United States Patent
Liang et al.

[15] 3,692,432
[45] Sept. 19, 1972

[54] TWO-STAGE POSITIVE DISPLACEMENT PUMP

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[73] Assignee: Ford Motor Company, Dearborn, Mich.

[22] Filed: Dec. 22, 1970

[21] Appl. No.: 100,611

[52] U.S. Cl. 417/286, 417/307
[51] Int. Cl. F04b 49/08
[58] Field of Search 417/286, 307, 311

[56] References Cited

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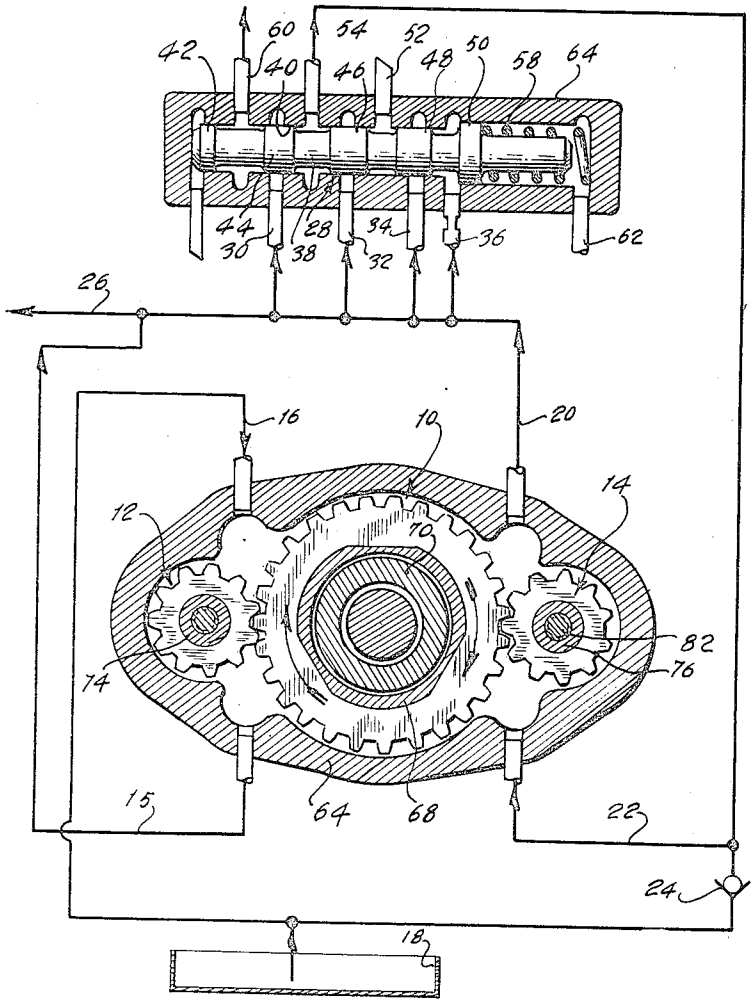
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[57] ABSTRACT

A positive displacement pump comprising a first pumping gear arranged in engagement with second and third pumping gears thereby establishing primary and secondary pump stages; each pump stage being adapted to displace fluid from a low pressure port to a high pressure port, regulator valve means communicating with the high pressure port of each pump for establishing a controlled bypass between said high pressure ports and low pressure fluid supply circuit and a feed-back circuit connecting the inlet side of the secondary pumping stage to the outlet side of said regulator valve means whereby a pressure buildup occurs on said inlet side thereby rendering the secondary pump stage inactive when the driven speed of said pumping gears exceeds a predetermined value, both pumps being active during operation at low speeds and the secondary pump being rendered inactive during operation at high speeds.

7 Claims, 10 Drawing Figures

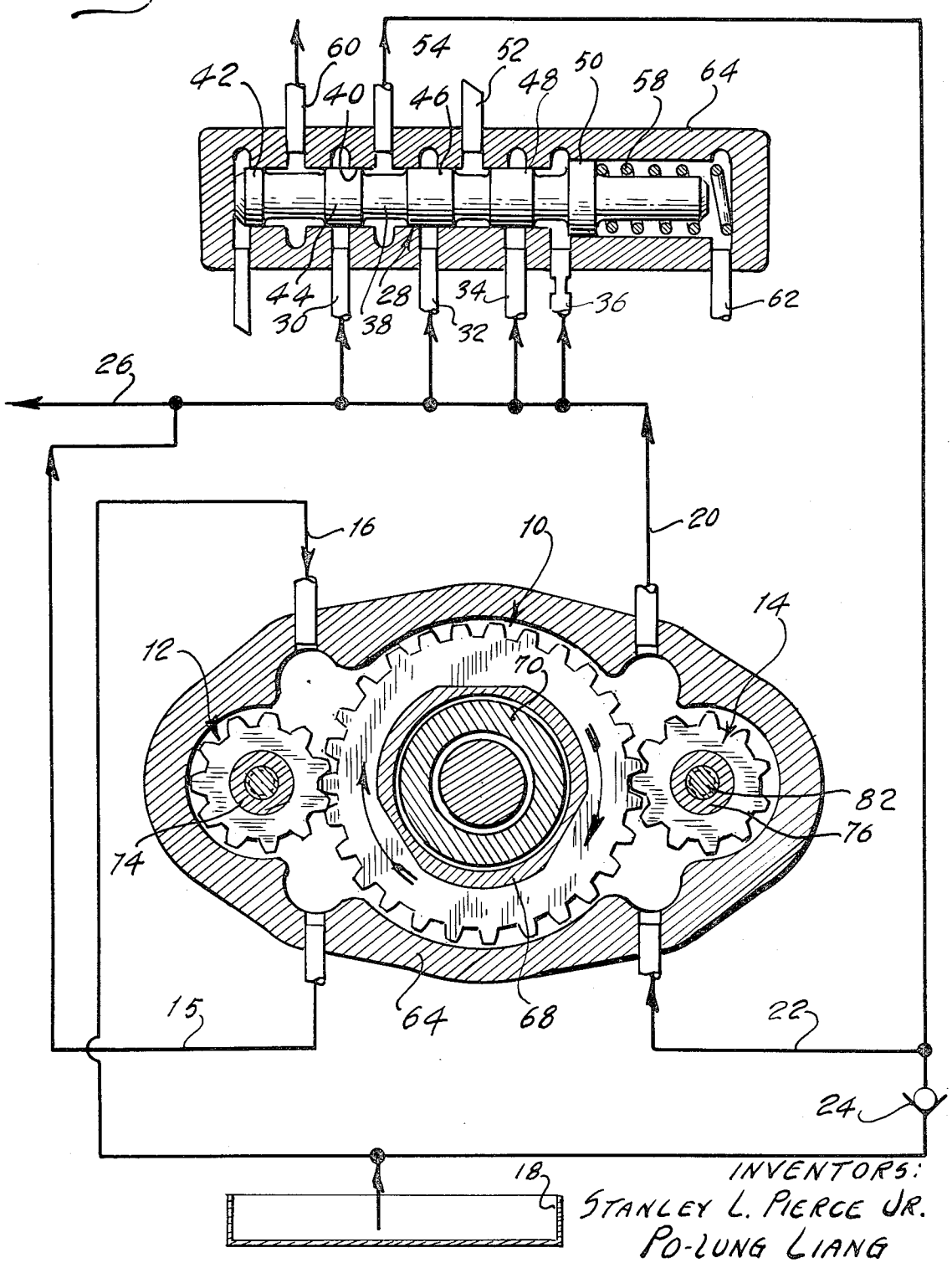


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SHEET 1 OF 7

Fig. 1



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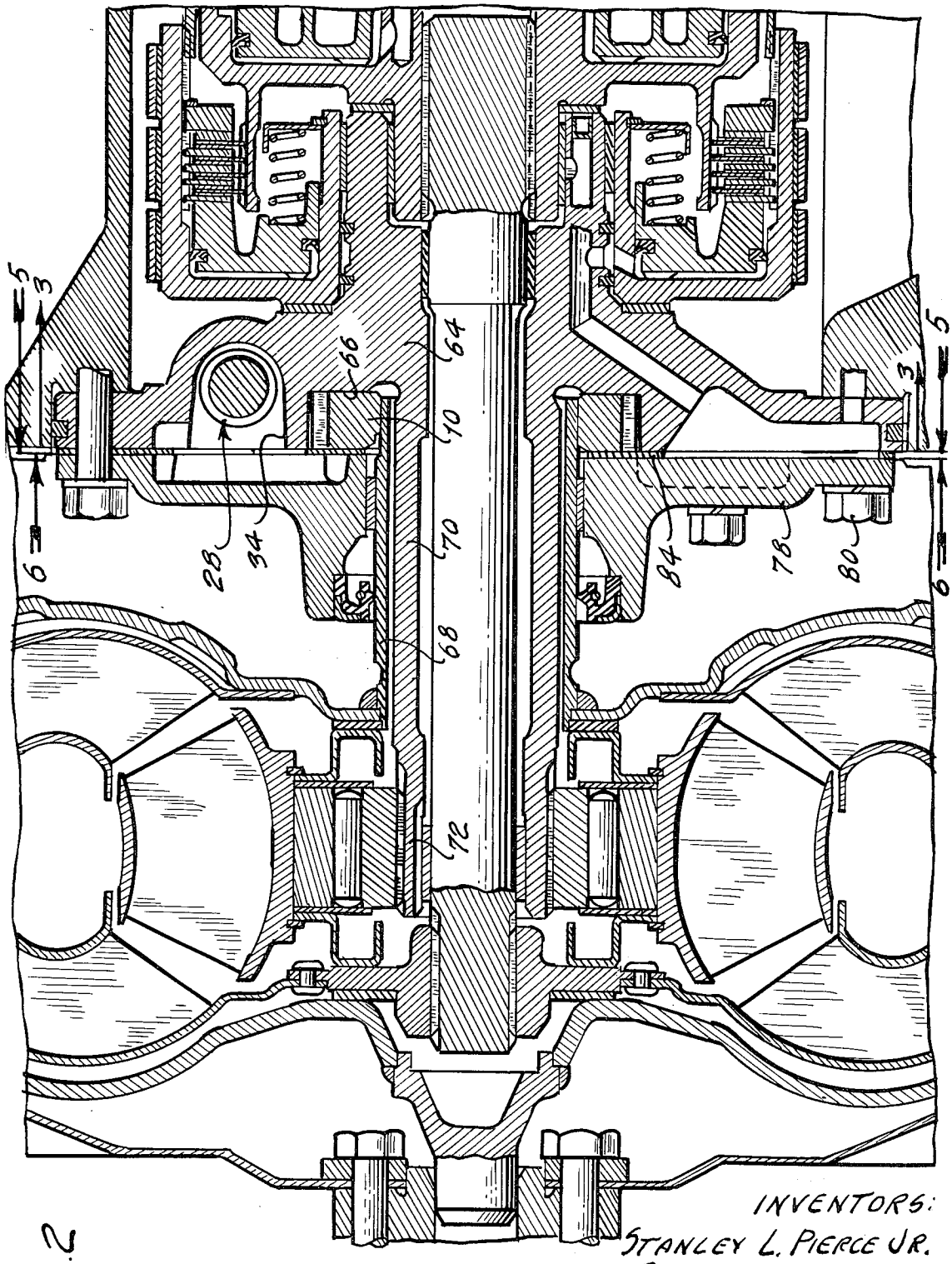


Fig. 2

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Fig. 3

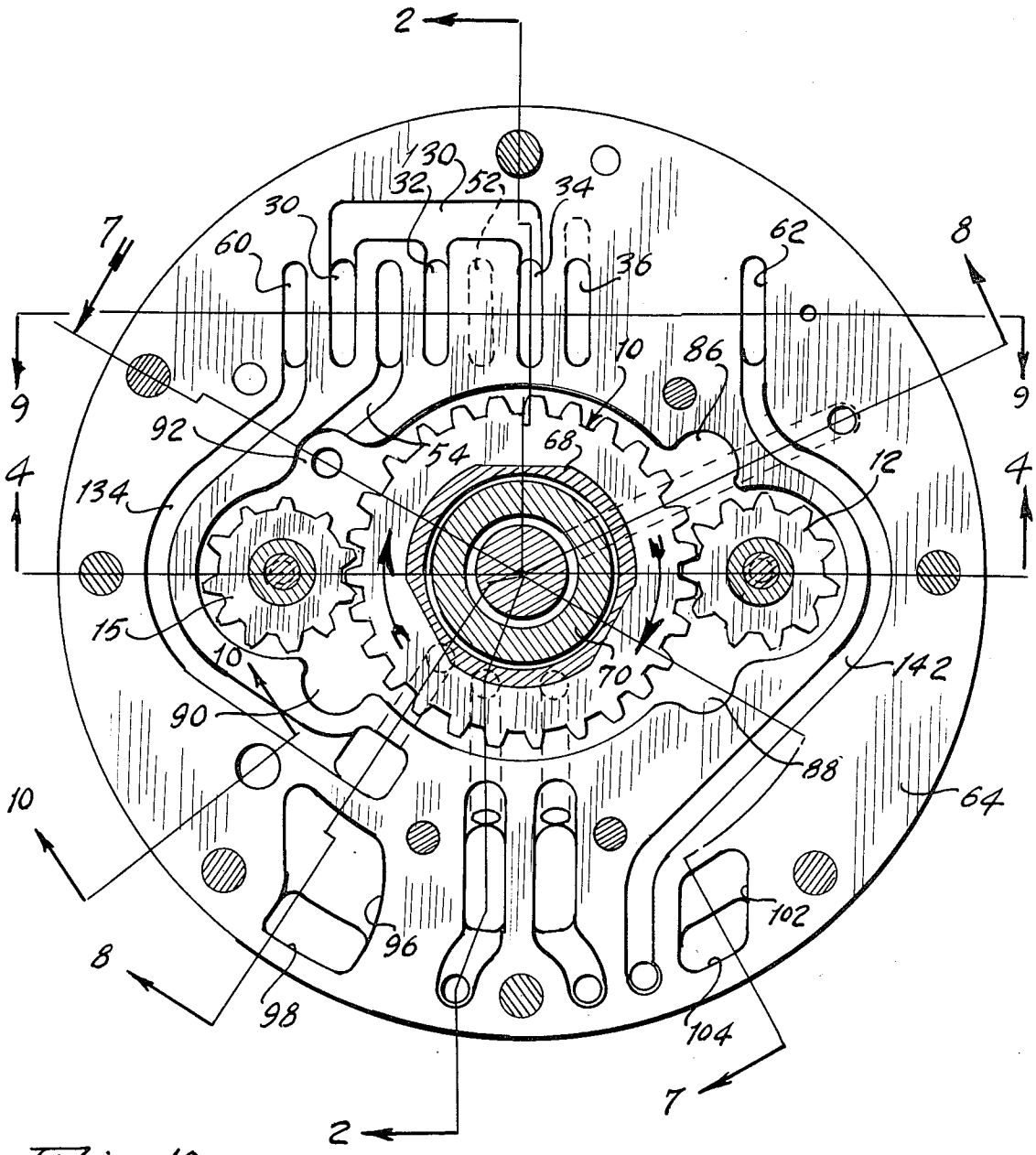
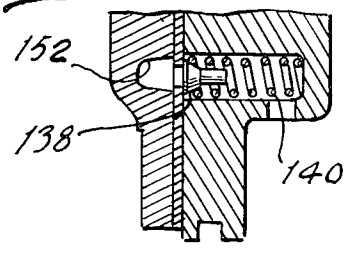
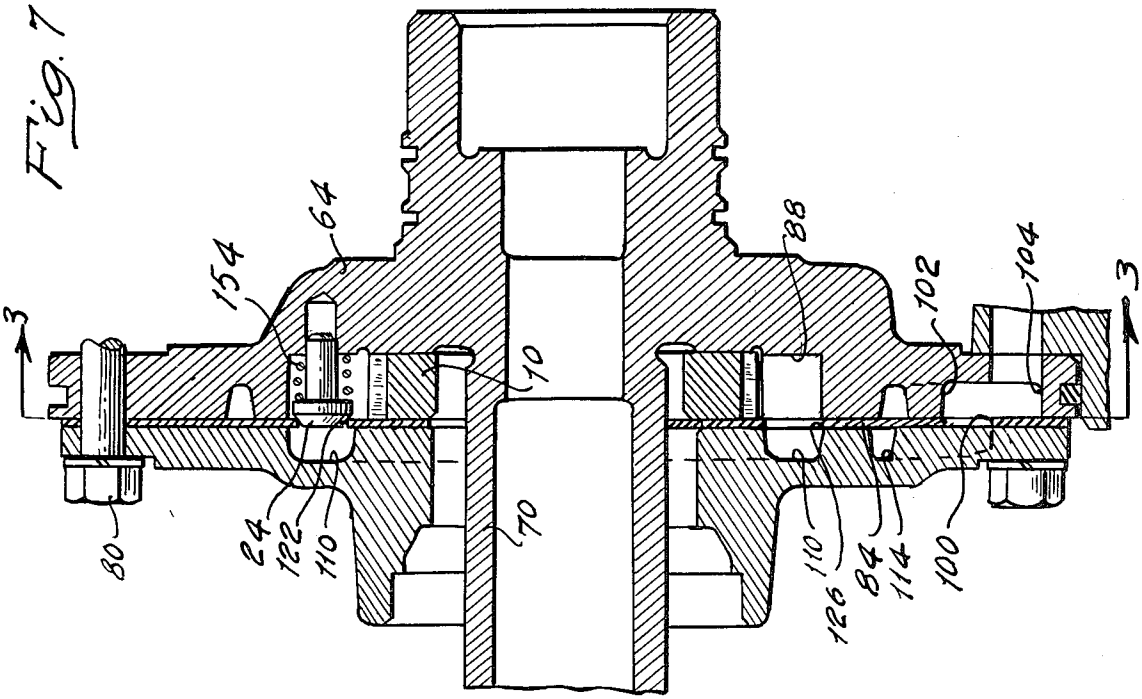


Fig. 10



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Fig. 7



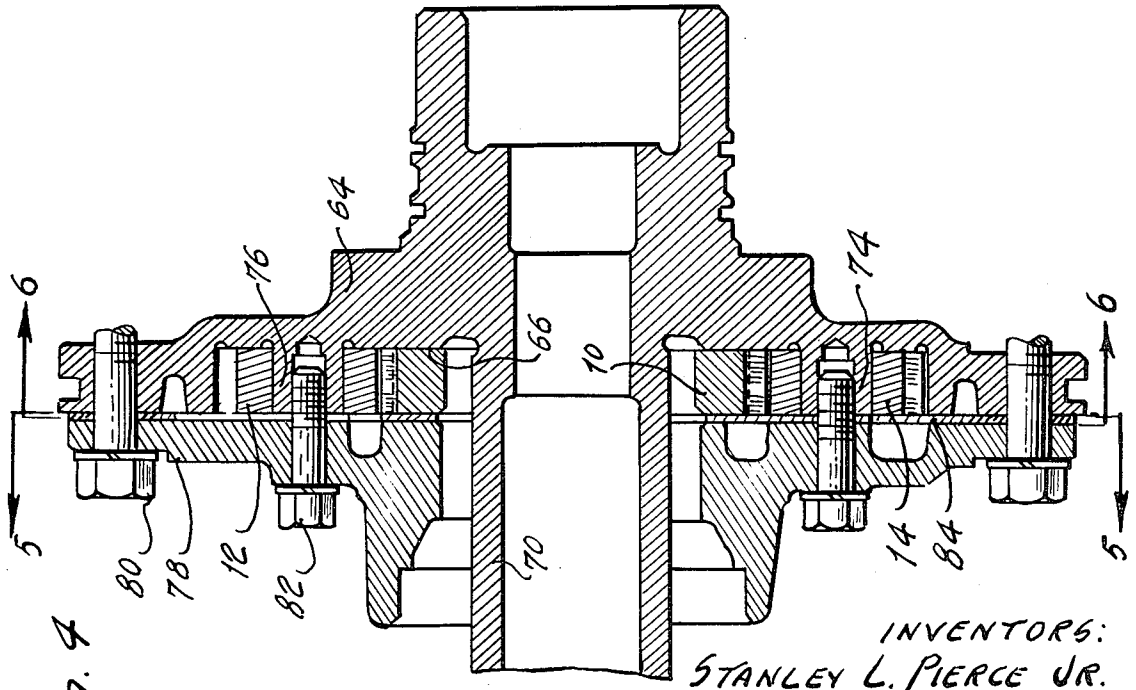
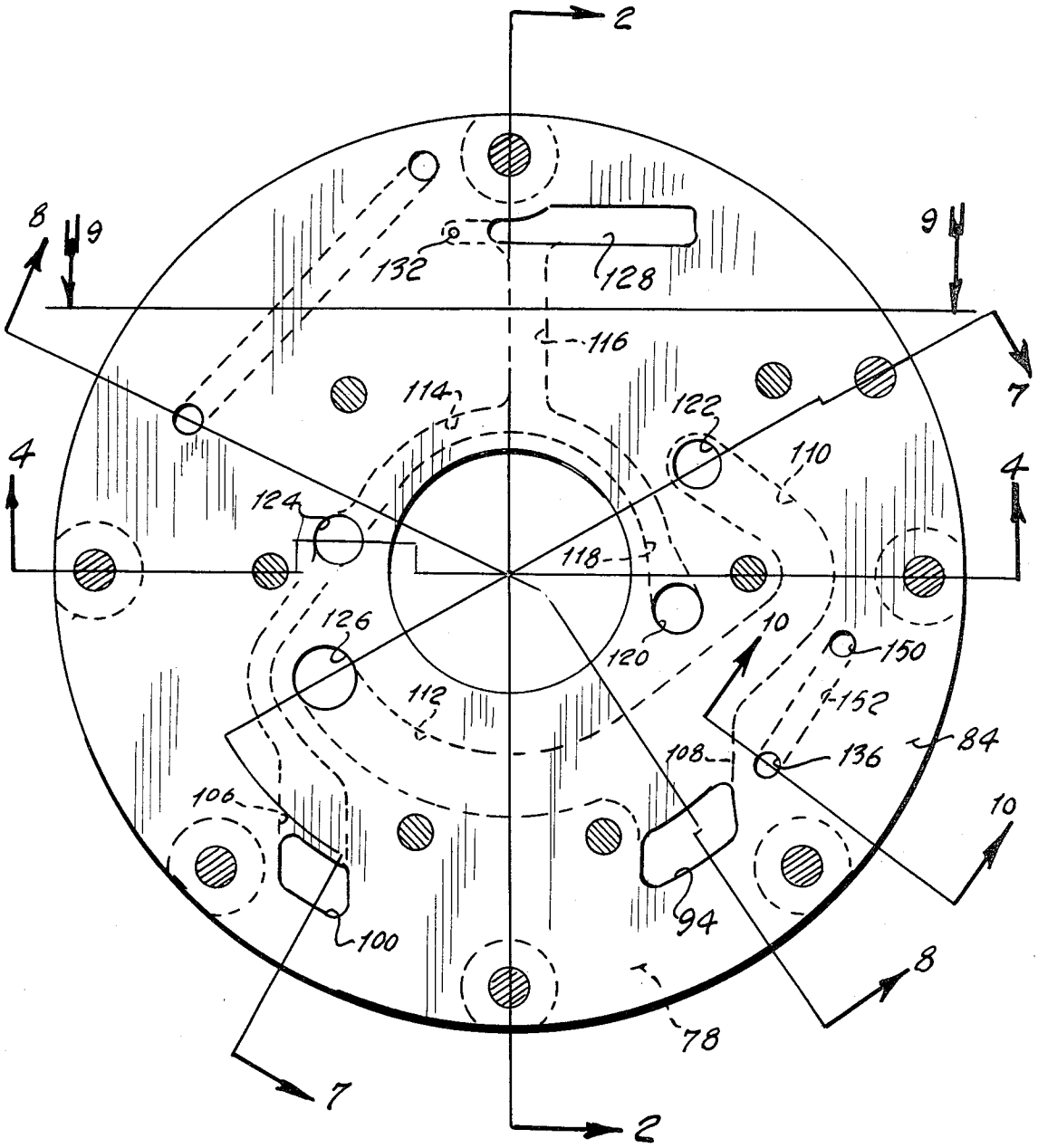


Fig. 4

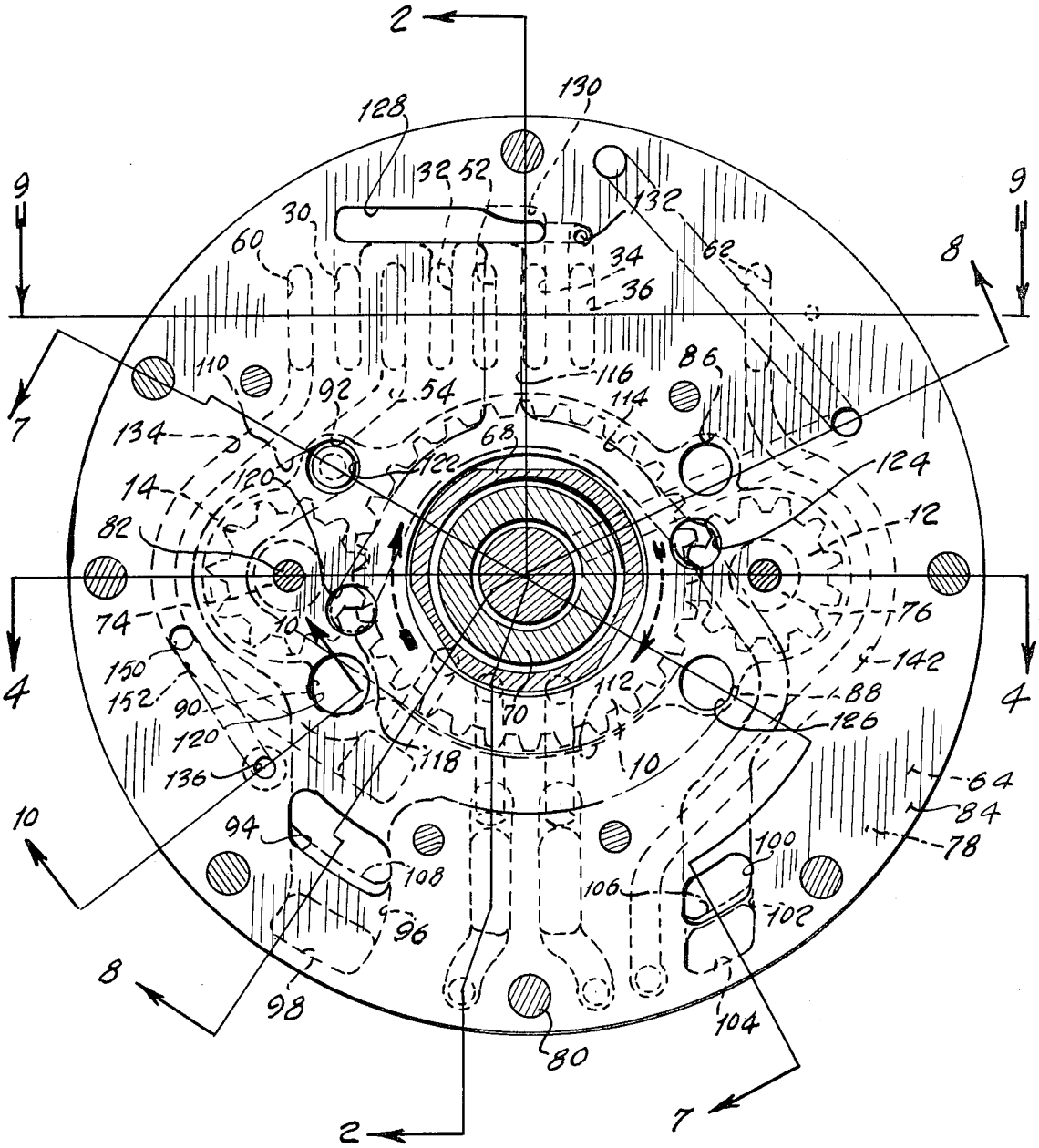
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Fig. 5



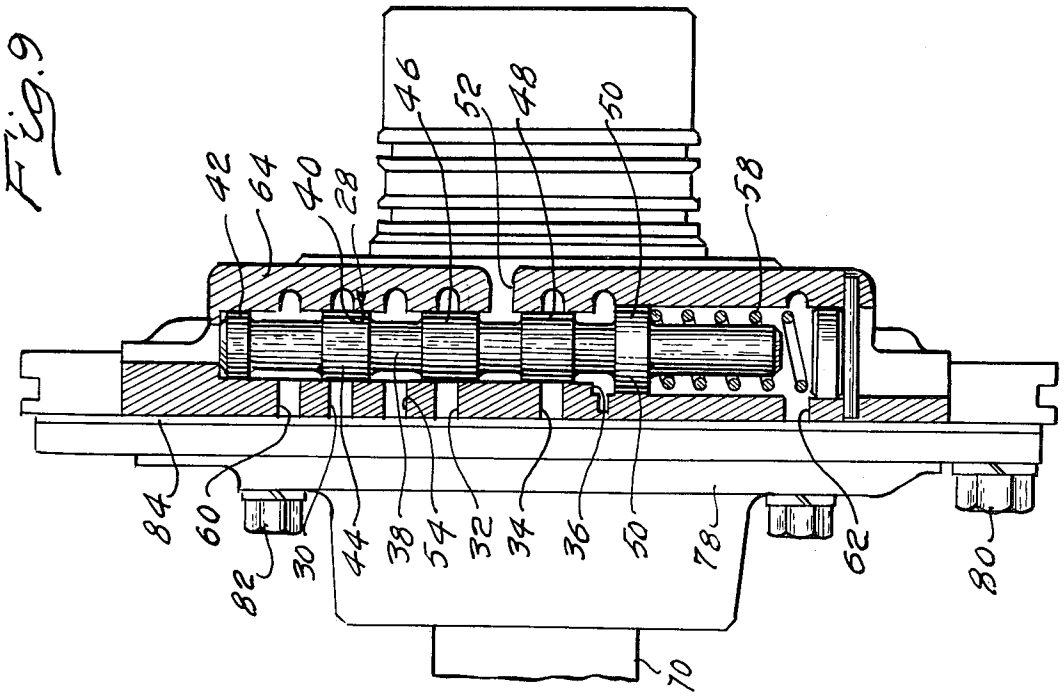
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Fig. 6



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Fig. 9



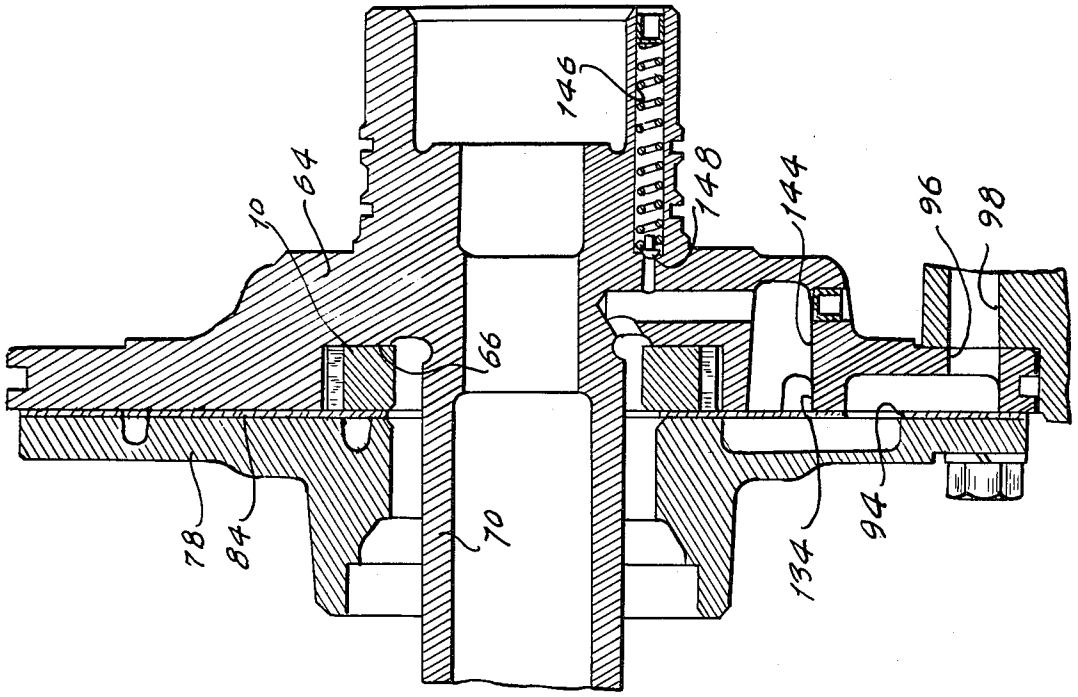


Fig. 8

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TWO-STAGE POSITIVE DISPLACEMENT PUMP

BRIEF DESCRIPTION OF THE INVENTION

My invention can be adapted readily for use in an automatic power transmission mechanism for use in an automotive vehicle driveline. It is an improvement in the structure described in U.S. Patent No. 2,257,095. Such mechanisms include pressure operated actuators for the transmission clutches and brakes, the latter being used to control the relative motion of the torque transmitting gear elements. An automatic control valve system controls the operation of the actuators so that suitable ratio changes will occur in response to changing operating variables such as vehicle speed and engine intake manifold pressure. The pressure source for the clutch and brake actuators in an engine driven pump which forms a part of the control valve circuit. In automatic transmission mechanisms that employ a hydrokinetic torque converter, the impeller of the torque converter is connected to the engine. The driving element of the positive displacement pump is connected to the impeller. The turbine of the hydrokinetic torque converter is arranged in toroidal fluid-flow relationship with respect to the impeller and is connected to the power input clutch structure for the transmission.

It is necessary in environments of this type to provide adequate circuit pressure to maintain the clutch and brake actuator capacity. The pumping capacity of the pump must be sufficient to supply the circuit requirements at low operating speeds as well as during operation at high speeds. It is necessary, therefore, to bypass a considerable volume of fluid during operation at high speeds. This causes a horsepower loss since the pump operates against a pressure head as it develops the necessary volume of fluid.

According to a principal feature of my invention, I have provided a positive displacement pump having two stages. Each stage comprises a pair of meshing gear elements and both stages are active during operation at low speeds. The pumping stages have a common gear which engages two driven gears. A pressure regulator valve is used to bypass excess fluid from the high pressure porting of the two pumping stages to a common supply circuit. The effective output pressure of the two pumping stages thus is maintained at a calibrated value depending upon the characteristics of the regulator valve.

A bypass circuit connects the inlet side of the secondary pumping stage to the outlet side of the regulator valve means so that a pressure build-up occurs on the inlet side of the secondary pump whenever the fluid flow bypass through the regulator valve means exceeds the desired value. This increases the pressure on the inlet side of the secondary pump thereby reducing the pressure difference across the secondary stage and, accordingly, decreasing the pumping horsepower required to maintain the circuit pressure.

As the operating speed of the pump gears decreases, the pressure difference across the secondary stage increases so that the secondary stage will contribute to the effective pressure maintained by the compound pump structure.

A one-way check valve is situated in the intake circuit so that fluid will be supplied from a common sump

to the inlet side of the secondary stage whenever the fluid flowing through the intake circuit is insufficient to supply the pump requirements of the secondary stage. Whenever the fluid flowing through the intake circuit is in excess of the supply requirements of the secondary stage, the check valve will close thereby preventing short-circuiting of the pressure from the feed back passage to the sump and causing a pressure build-up to occur in the inlet porting of the secondary stage.

BRIEF DESCRIPTION OF THE FIGURES OF THE DRAWING

FIG. 1 shows in schematic form my improved double stage pumping gears and a regulator valve arrangement with which it is used.

FIG. 2 is a cross-sectional view of my pump structure as seen from the plane of section line 2—2 of FIG. 3.

FIG. 3 is a cross-sectional view of my pump structure as seen from the plane of section line 3—3 of FIG. 7.

FIG. 4 is a cross-sectional view as seen from the plane of section line 4—4 of FIG. 3.

FIG. 5 is a view of a structure of FIG. 3 as seen from a plane of section line 5—5 of FIG. 2.

FIG. 6 is a view of the separator plate shown in FIG. 2.

FIG. 7 is a cross-sectional view as seen from the plane of section line 7—7 of FIG. 3.

FIG. 8 is a cross-sectional view as seen from the plane of section line 8—8 of FIG. 3.

FIG. 9 is a cross-sectional view as seen from the plane of section line 9—9 of FIG. 3.

FIG. 10 is a cross-sectional view taken along the plane of section line 10—10 of FIG. 3.

PARTICULAR DESCRIPTION OF THE INVENTION

In FIG. 1 reference character 10 designates generally a driving gear of a compound, double-stage pump assembly. The assembly includes also a primary pump gear 12 and a secondary pump gear 14. Gear 10 meshes driveably with each of the gears 12 and 14. The mesh provided between the gears 10 and 12 establishes a primary pumping stage and the mesh between gears 10 and 14 establishes a secondary pumping stage. The high pressure port for the primary pumping stage communicates with the pressure passage 14. The low pressure side of the primary pumping stage communicates with supply passage 60, which in turn communicates with a common sump 18 for both the primary and secondary stages.

The high pressure side of the secondary pumping stage communicates with pressure passage 20. The low pressure port of the secondary pumping stage communicates with low pressure passage 22 which communicates with a common sump 18 through a one-way check valve 24. Valve 24 will permit transfer of fluid from sump 18 to the supply passage 22, but it will prevent back flow of fluid from passage 22 to the sump 18.

Passage 14 and passage 20 communicate with a common line pressure output passage 26.

A pressure regulator valve assembly 28 communicates with a line pressure passage 26 through four spaced valve ports 30, 32, 34 and 36. The regulator valve assembly 28 includes a multiple land valve element 38 slidably situated in valve chamber 40. Valve

chamber 40 includes internal valve lands that register with external valve lands 42, 44, 46, 48 and 50 formed on the valve element 38. The region situated between valve lands 46 and 48 communicate with exhaust port 52. Feed-back pressure port 54 communicates with feed-back passage 56, which extends to the feed passage 22 for the secondary pump stage.

Valve element 38 normally is urged in a left-hand direction by valve spring 58, which acts directly on the end of the valve element. Lands 48 and 50 define a pressure differential area on which the pressure in port 36 is caused to act. This force balances the force of the spring 58.

A converter pressure feed passage 60 communicates with valve chamber 40 at a location intermediate valve lands 42 and 44. Valve land 44 controls the degree of communication between line pressure passage 26 and the port 60. Valve land 46 controls the degree of communication between feed-back passage 56 and line pressure passage 26. Valve land 48 controls the degree of communication between exhaust port 52 and line pressure passage 26. A control signal pressure is distributed to the right-hand side of the valve land 50 through port 62. This signal produces a force that supplements the force of the spring 58. The magnitude of the signal depends upon the vehicle speed and the engine intake manifold pressure, although in other environments a pressure signal may be used that depends upon other operating variables.

As the pressure in passage 20 increases, the pressure force acting in the right-hand direction on valve element 38 increases the degree of communication between ports 30 and 60, between ports 32 and 54, and between ports 34 and 52. The regulator valve will maintain a regulated pressure in line pressure passage 26 because of this tendency to increase the bypass flow from line pressure passage 26 through the valve chamber 40 whenever a pressure rise tends to occur. If the combined force of the spring and the force due to the pressure signal in port 62 should change, the regulated pressure in passage 26 will change accordingly.

During operation of the vehicle at low speeds, my two-stage pump assembly will be able to maintain the necessary control pressure in passage 26. A single stage pump of comparable size, on the other hand, may not have the necessary pumping capacity at low speeds. This is due in part to pump leakage around the pumping gears and due to flow of fluid through exhaust ports and lubrication ports in the valve circuit itself.

As the speed of the pump increases, the volume of fluid bypassed to passage 56 increases. The total intake for the secondary pump stage is equal to that bypass flow plus the flow of fluid from the sump through the check valve 24. As the percentage of the fluid passing through the passage 56 increases upon a further increase in the speed of rotation of the pump, the percentage of the fluid supplied from the sump through the valve 24 decreases. As soon as the bypass flow in passage 56 increases to a value that is sufficient to satisfy the fluid intake requirements for the secondary stage, check valve 24 will close and immediately the pressure in passage 22 and the inlet side of the pump will rise to a value close to the line pressure that exists in passage 26.

The pump structure includes, as best seen in FIGS. 3 and 4, a main pump housing 64. The housing is provided with a cavity 66 within which the gears 10, 12 and 14 are situated. The inner wall of the recess 66 is formed with a flat surface that is generally perpendicular with respect to the axis of rotation of gear 10. The gears 10, 12 and 14 have end faces which register with the flat surface of the recess 66.

Gear 10 is formed with an internal opening within which is positioned a drive sleeve shaft 68 which may be keyed or splined to the gear 10. Shaft 68 surrounds the stator sleeve shaft 70, which forms a part of the housing 64. An example of a gear pump of this type used in a power transmission mechanism may be seen by referring to U.S. Pat. No. 3,339,431, which is assigned to the assignee of this invention.

An automatic power transmission mechanism employing a hydrokinetic torque converter includes a driving connection between the impeller of the torque converter and the shaft 68 so that the gear 10 is driven by the engine which is connected to the impeller. The stationary, bladed, stator race of the torque converter would be splined at 72 to the stator sleeve shaft 70.

Gear 10 is mounted rotatably on gear support 74, and gear 12 is mounted on gear support 76. A cover plate 78 is bolted by means of bolts 80 and 82 to the face of the pump body 64 thereby completing the pumping chamber within which the pumping gears 10, 12 and 14 are situated. The separator plate 84 is situated between the cover plate 78 and the pump body 64. The separator plate is illustrated more particularly in FIG. 6.

The meshing gears 10 and 12 define a so-called primary pump, and meshing gears 10 and 14 define a so-called secondary pump. The primary pump includes a pressure cavity 86 and a low pressure cavity 88. Each of the cavities 86 and 88 communicate with the main pumping cavity 66.

The secondary pump also defines a high pressure cavity and low pressure cavity as seen at 90 and 92, respectively.

Separator plate 84 is provided with an intake port 94 which communicates with low pressure cavity 96 and low pressure inlet passage 98 formed in the pump body 64. Separator plate 84 is provided also with a pressure port 100, which is adapted to register with high pressure chamber 102 formed in the pump body 64 and with outlet port 104. The face of the separator plate 84 that appears in FIG. 6 is adapted to register with the face of the pump 64 that appears in FIG. 3. The opposite side of the pressure plate 84 registers with the face of the cover plate 78 that appears in FIG. 5. When the plate 84 registers with the plate illustrated in FIG. 5, port 100 registers with recess 106 and port 94 registers with recess 108. Recess 108 includes extensions 110 and 112 and recess 106 includes an extension 114 as well as two branch extensions 116 and 118. Port 120 in the separator plate 84 is a high pressure port which registers with the extension 118 and port 122. In the separator plate 84 is a low pressure port which registers with the extension 110. Port 122 registers also with low pressure cavity 92 and port 120 registers with high pressure cavity 90 in the secondary pump stage.

High pressure port 124 in the separator plate 84 registers with extension 114 of the high pressure port

106. Low pressure port 126 in the separator plate 84 registers with extension 112 for the low pressure cavity 108 formed in the cover plate. These ports 124 and 126 register, respectively, with high pressure chamber 86 and low pressure chamber 88 formed in the pump body 64.

Extension 116 registers with port 128 formed in the separator plate. This port receives high pressure from the recess 106 and distributes it to cross-over passage 130 formed in the pump body 64. This passage 130 communicates with each of three high pressure inlet ports for the regulator valve assembly. These ports have previously been identified by reference characters 30, 32 and 34. Orifice 132 in the separator plate 84 communicates with the extension 116 in the cover plate 78. It communicates also with port 36 in the regulator valve assembly so that line pressure can be distributed to the differential area provided by valve lands 48 and 50. The presence of the orifice 132 provides the dampening action for the regulator valve and reduces pressure fluctuations.

Port 60, previously described with reference to FIG. 1, is shown also in FIG. 3. It communicates with converter feed passage 134 which extends to port 136 formed in separator plate 84. This port is adapted to register with check valve 138 and is urged into sealing engagement against port 136 by valve spring 140. Reverse flow of fluid from the converter to the passage 134 is prevented by the check valve 138, but fluid distribution from passage 134 and port 60 to the converter is permitted.

Pump body 64 is provided also with an internal passage 142 through which compensator pressure is distributed to port 62, which communicates with the spring chamber for the regulator valve assembly.

Passage 134 communicates with lubrication passage 144, which extends to lubrication passage 146 through one-way check valve 148 as seen in FIG. 8.

Converter relief pressure port 150 in the separator plate 84 registers with passage 134 formed in pump body 64. The pressurized fluid then passes through recess 152 formed in the cover plate 78 to cavity 154 on the inlet side of the check valve 138.

Check valve 24 which forms a one-way fluid flow control between the sump and the inlet side of the secondary pump includes the port 122 which communicates on its other side with the extension 110 of the low pressure cavity 108. Valve 124 normally is seated against the port 122 by valve spring 154.

All of the pump cavities, the porting and the internal passageways necessary to effect the operation of the compound pump structure are defined by the pump body 64, the cooperating cover plate 78 and the separator plate 84. The over-all assembly is compact and adapted to be used in controls for automatic power transmissions for automotive vehicles.

Having thus described a preferred form of my invention, what I claim and desire to secure by U.S. Letters Patent is:

1. A compound pump assembly having a primary stage and a secondary stage, each stage being defined by meshing pumping gear elements, one gear element of each stage being common, a pump body within which said gear elements are rotatably mounted, said pump body defining in part separate high pressure outlet ports and separate low pressure inlet ports for said pumping stages, a high pressure circuit comprising internal passages formed in said pump body communicating with both of the outlet ports, a first fluid supply passage communicating with the inlet side of said primary pump stage, a second fluid supply passage communicating with the low pressure side of said secondary pump stage, a pressure regulating bypass valve means having a valve chamber and a movable valve element situated therein, said valve chamber and said valve element having registering valve lands, said high pressure circuit communicating with said valve chamber, exhaust ports communicating with said valve chamber for receiving fluid bypassed from said high pressure circuit through said valve means, said second supply passage communicating with said valve chamber, unidirectional flow valve means in said second supply passage for preventing flow of fluid from the inlet side of said secondary stage but accommodating transfer of fluid therethrough from said inlet side of said primary stage, means for biasing said valve element in one direction to restrict the degree of communication between said high pressure circuit and said exhaust ports and a pressure area on said valve element in communication with said high pressure circuit for opposing said biasing means whereby said regulator valve means establishes a regulated pressure in said high pressure circuit as the speed of rotation of said gear element changes, the degree of communication between said high pressure circuit and the inlet side of said secondary stage increasing as the degree of bypass flow through said regulator valve means increases, whereby the pressure differential across said secondary stage becomes substantially zero when the fluid supply requirements for said secondary stage are supplied by said secondary stage.

2. The combination as set forth in claim 1 wherein said valve element moves in one direction upon an increase in the speed of said gear elements to increase the degree of communication between said high pressure circuit and said exhaust ports and to increase the degree of communication between said high pressure circuit and the inlet side of said secondary pump, and means for supplying a control pressure signal to said valve chamber thereby establishing a force on said valve element that opposes the tendency of said valve element to uncover said exhaust ports.

3. The combination as set forth in claim 1 wherein said pumping stages comprise a first external gear and second and third external gears meshing with said first external gear, thereby defining two gear meshes, one mesh being associated with each pumping stage, and a common pumping chamber in said pump body for receiving said gear elements.

4. The combination as set forth in claim 2 wherein said pumping stages comprise a first external gear and second and third external gears meshing with said first external gear, thereby defining two gear meshes, one mesh being associated with each stage, and a common pumping chamber in said pump body for receiving said gear elements.

5. The combination as set forth in claim 3 wherein said pump body comprises a first body part in which said pumping chamber is formed, a cover plate secured to said first body part and cooperating therewith to define a closed pumping cavity, and a separator plate

situated between said cover plate and said first body part, said cover plate being formed with internal passages and said separator plate being formed with a plurality of ports establishing fluid communication between said passages and the low and high pressure sides of each of said stages.

6. The combination as set forth in claim 4 wherein said pump body comprises a first body part in which said pumping chamber is formed, a cover plate secured to said first body part and cooperating therewith to define a closed pumping cavity, and a separator plate situated between said cover plate and said first body part, said cover plate being formed with internal passages and said separator plate being formed with a plurality of ports establishing fluid communication between said passages and the low and high pressure sides of each of said stages.

7. The combination as set forth in claim 5 wherein said regulator valve means comprises a valve chamber formed in said body part, and a plurality of valve passages in said first body part communicating with the passages in said cover plate through said separator plate, said first body part also being formed with fluid pressure distributor passages communicating with the high pressure sides and low pressure sides of said stages and communicating with other portions of said valve chamber.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,692,432 Dated September 19, 1972

Inventor(s) Po-Lung Liang et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Title Page, cancel "Staley L. Pierce, Jr." and substitute --Stanley L. Pierce, Jr.--.

Column 6, line 36, cancel "secondary" and substitute --primary--.

Signed and sealed this 16th day of July 1974.

(SEAL)
Attest:

McCOY M. GIBSON, JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

FORM PO-1050 (10-69)

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