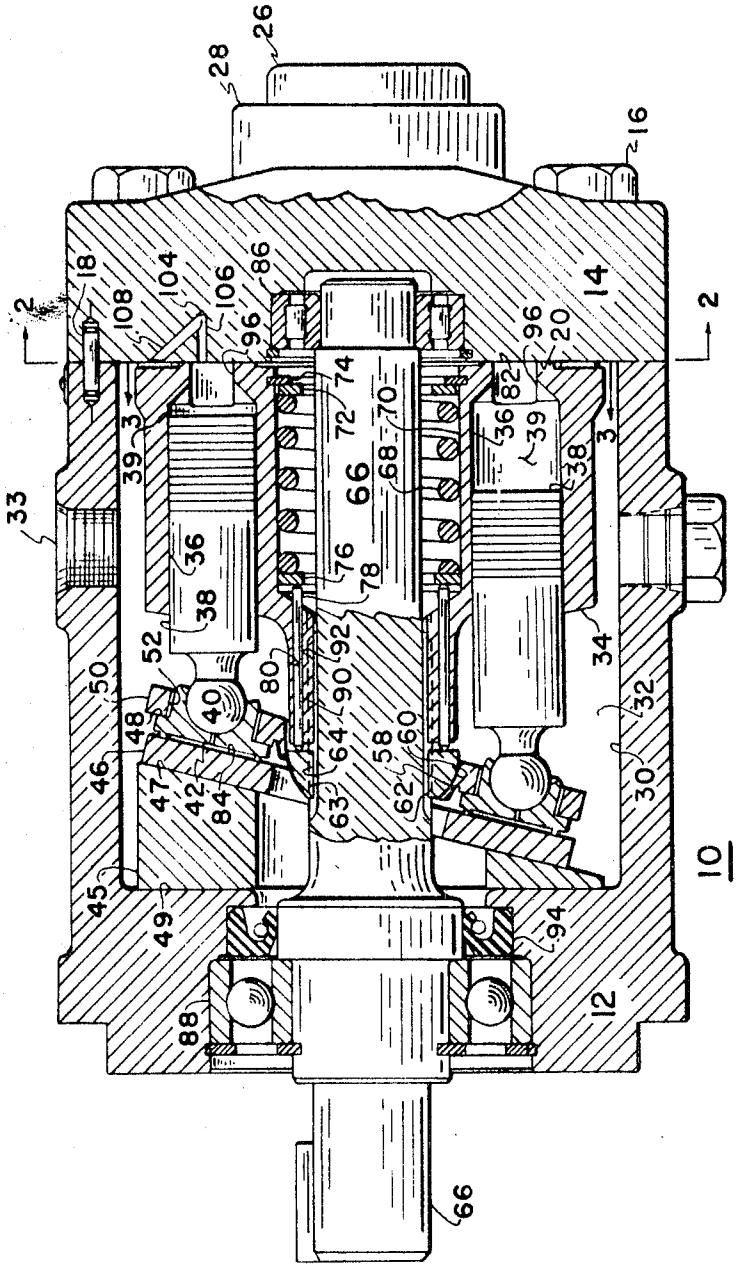


FIG. 1

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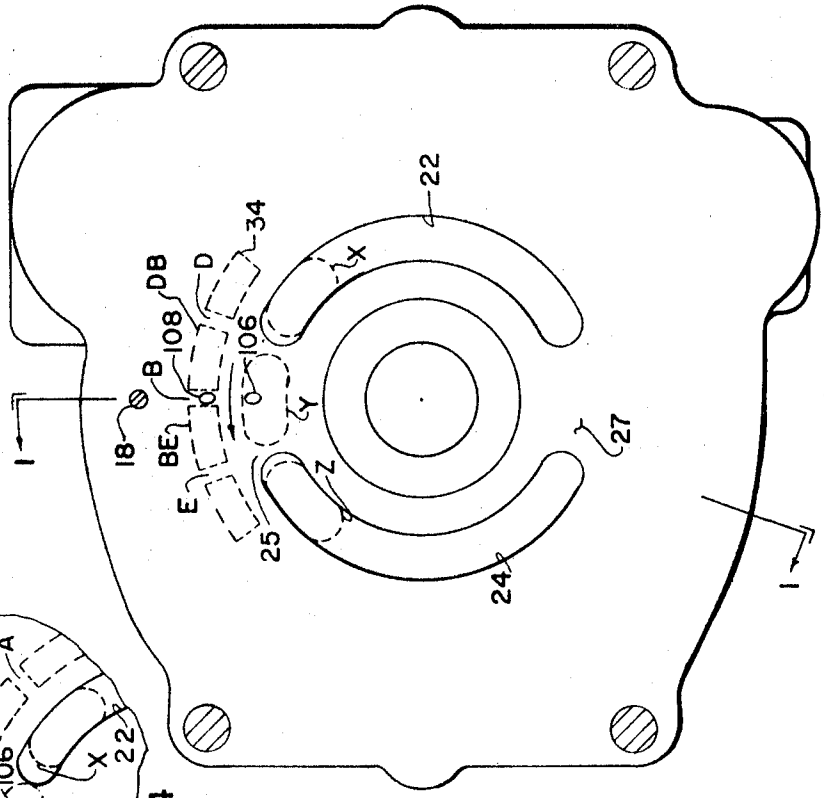


FIG. 2

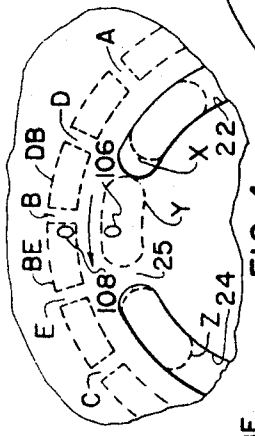


FIG. 4

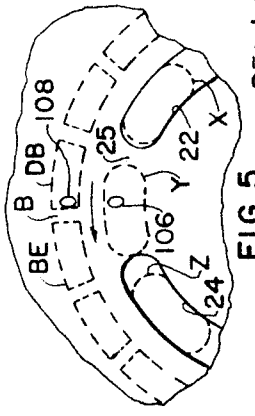


FIG. 5

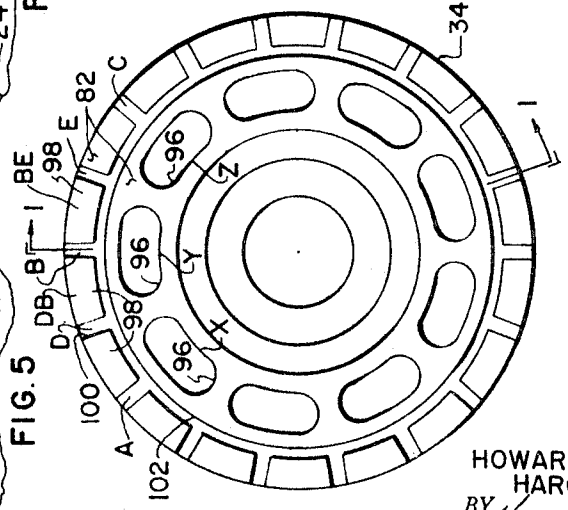


FIG. 3

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PUMPING CHAMBER DECOMPRESSION

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U.S. Cl. 103—162 2 Claims

ABSTRACT OF THE DISCLOSURE

A fluid pressure energy translating device having a high pressure port and a low pressure port separated by a barrier and having a pumping chamber which communicates first with the high pressure port; then is isolated from the high and low pressure ports by the barrier and then communicates with the low pressure port. The pumping chamber being connected to low pressure momentarily while isolated from both ports to decompress the high pressure fluid trapped in the pumping chamber resulting from its prior communication with the high pressure port.

BACKGROUND OF THE INVENTION

This invention pertains to power transmission and is particularly applicable to fluid pressure energy translating devices and specifically to those of the type commonly referred to in the art as hydraulic piston pumps. More specifically, this invention pertains to a unique pump construction of decompressing the pumping chamber prior to its communication with the low pressure inlet port while the pumping chamber moves from the high pressure port to the low pressure port. Pumps of this general classification, when operated at an atmospheric inlet pressureization condition, are subject to what may be termed flow saturation. That is, as pump speed increases the fluid flow rate from the pump increases proportionately until a predetermined speed is reached at which the rate of increase in fluid flow begins decreasing rapidly, even though pump speed continues increasing. Flow saturation occurs as a result of inadequate filling of the pumping chamber with inlet fluid and consequently results in a proportionate reduction in output fluid flow. For instance, as each pumping chamber moves from the high pressure outlet port to the low pressure inlet port, it passes through a region wherein the pumping chamber is isolated from both ports. While in this region, the fluid within this pumping chamber remains at a pressure level substantially equal to the outlet fluid pressure. When the pumping chamber first communicates with the low pressure fluid within the pumping chamber surges into the inlet port creating considerable turbulence within the pumping chamber surges into the inlet port creating considerable turbulence within the inlet port cavity. This turbulence disrupts the incoming flow of inlet fluid and thus prevents adequate filling of the inlet port and pumping chamber. At low pump speeds this effect is practically unnoticeable because the time interval during which the pumping chamber is in communication with the inlet port is such that the turbulence within the inlet cavity is dissipated and adequate filling of the inlet port and pumping chamber is substantially achieved. However, as pump speed increases, this time interval proportionately decreases and eventually reaches a critical point at which this turbulence prevents adequate filling of the pumping chamber, thus producing the characteristic referred to as flow saturation. This characteristics is further exaggerated when the outlet fluid pressure is increased. Decompression of the pumping chamber prior to communication with the inlet port substantially alleviates this problem and permits higher pump speed operation.

The prior art discloses pump construction of various types which decompresses the pumping chamber. One such method is the use of a V-shaped metering groove starting at the entrance to the inlet port, which gradually enlarges in cross-sectional area as it approaches the inlet port. This allows fluid trapped in the pumping chamber to be slowly metered from the pumping chamber into the inlet port, thus gradually decompressing the pumping chamber prior to its communication with the inlet port. Another method, as shown in P.N. 2,619,041 issued to E. H. Born, discloses a passage in the valve block which extends from the valving surface of the valve plate in the region of the barrier separating the high and low pressure ports to the inlet port. Thus, as the pumping chamber moves across the barrier in the region of the passage, the pumping chamber is decompressed by allowing fluid to flow through the passages into the inlet port. These methods, however, fail to alleviate the problem of flow saturation, in that the fluid used to decompress the pumping chamber still flows into the inlet port causing turbulence and thus disrupting the flow of inlet fluid to the pumping chamber. Another method which is used primarily on radial piston type units, as disclosed in P.N. 2,075,017 issued to E. Benedek, employs a fixed volume cavity between the high and low pressure ports which functions as an accumulator for providing predetermined, precompression pre-expansion of the pumping chamber between the exhaust and intake strokes. This method does not sufficiently decompress the pumping chamber prior to communication with the inlet port and consequently the same basic problem results.

An object of this invention is to increase the speed range of a fluid pump operating at elevated discharge pressures to approximate the speed range of a fluid pump operating at reduced discharge pressures without experiencing a substantial loss in its volumetric efficiency when operated with low inlet pressurization.

Another object of this invention is to provide a fluid pump with simple means for decompressing the pumping chamber as it moves from the high pressure port to the low pressure port.

A further object of this invention is to precisely control the period of decompression while the pumping chamber is out of communication with the high and low pressure ports.

Another object of this invention is to provide a fluid pump with passage means which communicates with the pumping chamber as the pumping chamber moves between the high and low pressure ports and simple valving means which normally closes the passage means but which momentarily opens the passage means to connect the pumping chamber to a low pressure region disassociated from the low pressure port.

A further object of this invention is to arrange the passage means with a spaced relationship with respect to the high and low pressure ports and arrange the valving means with a spaced relationship with respect to the pumping chamber such that the distance between the high and low pressure ports may be minimal.

In the drawings:

FIG. 1 is a longitudinal transverse sectional view of a device embodying the present invention.

FIG. 2 is a view taken along the line 2—2 in FIG. 1.

FIG. 3 is a view taken along line 3—3 in FIG. 1.

FIGS. 4 and 5 are fragmentary views of FIG. 2.

Referring now to FIG. 1, the embodiment of the invention selected for illustration comprises a fluid pressure energy translating device **10** having a housing **12**

and a valve block **14** secured thereto by mounting bolts **16**. The dowel **18** maintains proper angular alignment between the valve block **14** and the housing **12**. The valve block **14** has a valving surface **20** having arcuate shaped high and low pressure ports **22** and **24** illustrated in FIG. 2. The portions of the valving surface between these ports constitute barriers **25** and **27**. High pressure port **22** and low pressure port **24** are individually connected by suitable passages, not shown, for fluid communication to external outlet and inlet ports **26** and **28**, respectively.

The housing **12** has a longitudinal bore **30** providing a case chamber **32** containing a rotatable cylinder block **34** positioned therein. A case drain port **33** is provided for the removal of fluid from case chamber **32** which may accumulate during the operation of the device **10**. Drain port **33** may be connected by suitable conduit means to a reservoir, not shown. Cylinder block **34** has a plurality of cylinders **36** in which pistons **38** are fitted for reciprocal motion to form pumping chambers **39**. The pistons **38** have spherical ends **40** on which are swaged socketed shoes **42**. The cylinder block **34** is positioned axially between the valve block **14** and a thrust plate **46** which, in turn, is mounted on a cylindrical thrust block **45** having an inclined surface **47** and attached there to by means not shown. Thrust block **45** is secured to shoulder **49** forming the bottom of bore **30** by means not shown. The shoes have outwardly extending flanges **48** which are contacted by an angular cage **50** provided with holes **52** corresponding to each piston **38**. The cage **50** has a truncated conical bore **58** which contracts a spherical outer surface **60** of a collar **62** which is provided with a female spline **63** to engage a male spline **64** on a drive shaft **66**.

A spring **68** is positioned in a central recess **70** in cylinder block **34**. One end of spring **68** acts against a washer **72** and a snap ring **74** in cylinder block **34**. The other end of spring **68** is exerted against a washer **76** which abuts a plurality of push rods **78** extending axially through holes **80** in cylinder block **34** into engagement with collar **62**. The force exerted by spring **68** thus brings the valving face **82** of cylinder block **34** into engagement with face **20** of valve plate **14** and also biases the shoes **42** into engagement with the face **84** of thrust plate **46**.

Drive shaft **66** is supported between bearings **86** and **88** and is effective to transmit torque from a prime mover, not shown, to the cylinder block **34** having a female spline **90** which engages the male spline **64**, thus forming a driving connection at **92**. A conventional shaft seal is provided at **94**.

Each cylinder **36** has a cylinder port **96** as shown in FIGS. 1 and 3. Referring to FIG. 3, a plurality of Kingsbury pads **98**, radially disposed at the outer edge of the cylinder block valving face **82**, are formed by a plurality of radial recesses or slots **100** and a circular groove **102**. Slots **100** are centrally located with respect to each cylinder port **96** and between each adjacent cylinder port. For instance, the slots **100** designated A, B, and C are centrally located with respect to the cylinder ports **96** designated X, Y, and Z; and slots **100** designated D and E are centrally located between cylinder ports **96** designated X and Y, and Y and Z, respectively. For convenience of explanation, the Kingsbury pads **98** adjacent slot B are designated DB and BE. A passage **104** is formed in valve block **14** by an entrance passage **106** perpendicular to the valving surface **20** and an exit passage **108** inclined to the valving surface **20**. Passage **106**, as shown in FIG. 2, is located in the valving surface barrier **25** at a point midway between the high and low pressure ports **22** and **24**. Passage **108** is located radially outwardly of passage **106** and extends from the valving surface **20** in the region where the Kingsbury pads **98** contact the valving surface **20**. The width of the slots **100** is substantially the same as the diameter of the exit passage **108**.

Referring to FIG. 2, a portion of cylinder block valving face **82**, illustrated by the dotted lines, is superimposed upon the valve block valving surface **20** to show the relative relationship of the cylinder ports **96**, the Kingsbury pads **98** and the slots **100** with respect to the high and low pressure ports **22** and **24** and the entrance and exit passages **106** and **108**. FIG. 4 and FIG. 5 are fragmentary portions of FIG. 2 illustrating the position of the cylinder block **34** rotated slightly clockwise and counterclockwise, respectively, from that illustrated in FIG. 2.

In operation, considering the device disclosed to be used as a fixed displacement pump, the external outlet port **26** is connected to a suitable load device such as a fluid motor, not shown, and external inlet port **28** is connected to a reservoir at atmospheric pressure, not shown. Thus the fluid supplied to the external inlet port **28** is substantially at atmospheric pressure. Rotation of shaft **66** drives cylinder block **34** relatively to the stationary valve block **14**. Referring to FIG. 2 with the shaft **66** and cylinder block **34** being rotated in a counterclockwise direction, fluid enters the external port **28** and flows to port **24**. As the cylinders **36** circumscribes the arc corresponding to port **24**, the pistons **38** move away from the valve block **14** allowing fluid from port **24** to fill the pumping chamber **39**. This is commonly referred to as the inlet or suction stroke of the pump. Conversely, as the cylinders **36** circumscribes the arc corresponding to port **22**, pistons **38** move toward the valve block **14** forcing fluid out of the pumping chamber **39** through port **22** to external port **26**. This is commonly referred to as the outlet or exhaust stroke of the pump. The outlet fluid pressure, of course, depends upon the requirement posed by the load device connected to the external outlet port **26**, and may be in the magnitude of 3000 p.s.i.

As each cylinder port **96** moves out of communication with the high presusre port **22** toward the low pressure port **24** across the barrier **25**, the fluid remaining within the pumping chamber **39** remains at substantially outlet pressure. Ordinarily, this fluid would be discharged into the low pressure port **24** when the pumping chamber **39** initially communicates with the low pressure port at a relatively high velocity thus causing considerable turbulence within the low pressure port. This turbulence is especially undesirable when the pressure of the fluid supplied to the external inlet port **28** is approximately 14.7 p.s.i. or substantially atmospheric pressure, in that this turbulence obstructs the flow of inlet fluid into port **24** and consequently prevents proper filling of the pumping chamber **39**. This results in a noticeable decrease in the volumetric efficiency of the pump when operated at high speeds.

This undesirable result is alleviated by decompressing the pumping chamber **39** prior to its communication with the low pressure port **24** through passage **104** to cavity **32**. However, to maintain a high volumetric efficiency of the pump while decompressing the pumping chamber **39**, direct communication between the high pressure port **22** or the low pressure port **24** and cavity **32** must be prevented and the period of decompression should be minimal.

As the drive shaft **66** drives the cylinder block **34** in a counterclockwise direction, each cylinder port **96**, successively, moves from the high pressure port **22** across the barrier **25** to the low pressure inlet port **24**.

Referring now to FIG. 4, which illustrates the position of the cylinder block just prior to decompression of the pumping chamber **39**. Cylinder port Y first communicates with entrance passage **106** while still in communication with high pressure port **22**. Kingsbury pad BE, however, blocks exit passage **108**, thus preventing direct communication between the high pressure port **22** and cavity **32**. When cylinder port Y rotates to the position shown in FIG. 4 an intermediate condition exists for an instant when the cylinder port is out of communication with port **22** and Kingsbury pad BE still blocks exit passage **108**. As the

cylinder port Y continues moving, the edge of Kingsbury pad BE forming one side of slot B gradually uncovers exit passage **108** communicating cylinder port Y with cavity **32**. When the cylinder block **34** rotates to the position shown in FIG. 2, slot B fully uncovers the exit passage **108**. As the cylinder port Y continues moving the edge of Kingsbury pad DB, forming the other side of slot B, gradually blocks exit passage **108**. When the cylinder block **34** rotates to the position shown in FIG. 5, the exit passage is completely covered by the Kingsbury pad DB, thus preventing further communication between cylinder port Y and cavity **32**. At this point cylinder port Y is not yet in communication with the low pressure port **24**. As the cylinder block **34** continues to rotate, cylinder port Y communicates with the inlet port **24** while remaining in communication with entrance passage **106**. However, communication between inlet port **24** and cavity **32** is prevented by Kingsbury pad DB blocking exit passage **108**.

While the cylinder block rotates from the position illustrated in FIG. 4 to that position illustrated in FIG. 5, the fluid pressure within pumping chamber **39** is decompressed to a value substantially equal to the fluid pressure within cavity **32**, which in turn is substantially equal to the atmospheric pressure of fluid in the reservoir.

After the pump chamber has been decompressed, the pressure of the fluid in the pumping chamber **39** and in the low pressure inlet port **24** are substantially equal. Thus, as the cylinder port **96** continues to rotate and communicates with the low pressure port **24** there is no sudden surge of fluid flow from the pumping chamber **39** to the low pressure port **24** to cause turbulence, thereby allowing proper filling of the pumping chamber during the suction stroke and increased flow capability at increased operating speed of the pump. The preceding explanation of the invention applies equally for either direction of rotation of the drive shaft **66**.

Although the description of the invention contained herein pertains to a fixed displacement pump, the invention is equally applicable to a variable displacement pump. Also, by employing another passage identical to passage **104** but diametrically opposed to that shown, the invention herein disclosed is made applicable to a variable displacement pump in which the thrust plate **46** is rotatable to inclined positions on opposite sides of a center position for alternating the inlet and outlet port.

It will thus be seen that the invention herein disclosed provides a unique means for improving the speed and flow capability of a fluid pressure energy translating device when operated at elevated outlet pressures and at a depressed or atmospheric inlet pressurization to approximate the speed range and flow capability of a device operating at a low discharge pressure without a substantial loss in volumetric efficiency by decompressing the pumping chamber while it is out of communication with the high and low pressure ports.

It will further be seen that this invention provides a unique means of decompressing the pumping chamber so as to not appreciably effect the volumetric efficiency of the device by precisely controlling the decompression period. More specifically, it will be seen that this invention concerns the use of a passage which communicates with the pumping chamber of the device as the pumping chamber moves from the high to low pressure ports and valving means comprising the Kinsbury pads and slots therebetween to momentarily open the passage to thereby relieve the fluid pressure within the pumping chamber when the pumping chamber is out of communication with the high and low pressure ports, by providing a fluid flow path between the pumping chamber and the interior of the device.

What is claimed is as follows:

1. In a fluid pressure energy translating device comprising a stationary valve member having a valving surface with high and low pressure ports separated by a barrier, a rotary cylinder barrel having a valve face juxtaposed against said valving surface, said barrel having a plurality of radially disposed cyclically contracting and expanding pumping chambers exposed to said face and movable relative to said valve member such that each chamber successively communicates first with said high pressure port, then isolated from both of said ports by said barrier, and then communicates with said low pressure port, that improvement comprising: passage means having an entrance and an exit, said entrance of said passageway means being located in said barrier in said valve surface midway between said high and said low pressure ports, said chamber communicating with said entrance before said chamber moves out of communication with said high pressure port and remaining in communication with said entrance until after said chamber communicates with said low pressure port, and a plurality of Kingsbury pads arranged on said valving surface of said barrel and slots separating said pads, said Kingsbury pads and slots being disposed radially from said chamber, said slots between said Kingsbury pads being centrally located with respect to said chamber, said exit of said passage being radially disposed from said entrance in said valving surface in a region contacted by said Kingsbury pads and slots and said exit having a width less than the width of said slot, said Kingsbury pads normally blocking said exit and movable relative to said exit so as to momentarily open said exit to each slot to provide limited communication between said chamber and a low pressure region disassociated with said low pressure port for decompressing said chamber while said chamber is out of communication with said high and low pressure ports.

2. The combination, as defined in claim **1**, wherein said barrier has a width substantially equal to twice the width of said slot plus the width of said chamber, whereby the width of said barrier is minimal.

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