Dec. 31, 1968 J. S. CARDILLO ET AL 3,418,937

RADIAL PISTON PUMP

Filed Nov. 4, 1966 Sheet 1 of 3

Fig. 1

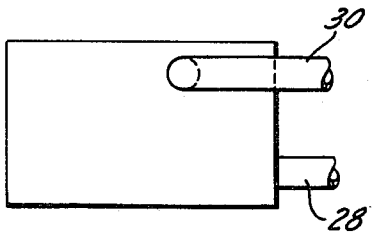


Fig. 2

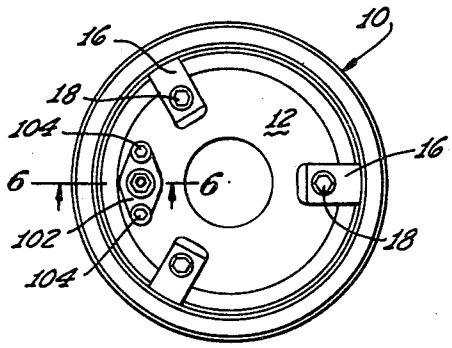
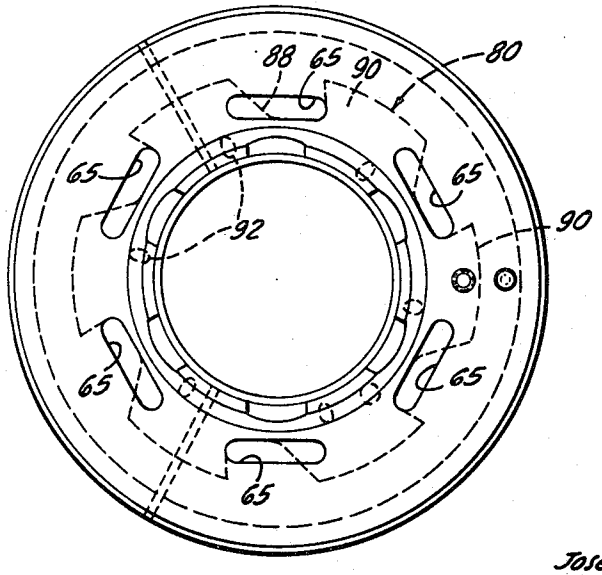


Fig. 5



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Filed Nov. 4, 1966 Sheet 2 of 3

Fig. 3

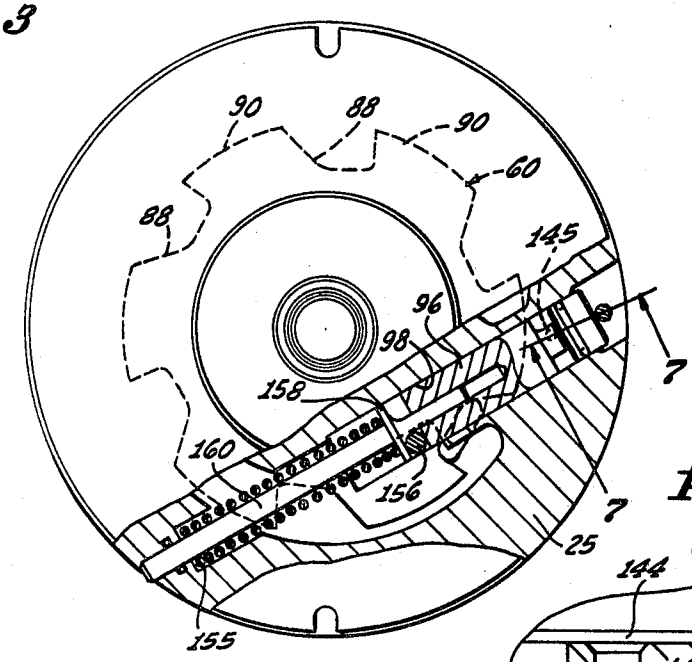


Fig. 7

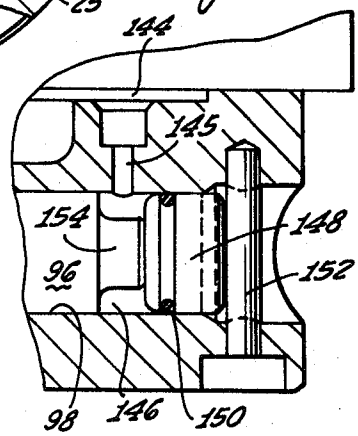
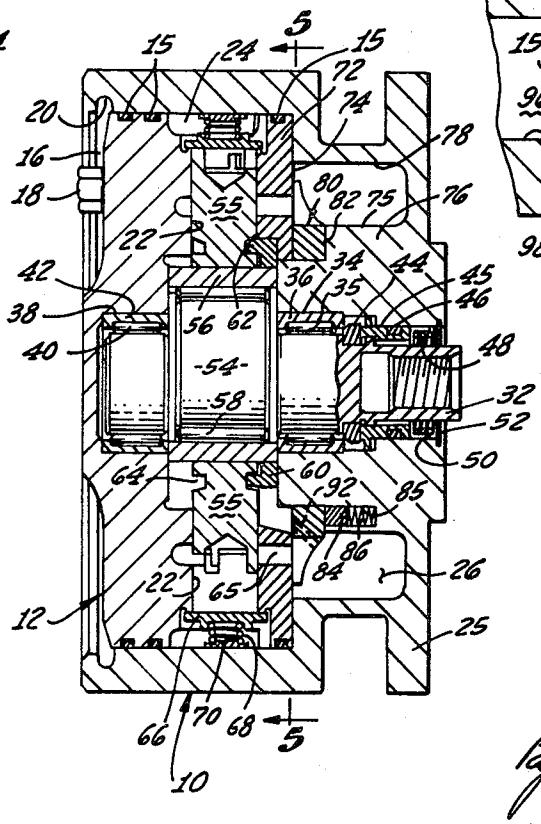


Fig. 4



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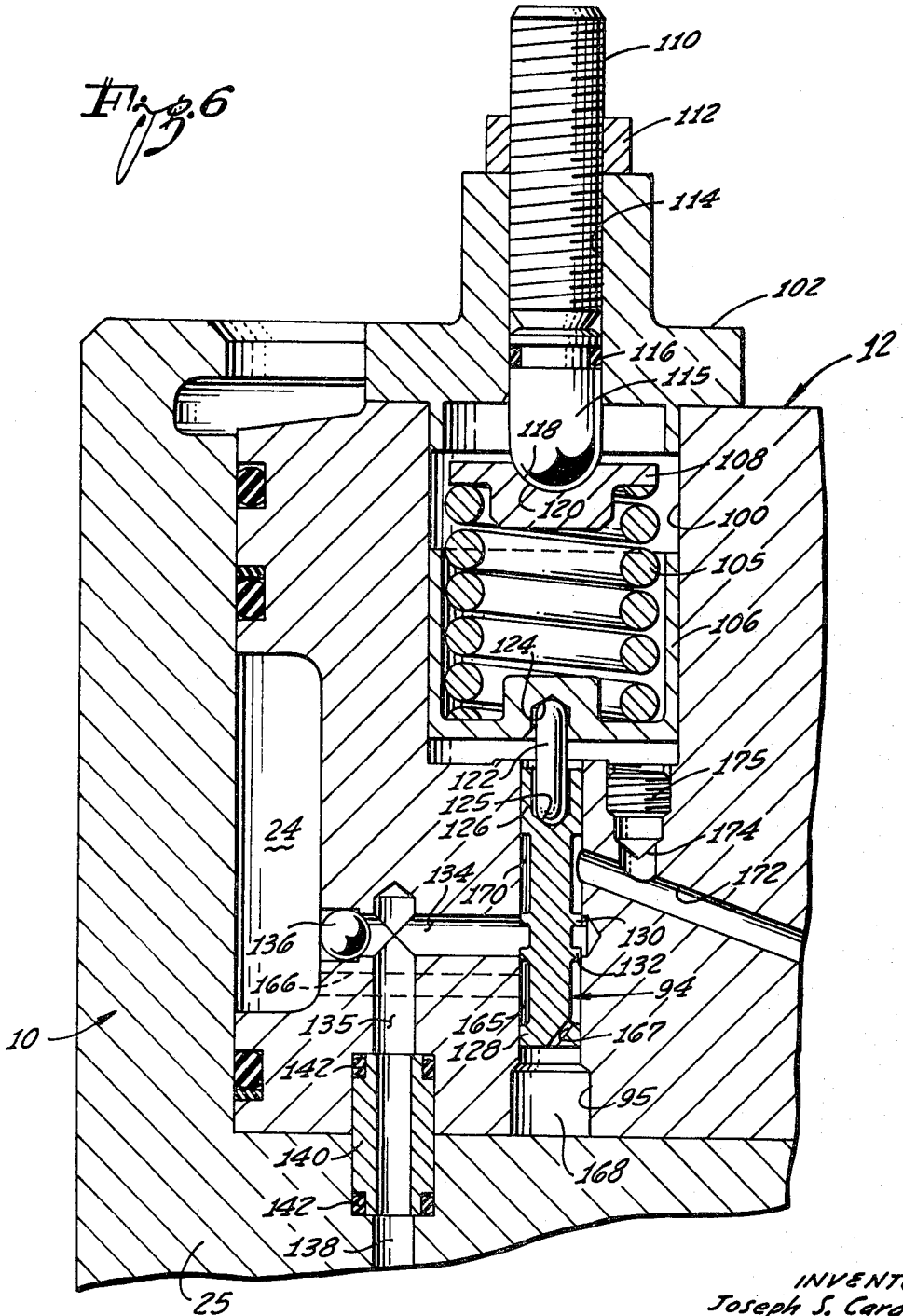
Filed Nov. 4, 1966 Sheet 3 of 3

Fig. 6



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RADIAL PISTON PUMP

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2 Claims. (Cl. 103—39)

ABSTRACT OF THE DISCLOSURE

In a radial piston pump an annular low pressure manifold is immediately adjacent the radial cylinders and is separated from the cylinders solely by a radial wall having apertures to serve as intake ports so that the distance of fluid flow from the low pressure manifold into the cylinders is merely the thickness of the radial wall. A rotary throttling valve with a planar face abutting the radial wall has spaced masking parts cooperative with the intake ports to variably restrict intake flow into the cylinders.

This invention relates to a pump of the type having a plurality of radial cylinders drawing fluid from a low pressure intake manifold and discharging the fluid into a high pressure output manifold. The invention is primarily directed to the problem of varying the intake flow into the pump cylinders for the purpose of controlling the pump output. In the preferred practice of the invention the intake flow to the radial cylinders is controlled automatically for the purpose of keeping the output pressure substantially constant under conditions of changing output demand. For example, the pump may be incorporated in a hydraulic system of a tractor where substantially constant pressure is desirable as the demand on the pump is varied by intermittent operation of various hydraulic power cylinders.

It is old in the art to employ some kind of adjustable valve arrangement to variably restrict the intake into the cylinders of a radial piston pump. In one prior art pump, for example, a cylindrical throttling valve rotatably embraces a radial array of intake passages and is apertured to variably mask the entrances to the intake passages. Thus the cylindrical throttling valve member may be adjustably rotated about its axis to variably restrict flow into all of the intake passages simultaneously.

It has been found that, for a number of reasons, the mass of liquid must be minimized that is confined in the intake passages between the throttling valve and the radial pistons in the radial cylinders. The basic difficulty in the prior art pumps such as the above described pump, is that the intake passages between the throttling valve and the intake ports of the cylinders are necessarily long because of the configuration of the valve-and-passage arrangement.

Since the intake passages are relatively long, the requirement that the mass of liquid therein be minimized can be met only by severely reducing the cross section of the intake passages. In fact, the cross-sectional dimensions of the relatively long intake passages are so thin that the intake passages are comparable to clearance spaces. The resistance to flow through such relatively long and severely restricted intake passages is exceedingly high and consequently satisfactory flow into the intake passages requires an auxiliary gear pump to boost the intake flow.

The present invention avoids this basic difficulty and at the same time simplifies the construction of a radial piston pump by, in effect, eliminating the relatively long intake passages from the low pressure manifold to the radial cylinders. In the construction taught by the present invention, the low pressure manifold is in direct communication with the radial cylinders through the intake ports.

To accomplish this elimination of long intake passages to the individual cylinders, the intake ports are in a wall that separates the low pressure manifold from the radial cylinders and a rotatably adjustable throttling valve is mounted inside the low pressure manifold to cooperate with the intake ports. Portions of the throttling valve normally partially overlap the intake ports so that the valve may be rotatably adjusted to vary the flow into all of the intake ports simultaneously.

In the preferred practice of the invention, the radial pistons are moved radially outward in a well known manner by means of an eccentric and a piston retainer operated by the same eccentric returns the pistons radially inwardly. The retainer is moved in a circular orbit by the eccentric and is formed with a circumferential flange which engages the heads of the radial pistons for the return movement of the pistons.

A feature of the invention is that the pump body comprises the combination of a one-piece housing and a cylinder block that provides the radial cylinders, the housing having a cavity to receive the cylinder block. The housing has a relatively thick base portion adjacent the bottom of the cavity and a concentric annular low pressure intake manifold is formed in the base portion. The rotatably adjustable throttling valve is interposed between the cylinder block and the bottom of the cavity in the pump housing. This arrangement simplifies assembly of the pump and at the same time results in a compact pump configuration with minimum sealing problems.

In the preferred practice of the invention, means is provided for automatic adjustment of the rotary throttling valve to maintain substantially constant output pressure under conditions of varying output demand. Thus with an output pressure on the order of 2,000 p.s.i., it is contemplated that the pressure will be maintained constant within a tolerance of 50 p.s.i. Automatic control of the throttling valve is accomplished by operatively connecting the throttling valve to a movable wall in the form of a control piston that responds to variations in the volume of confined body of control fluid. A suitable pilot valve regulates the volume of the confined control fluid in response to variations in the pressure in the high pressure manifold of the pump. A feature of the invention is that this control arrangement is incorporated in the pump in a compact manner by placing the pilot valve in the cylinder block between two of the radial cylinders and by placing the control piston in the thick base portion of the housing in the same radial plane as the annular low pressure manifold.

The features and advantages of the invention may be understood from the following detailed description and the accompanying drawings.

In the drawings, which are to be regarded as merely illustrative:

FIG. 1 is a side elevation of a preferred embodiment of the invention;

FIG. 2 is a plan view of the same embodiment;

FIG. 3 is a bottom view on a larger scale with portions broken away to show how the control piston is operatively connected to the rotary throttling valve;

FIG. 4 is an axial cross section of the pump;

FIG. 5 is a transverse sectional view of the pump taken along the line 5—5 of FIG. 4 with the throttling valve shown in phantom;

FIG. 6 is a greatly enlarged radial section showing how the pilot valve is incorporated in the pump block; and

FIG. 7 is a fragmentary section along the line 7—7 of FIG. 3.

Referring to the drawings, the body of the radial piston pump comprises a housing, generally designated **10**, and a cylinder block generally designated **12**, the housing forming a cylindrical cavity **14** in which the cylinder block is

fixedly seated and sealed by suitable O-rings **15**. The cylinder block may be releasably retained in the cylindrical cavity **14** by suitable means such as three radial keepers **16** that are anchored to the pump block by cap screws **18** with the keepers engaging an inner circumferential groove **20** of the pump housing.

The cylinder block **12** forms six radial cylinders **22** and cooperates with the surrounding pump housing to form an annular high pressure manifold **24**. The pump housing has a relatively thick base portion **25** adjacent the bottom of the cavity **14** and this base portion forms a concentric annular low pressure manifold **26**. As shown in FIG. 1, a low pressure intake pipe **28** is connected to a radial port of the low pressure manifold and in like manner a high pressure output pipe **30** is connected to a radial port of the high pressure manifold **24**.

As shown in FIG. 4, a portion of a drive shaft **32** is journalled in a bore **34** of the housing **10** by rollers **35** in cooperation with a surrounding race **36** and the end portion of the drive shaft is journalled in a cylindrical cavity **38** of the block **12** by similar rollers **40** and a surrounding race **42**. The drive shaft **32** may be sealed by a sealing ring **44** that rotates with the shaft in cooperation with an abutting sleeve **45** that carries an O-ring **46**. The sleeve **35** is urged against the sealing ring **44** by a coil spring **48** that backs against a spring seat **50** which in turn backs against a snap ring **52**.

Between the two races **36** and **42**, the drive shaft **32** is formed with an eccentric **54** to cooperate with radial pistons **55** in the radial cylinders **22** in a well known manner, the eccentric functioning to drive the pistons radially outward in sequence. In the construction shown, a race in the form of a cylindrical sleeve **56** acts directly on the radial pistons, the cylindrical sleeve being mounted on the eccentric **54** by suitable spaced rollers **58**.

Preferably a suitable retainer **60** cooperates with the eccentric **54** to return the pistons **55** radially inwardly. The retainer **60** may be in the form of a ring that embraces the cylindrical sleeve **56**, the ring being formed with a peripheral flange **62** that engages circumferential grooves **64** in the pistons.

Each of the six radial cylinders **22** is provided with a corresponding lateral intake port **65** and, as shown in FIG. 5, the intake ports **65** are preferably elongated and arranged tangentially to a circle that is concentric to the axis of the pump. The outer end of each of the radial cylinders **22** is countersunk to form a seat for a corresponding outlet valve **66**, the periphery of the outlet valve being provided with notches (not shown) for free flow of fluid past the periphery of the valve when the valve is unseated. In the construction shown, each of the outlet valves **66** is biased towards its closed position by a corresponding coil spring **68** in the high pressure manifold **24**, the coil spring backing against a suitable spring guide **70**.

As may be seen in FIG. 4, the cylinder block **12** forms a radial wall **72** that separates the radial cylinders **22** from the low pressure manifold **26**, the radial wall having a planar surface **74** which is an inner surface of the low pressure manifold. The previously mentioned intake ports **65** are apertures in the radial wall **72** spaced apart in the same radial zone as the radial cylinders. The low pressure manifold **26** has two concentric inner surfaces, namely an inner circumferential surface **75** which defines a hub **76** and a second concentric surface **78** that is spaced radially outward from the surface **75**.

It is contemplated that the throttling valve for variably restricting the intake ports **65** will be in the form of a ring member associated with one of the two surfaces **75** and **78**. In this instance the throttling valve is in the form of a ring **80** that is journalled on the hub **76**, the ring being mounted on a radial shoulder **82** of the hub. Thus the whole of the throttling valve **80** is mounted inside the low pressure manifold **26**. To hold the throttling valve **80** snugly against the planar surface **74** of the radial wall **72**, a plurality of equally circumferentially spaced pressure blocks **84** may be mounted in suitable bores **85** in the hub **76**, each pressure block being under the pressure of a corresponding spring **86**.

The periphery of the throttling valve **80** is formed with six wide notches **88**, as best shown in FIG. 5, which define six peripheral wings or masking portions **90**. As indicated in phantom in FIG. 5, the peripheral masking portions **90** of the ring-shaped valve **80** normally partially overlap the elongated intake ports **65** so that the throttling valve may be adjustably rotated to restrict flow through the six intake ports simultaneously. Preferably, as may be seen in FIG. 4, the masking portions **90** of the throttling valve **80** are tapered in radial section. It is also contemplated that the regulating valve **80** will be provided with a plurality of equally circumferentially spaced inclined ports **92** as indicated in FIGS. 4 and 5 to permit fluid from the low pressure manifold **26** to splash into the region of the retainer **60** for the purpose of lubricating moving parts in this region.

It is apparent that rotation of the throttling valve **80** in one direction will reduce intake flow into all of the radial cylinders **22** and rotation in the opposite direction will increase the intake flow.

The ring-shaped throttling valve **80** may be controlled in any suitable manner and conceivably may be manually controlled. As heretofore indicated, in this particular embodiment of the invention it is contemplated that the throttling valve **80** will be controlled automatically to maintain substantially constant pressure in the high pressure manifold **24**. For this purpose, a pilot valve, generally designated **94** in FIG. 6, is mounted in a bore **95** in the cylinder block **12** and a cooperating movable wall in the form of a piston **96** (FIG. 3) is mounted in a transverse bore **98** in the base portion **25** of the pump housing **10**.

In the pilot valve arrangement shown in FIG. 6, a cylindrical cavity **100** on the outer side of the cylinder block **12** is closed by a removable plug **102** that is anchored to the cylinder block by a pair of cap screws **104** shown in FIG. 2. A heavy spring **105** seats in a slidable cup **106** in the cavity **100** with the outer end of the spring backing against a spring seat **108**.

A socket head adjustment screw **110** provided with a lock nut **112** is threaded into a threaded portion of an auxiliary bore **114** in the plug **102** and adjustably abuts a plunger **115**. The plunger **115** is slidingly mounted in a smooth portion of the axial bore and is provided with an O-ring **116**. The inner end of the plunger **115** is formed with a spherically curved nose **118** that seats in a spherical socket **120** in the spring seat **108**. It is apparent that the heavy spring **105** may be variably stressed in compression by adjustment of the screw **110** against the plunger **115**.

The previously mentioned pilot valve **94** is suitably operatively connected to the slidable cup **106** and for this purpose a short pin **122** may be seated at one end in a socket **124** in the slidable cup and may be seated at its opposite end in a socket **125** in the pilot valve.

The pilot valve **94** comprises a spool with two lands **126** and **128** at its opposite ends, respectively, and with two narrow relatively closely spaced central lands **130** and **132** respectively. The two narrow lands **130** and **132** control flow from the bore **95** into a radial bore **134** that is part of a passage that places the pilot valve in communication with the previously mentioned control piston **96**.

In the construction shown, the radial bore **134** is intersected by a bore **135**, the outer end of the radial bore being permanently closed by a ball **136**. The bore **135** in the cylinder block **12** communicates with a similar bore **138** in the base **25** of the pump housing **10**. For the purpose of interconnecting the two bores **135** and **138** in a sealed manner the two bores are counterbored to receive a connecting tube **140** which is provided with two O-rings **142** as shown. The bore **138** connects with other bores (not shown) which lead to a clearance space **144** in FIG. 7 which clearance space in turn communicates with a

small bore **145** that is positioned radially of the previously mentioned bore **98**.

As may be seen in FIG. 7, the bore **145** communicates with a space **146** in the bore **98**, the space **146** being between the previously mentioned control piston **96** and a plug **148** that closes the outer end of the bore **98**. In the construction shown, the plug **148** is provided with an O-ring **150** and backs against a retainer pin **152**. The control piston **98** is formed with a reduced end portion **154** to avoid closing the radial bore **145**.

With the pilot valve **94** in the neutral position shown in FIG. 6, the two narrow lands **130** and **132** of the pilot valve close the end of the radial bore **134** thereby trapping a body of liquid between the pilot valve and the control piston **96**. As shown in FIG. 3 a relatively light spring **155** continuously urges the piston **96** against the confined fluid so that the position of the piston is determined by the volume of the confined fluid. The piston **96** is operatively connected to the rotatable throttling valve **80** in a suitable manner. In the construction shown in FIG. 3, a pin or dowel **156** that is fixedly mounted on the throttle valve **80** is confined between the piston **96** and a radial flange **158** of a spring guide **160**. The previously mentioned spring **155** surrounds the spring guide **160** in abutment against the flange **158** and an axial extension **162** of the spring guide telescopes into an axial bore **164** in the control piston **96**. It is apparent that the control piston **96** acts against the dowel **156** to rotate the regulating valve **60** clockwise as viewed in FIG. 3 to reduce intake flow and that the coil spring **155** when permitted to expand acts on the dowel to rotate the throttling valve counterclockwise to increase intake flow.

The function of the pilot valve **94** is to respond to changes in the pressure in the high pressure manifold **24** by admitting fluid from the high pressure manifold into the bore **134** whenever the pressure in the high pressure manifold drops below a predetermined magnitude and to release fluid from the bore **134** whenever the pressure in the high pressure manifold raises above the predetermined magnitude. The two lands **132** and **128** of the pilot valve define a high pressure annular chamber **165** which is in communication with the high pressure manifold **24** through a bore **166** and the high pressure chamber **165** communicates through an inclined bore **167** which acts on the inner end of the pilot valve **94** to urge the pilot valve towards the heavy spring **105**.

The two lands **126** and **130** of the pilot valve **94** form a low pressure annular chamber **170** which communicates with an inclined lateral relief bore **172** which in turn communicates with the previously mentioned low pressure manifold **26**. A branch **174** of the relief bore **172** communicates with the previously mentioned cavity **100** through a suitable orifice fitting **175**.

In the neutral position of the pilot valve **94** shown in FIG. 6, the land **130** cuts off the radial bore **134** from the annular relief chamber **170** and at the same time the land **132** isolates the radial bore from the high pressure annular chamber **165**. This neutral position of the pilot valve occurs at a predetermined pressure in the high pressure manifold **24** that is governed by the adjustment of the screw **110** against the spring **105**. Under actual operating conditions small pressure pulsations and leakage past the pilot valve cause the pilot valve to hunt with low amplitude reciprocation at a relatively high frequency. Consequently, the pilot valve responds quickly to changes in the discharge pressure.

When the discharge pressure rises above the predetermined pressure, fluid from the high pressure annular chamber **165** is transmitted through the diagonal bore **166** to the space **168** to drive the pilot valve **94** towards the heavy spring **105**. The consequent flow from the high pressure chamber **165** into the bore **134** increases the volume of the confined fluid that determines the position of the control piston **96** and the resulting leftward movement of the control piston **96**, as viewed in FIG. 3, rotates the throttle valve **60** in the direction to reduce flow into the radial cylinders and thereby lower the output pressure. On the other hand, if the output pressure drops below the predetermined value, the pilot valve **94** retreats from the heavy spring **105** to place the bore **134** in communication with the annular relief chamber **170** and relief bore **172** to reduce the volume of the confined fluid that determines the position of the control piston **96**. Accordingly, the control piston shifts in the opposite direction to rotate the throttle valve **60** in the direction to increase the intake flow into the radial cylinders.

What is claimed is:

1. In a pump having radial cylinders and power-actuated pistons therein with the cylinders in communication with a high pressure manifold through outlet ports and in communication with a low pressure manifold through intake ports, the improvement to control the rate of inflow into the cylinders, comprising:

said low pressure manifold extending circumferentially of the pump in a radial zone aligned with the radial zone of the cylinders and immediately adjacent the cylinders;

a radial wall having a planar surface forming part of the low pressure manifold and constituting the sole structure separating the cylinders from the low pressure manifold, the intake ports of the cylinders being spaced apertures in the radial wall in said first mentioned radial zone whereby the distance of fluid flow from the low pressure manifold to the cylinders is the thickness of the radial wall;

a throttling valve having a planar face abutting said planar surface of the radial wall and having spaced masking portions in said radial zone to cooperate with said intake ports, the throttling valve being adjustable to vary the extent to which said masking portions overlap the intake ports to restrict flow therethrough;

the body of the pump comprising a housing and a cylinder block with said cylinders arranged laterally therein, the housing having a base portion and a cavity, said cylinder block being seated in the cavity;

said throttling valve being interposed between the housing and the cylinder block at the bottom of said cavity; and

means responsive to changes in pressure in said high pressure manifold to regulate the position of said throttling valve to decrease the overlap of the intake parts by the masking portions in response to drop in pressure in the high pressure manifold and to increase the overlap in response to rise of the pressure in the high pressure manifold, thereby to minimize the changes in the pressure in the high pressure manifold throughout a range of variations in the rate of fluid discharge by the pump, said responsive means including:

a movable wall operatively connected to the throttling valve;

means including said movable wall to confine a body of fluid, said movable wall being biased against the confined body of fluid whereby the position of the movable wall and therefore the position of the throttling valve depends upon the volume of the confined body of fluid, decrease in the volume of the confined fluid decreasing the overlap of the intake ports by said masking portions and vice versa; and

a pilot valve to place said body of fluid in communication with the low pressure manifold in response to rise of pressure in the high pressure manifold and to place the body of fluid in communication with the high pressure manifold in response to drop in pressure in the high pressure manifold,

said pilot valve being in the cylinder block between two of the radial cylinders,

said movable wall being in the base portion of the housing.

2. In a pump having radial cylinders and pistons therein with the cylinders in communication with a high pressure manifold through outlet ports and in communication with a low pressure manifold through intake ports, the improvement comprising:

a radial wall having a planar surface forming part of the low pressure manifold, said radial wall constituting the sole structure separating the cylinders from the low pressure manifold, said intake ports of the cylinders being spaced apertures in the radial wall whereby the distance of fluid flow from the low pressure manifold to the cylinders is the thickness of the radial wall;

a drive shaft having an eccentric portion to drive said pistons radially outwardly, said eccentric portion extending into said opening in the radial wall;

a retainer in said opening of the radial wall surrounding said eccentric portion of the drive shaft for movement thereby in a circular orbit,

said retainer engaging said pistons to return the pistons radially inwardly; and

a throttling valve having a planar face abutting said planar surface of the radial wall and having circumferentially spaced portions to cooperate with said intake ports, the throttling valve being rotatably adjustable to vary the extent to which said masking portions overlap the intake ports to restrict flow therethrough,

said throttling valve having circumferentially spaced apertures therein placing the low pressure manifold in communication with said opening in the radial wall to provide lubrication for working parts including said retainer.

References Cited

UNITED STATES PATENTS

2,426,100	8/1947	Holden et al.	103—174
2,818,816	1/1958	Christenson	103—174
3,050,004	8/1962	Heintzmann	103—39 X
3,117,529	1/1964	Firth et al.	103—162
3,151,569	10/1964	Muller	103—173
3,185,105	5/1965	Headings et al.	103—162
3,259,074	7/1966	Erdmann	103—174

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U.S. Cl. X.R.

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